



TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering & Technology

Department of Electrical & Electronic Engineering

UNIVERSITY EXAMINATION FOR:

Bachelor of Technology in electrical Engineering

TEE4305 INSTRUMENTATION TECHNOLOGY

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: APRIL 2024

Instructions to Candidates

You should have the following for this examination

-Answer Booklet, examination pass and student ID

This paper consists of **FIVE** Questions; Attempt Question ONE and any other TWO Questions.

Do not write on the question paper.

Question ONE

a) Explain the following terms as applied to instrumentation

i) Range ii) span iii) Repeatability iv) Reproducibility **(4 marks)**

b) i) Give any TWO reasons why platinum material is preferred to copper in

resistance temperature detectors (RTDs)

ii) A platinum resistance thermometer has a resistance of 100Ω at 20°C . Determine the resistance at 55°C given the temperature coefficient of resistance of platinum (α) at 20°C is $0.00394/^\circ\text{C}$.

Assume a linear resistance –temperature relationship.

iii) The platinum resistance thermometer in part ii was incorporated in a bridge whose resistances in the three arms is 100Ω . The bridge is supplied by a 12 V supply, determine the offset voltage

(6marks)

c) i) Explain why the material used in photoconductive transducers is made thin and wound back and forth

- ii) A capacitor transducer is made up of two concentric cylindrical electrodes .The outer diameter of the inner electrode is 6mm and the inner diameter of the outer electrode is 6.4mm. Length of the electrode is 30mm, Calculate the change in capacitance if the inner electrode is moved a distance of 5mm. (Take permittivity of free space is $8.85 \times 10^{-12} \text{ F/m}$) (5 marks)
- d) Explain the operation of the arrangement shown in Figure Q1d (5marks)

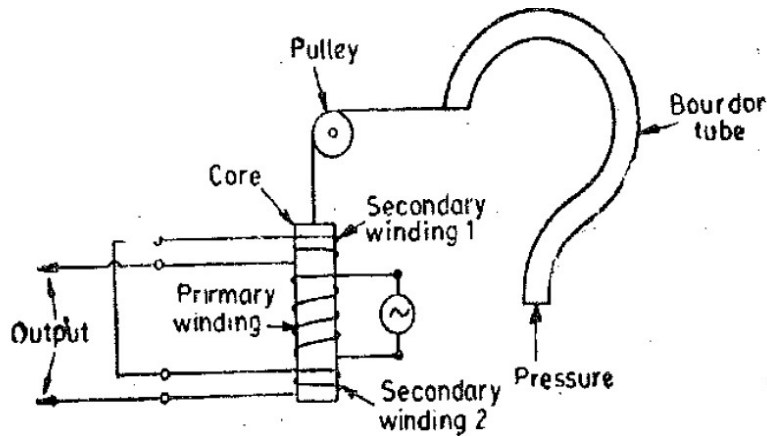


Figure Q1d

Question TWO

- a) With the aid of a diagram, describe the operation of a drag cup tachogenerator (6 marks)
- b) A capacitor employing change of permittivity (dielectric medium) is shown in Figure Q2b. When the dielectric material is moved through a distance x , Show that the change in capacitance is given by;

$$\Delta C = \epsilon_0 w \frac{l_1 l_2}{d} \quad (5 \text{ marks})$$

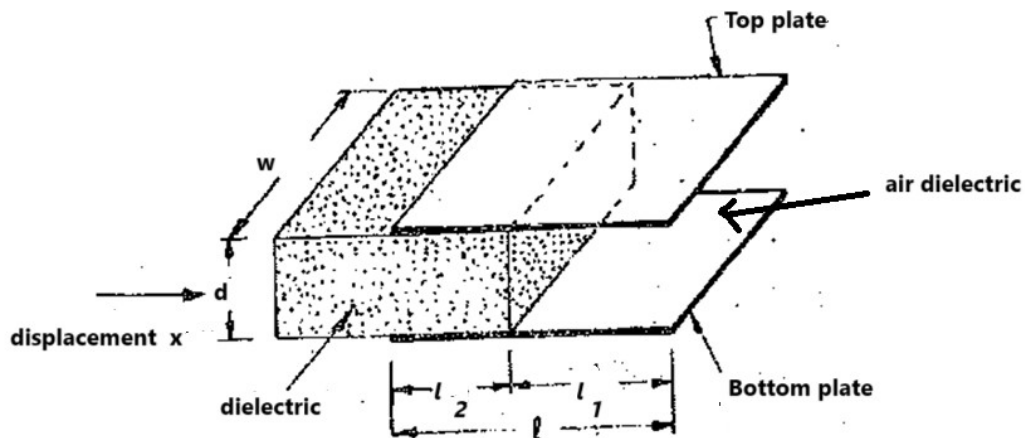


Figure Q2b

- c) In a measurement system to measure pressure, the diaphragm is deflected through $0.5 \times 10^{-3} \text{ mm}$ when a pressure of 1000 N/m^2 is applied. The diaphragm is connected to an LVDT which has an output of 6 V rms when the displacement is $0.4 \times 10^{-3} \text{ mm}$. The output of the LVDT is connected to a 10 V voltmeter with 100 scale divisions. $\frac{1}{5}$ of division can be estimated with ease.
- Determine
- The sensitivity of the diaphragm
 - the sensitivity of the LVDT
 - the overall sensitivity of the measurement system
 - the resolution of the whole system **(6 marks)**
- d) A piezo electric crystal having a thickness of 8 mm and a voltage sensitivity of $0.055 \text{ Vm}^2/\text{N}$. The material has absolute permittivity of $56 \times 10^{-12} \text{ F/m}$. The output voltage is 150 V , determine
- the pressure applied
 - Charge sensitivity **(3 marks)**

Question THREE

- a) Explain the following terms
- piezo resistive
 - piezoelectric
 - Seebeck effect **(3 marks)**
- b) Derive the expression relating the output voltage V_o to the displacement x of the material due to the applied force on piezoelectric transducer having a thickness $t \text{ mm}$ **(4 marks)**
- c) The following data was obtained from the tensile test on a strain gauged rod.;
- Original resistance of gauge $= 450 \Omega$
 - Final resistance of the gauge $= 450.35 \Omega$
 - Gauge factor $= 2$
 - Modulus of Elasticity of the rod $= 200 \text{ GN/m}^2$
 - Diameter of rod $= 14 \text{ mm}$
- Determine the tensile load applied on the strain gauge **(5 marks)**
- d) i) State the Law of intermediate temperatures as applied to thermocouples **(2 marks)**
- ii) A type J thermocouple was used to measure the temperature of a liquid (T^1). The temperature of the reference junction was maintained at 30°C . The emf was found to be 7.545 mV . Use the thermocouples tables provided to find the temperature of the liquid. **(4 marks)**
- e) Distinguish between the following transducer types

i) passive and active

ii) primary and secondary

(2 marks)

Question FOUR

- a) For the equal arm bridge circuit of Figure Q4a, a thermistor is connected to one of the arms. Derive the expression for the output voltage when the temperature is applied, the thermistor resistance increases to $R+\Delta R$ (4 marks)

b)

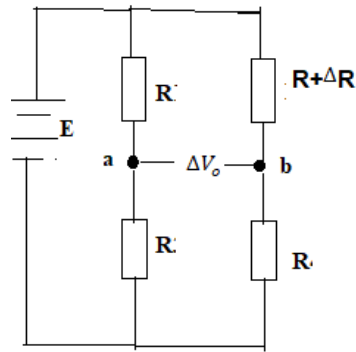


Figure Q4a

- b) For the circuit of Figure Q4b, derive the expression for the output voltage (6 marks)

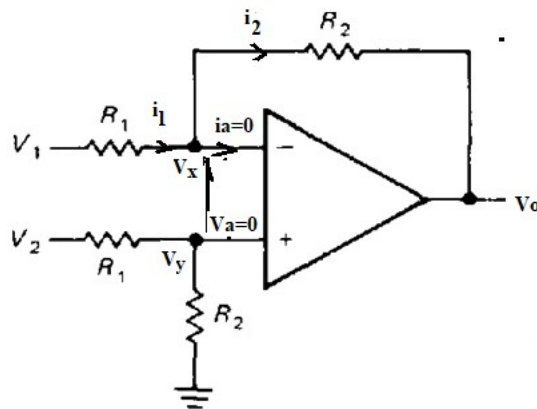


Figure Q4b

- c) Figure Q4c shows an instrumentation amplifier with a potentiometer $R_A = 200 \text{ k}\Omega$ when R_A is varied, Determine

- the minimum output voltage V_o
- the maximum output voltage V_o
- the output when R_A is set at the middle

(4marks)

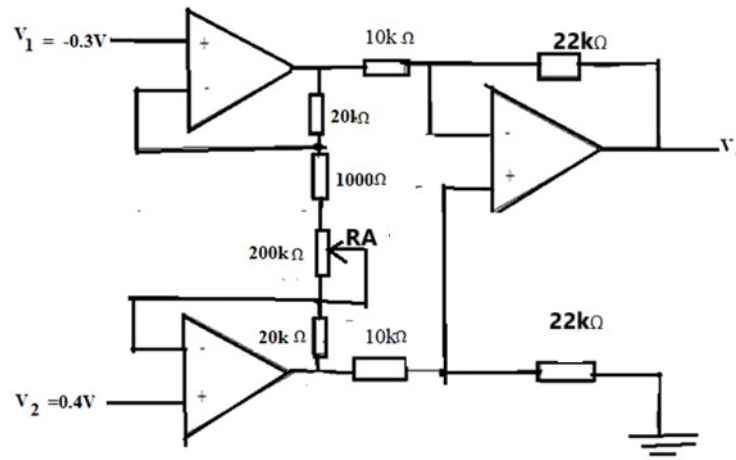


Figure Q4c

- d) Draw the block diagram to show the elements of a instrumentation system and explain the function of each component

Question FIVE

- Explain any THREE advantages of electronic instrumentation system over the mechanical types **(3 marks)**
- Explain any TWO applications of instrumentation systems **(2 marks)**
- An instrument system to convert temperature into a Digital output is shown in Figure Q5c. The transducer has a sensitivity of $7.5\text{mV}/^\circ\text{C}$ and must measure up to 100°C . The 6 bit ADC is used with a 12 volt reference. Determine
 - the ADC input voltage corresponding to full scale output
 - the gain of the amplifier
 - analogue voltage corresponding to 1 bit change in the ADC**(6 marks)**

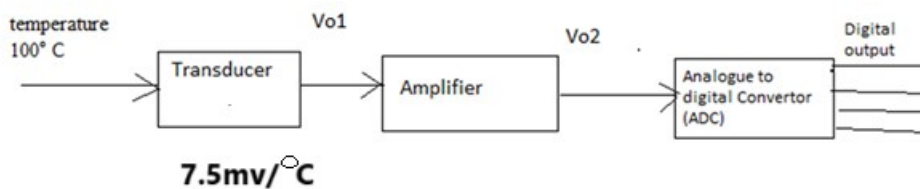


Figure Q5c

- d) Draw a diagram of an x-y recorder and explain its operation **(9 marks)**

THERMOCOUPLE TABLE

<i>Temp. (°C)</i>	<i>Type E</i>	<i>Type J</i>	<i>Type K</i>	<i>Type N</i>	<i>Type S</i>	<i>Type T</i>
−40	−2.254	−1.960	−1.527	−1.023	−0.194	−1.475
−30	−1.709	−1.481	−1.156	−0.772	−0.150	−1.121
−20	−1.151	−0.995	−0.777	−0.518	−0.103	−0.757
−10	−0.581	−0.501	−0.392	−0.260	−0.053	−0.383
0	0.000	0.000	0.000	0.000	0.000	0.000
10	0.591	0.507	0.397	0.261	0.055	0.391
20	1.192	1.019	0.798	0.525	0.113	0.789
30	1.801	1.536	1.203	0.793	0.173	1.196
40	2.419	2.058	1.611	1.064	0.235	1.611
50	3.047	2.585	2.022	1.339	0.299	2.035
60	3.683	3.115	2.436	1.619	0.365	2.467
70	4.329	3.649	2.850	1.902	0.432	2.908
80	4.983	4.186	3.266	2.188	0.502	3.357
90	5.646	4.725	3.681	2.479	0.573	3.813
100	6.317	5.268	4.095	2.774	0.645	4.277
110	6.996	5.812	4.508	3.072	0.719	4.749
120	7.683	6.359	4.919	3.374	0.795	5.227
130	8.377	6.907	5.327	3.679	0.872	5.712
140	9.078	7.457	5.733	3.988	0.950	6.204
150	9.787	8.008	6.137	4.301	1.029	6.702
160	10.501	8.560	6.539	4.617	1.109	7.207
170	11.222	9.113	6.939	4.936	1.190	7.718
180	11.949	9.667	7.338	5.258	1.273	8.235
190	12.681	10.222	7.737	5.584	1.356	8.757
200	13.419	10.777	8.137	5.912	1.440	9.286
210	14.161	11.332	8.537	6.243	1.525	9.820
220	14.909	11.887	8.938	6.577	1.611	10.360
230	15.661	12.442	9.341	6.914	1.698	10.905
240	16.417	12.998	9.745	7.254	1.785	11.456
250	17.178	13.553	10.151	7.596	1.873	12.011
260	17.942	14.108	10.560	7.940	1.962	12.572
270	18.710	14.663	10.969	8.287	2.051	13.137
280	19.481	15.217	11.381	8.636	2.141	13.707
290	20.256	15.771	11.793	8.987	2.232	14.281
300	21.033	16.325	12.207	9.340	2.323	14.860
310	21.814	16.879	12.623	9.695	2.414	15.443