MACHAKOS UNIVERSITY

University Examinations 2023/2024 Academic Year

SCHOOL OF PURE AND APPLIED SCIENCES

DEPARTMENT OF PHYSICAL SCIENCES

FOURTH YEAR SECOND SEMESTER EXAMINATION FOR

BACHELOR OF SCIENCE IN APPLIED PHYSICS AND TECHNOLOGY

SPH 410: SENSORS AND TRANSDUCERS

DATE: **TIME:**

INSTRUCTIONS:

- The paper consists of two sections.
- Section A is compulsory (30 marks).
- Answer any two questions from section B (each 20 marks).

SECTION A

QUESTION ONE (30 MARKS)

a) List at least four (4) fundamental principles for operation of thermocouples (4 marks)

b) Give a brief explanation of the following as used in sensors and transducers

i. Beer – Lambert's law (1 mark)

ii. Primary transducer (1 mark)

iii. Secondary transducer (1 mark)

iv. Active transducer (1 mark)

v. Piezoresistive effect (1 mark)

vi. Measurand (1 mark)

c) With the aid of a block diagram, briefly describe the activities that take place during signal processing at the detector- transducer stage (5 marks)

d) State the five basic requirements of a transducer for effective performance (5 marks)

e) Briefly explain the process of signal conditioning (5 marks)

f) Give five advantages of electrical transducers (5 marks)

SECTION B

QUESTION TWO (20 MARKS)

a) A heliport is provided with 40 turns/mm. The gearing arrangement is such that the motion of the main shaft by one revolution causes five revolutions of the potentiometer shaft. Calculate the resolution of the potentiometer. (5 marks)

b) A capacitance transducer of two parallel plates of overlapping area of $5\times10^{-4}m^2$ is immersed in water. The capacitance, C, has been found to be 9.50pF. Calculate the separation, d, between the plates and the sensitivity, $s=\frac{\partial C}{\partial d}$, of this transducer, given $\varepsilon_{r,water}$ = 81, $\varepsilon_o = 8.854\ pF/m$ (5 marks)

c) A pressure measuring instrument uses a capacitive transducer having a spacing of 4mm between its diaphragms. A pressure of 600KN/m^2 produces an average deflection of 0.3mm of the diaphragm of the transducer. The transducer which has a capacitance of 300pF before application of pressure is connected to an oscillator circuit having a frequency of 100 kHz. Determine the change in frequency of the oscillator after the pressure is applied to the transducer. (10 marks)

QUESTION THREE (20 MARKS)

a) (i) Describe the construction and operation of an electromagnetic flow transducer. (3 marks)

(ii) Hence show that

$$e=\frac{4BQ}{\pi D}$$

where B is flux density, Q is volumetric flow rate and D is the diameter of the pipe (3 marks)

b) A compressive force is applied to a structural member. The strain is 5 microstrain. Two separate strain gauges are attached to the structural member, one is a nickel wire strain gauge having a gauge factor of -12 and the other is nichrome wire having a gauge factor of -12. Calculate the value of resistance of the gauges if they are strained given that the resistance before being strained is 120Ω for both strain gauges. (9 marks)

c) In a piezoelectric transducer, a flat frequency response within 5% is required. Find the value of minimum frequency in terms of time constant for which it can be used. If the time constant of the transducer is 1.5ms, find the value of minimum frequency. Find the phase shift at the frequency. (5 marks)

QUESTION FOUR (20 MARKS)

a) State the THREE main forms of error presentation in a reading (3 marks)

b) Two instruments used in a field study record the following results: V1= 37.5V, T1 = 25.0 ^oC, V2 = 36.26V, T2 = 63.5 ^oC. If the values are used in the following equation

$$T_C(\%)=\frac{V2-V1}{T2-T1}(\%)$$

Determine the error in T_C if the reading errors in the readings are: V1= $\pm$ 0.1V, T1 = $\pm$ 0.2 ^oC, V2 = $\pm$ 0.1V, T2 = $\pm$ 0.2 ^oC. (5 marks)

c) With the aid of a suitable block diagram, describe all stages a signal picked up from a physical environment goes through to its final form. (12 marks)

QUESTION FIVE (20 MARKS)

a) With the aid of a suitable diagram, describe the construction and operation of a linear variable differential transformer (LVDT). (6 marks)

b) State and explain two advantages and two disadvantages of resistive digital encoders (4 marks)

c) The output of an LVDT is connected to a 5V voltmeter through an amplifier whose amplification factor is 250. An output of 2mV appears across the terminals of LVDT when the core moves through a distance of 0.5mm. Calculate the sensitivity of the LVDT and that of the whole set up. The mili-voltmeter scale has 100 divisions. The scale can be read to *1/s* of a division. Calculate the resolution of the instrument in mm. (10 marks)