PP2

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: JULY 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 (Compulsory 20 marks)

a) Define the following terms as applied to strain gauges

i) piezoelectric ii) gauge factor **(2 marks)**

b) A strain gauge is bonded to a beam 0.4m long and cross sectional area of $6cm^2$

Young's modulus of the beam is 210 GN/m^2.The strain gauge has an unstrained resistance of 220Ω and a gauge factor of 4.8.When the Load is applied , the resistance of the gauge changes by 0.0156 Ω. Calculate ;

I) the change in length

II) the amount of force applied to the beam **(6 marks)**

c) Distinguish between null and deflection bridges **(2 marks)**

d) A potential divider potentiometer has a resistance of 10kΩ and is used to measure angular displacement. The angle of displacement is 50 ° and the total angle of travel of potentiometer is 355 ° If the exciting voltage is 100V,Calculate

i) the open circuit output voltage

ii) the actual value of the output voltage at this setting if a voltmeter of 50kΩ

iii) the % error due to loading effect **(6 marks)**

e) A type K thermocouple was used to measure the temperature of a liquid (T_1) .The temperature of the reference junction was maintained at 20°C. The emf was found to be 5.3mV .Use the thermocouples tables provided to find the temperature of the liquid. **(4 marks**

Question TWO

a) For the circuit of Figure Q2a, derive the expression for the output voltage **(8 marks)**

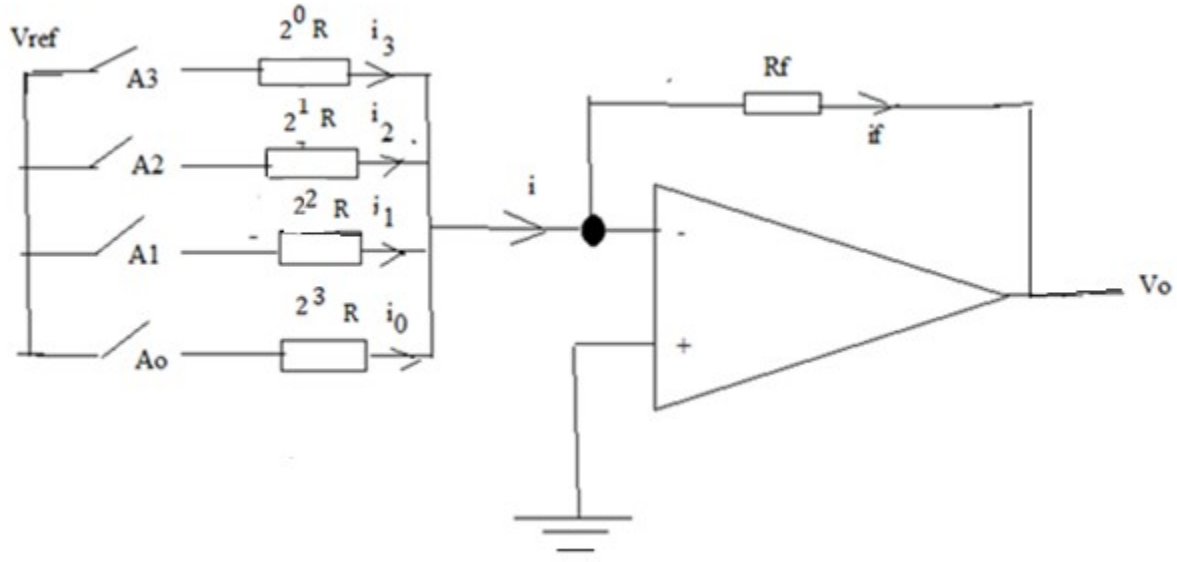

Figure Q2a

b) An instrument system to convert temperature into a Digital output is shown in figure Q2b.The transducer has a sensitivity of 6.5mV/ °C and must measure up to 100 °C. An 8 bit ADC is used with a 15 volt reference. Determine

i) the ADC input voltage corresponding to full scale output

ii) the gain of the amplifier

iii) analogue voltage corresponding to 1 bit change in the ADC (resolution) **(6 marks)**

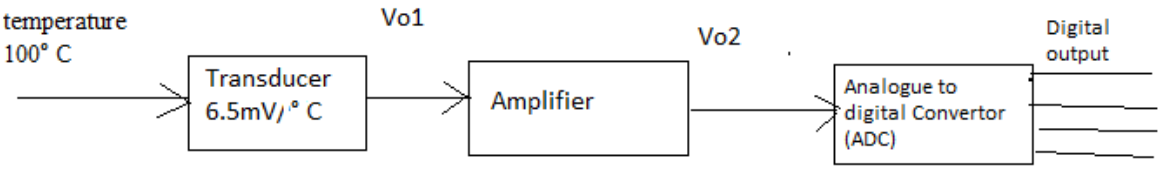

Figure Q2b

c) A barium titanate piezoelectric sensor has the dimensions of 5mmx5mmx1.25mm.The force acting on it is 5N.The charge sensitivity of barium titanate is $150x10^{-12}$C/N and its absolute permittivity is 12.5x 10^{-9} F/m.If the Modulus of elasticity of the material is $12x10^{6}$ N/m^2, calculate

i) The strain
ii) The charge
iii) The capacitance **(6 marks)**

Question THREE

a) i) Distinguish between null and deflection bridges

ii) For the bridge circuit of figure Q3b, Derive the expression for the output voltage V_o

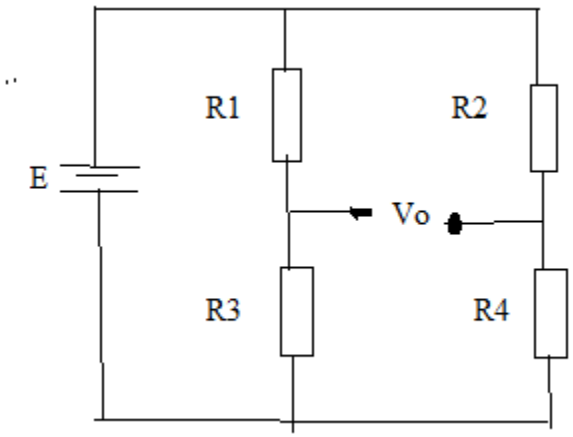

Figure Q3a **(5 marks)**

b) Draw a diagram of an instrumentation amplifier and derive the expression for the output voltage

(6 marks)

c) The bridge arrangement of Figure Q3c contains in its fourth arm a resistive strain gauge transducer of value R=1000Ω when unloaded. When loaded the transistor changes by ΔR depending on the load . If for a particular case ΔR= 100Ω, determine the reading of the voltmeter **(4 marks)**

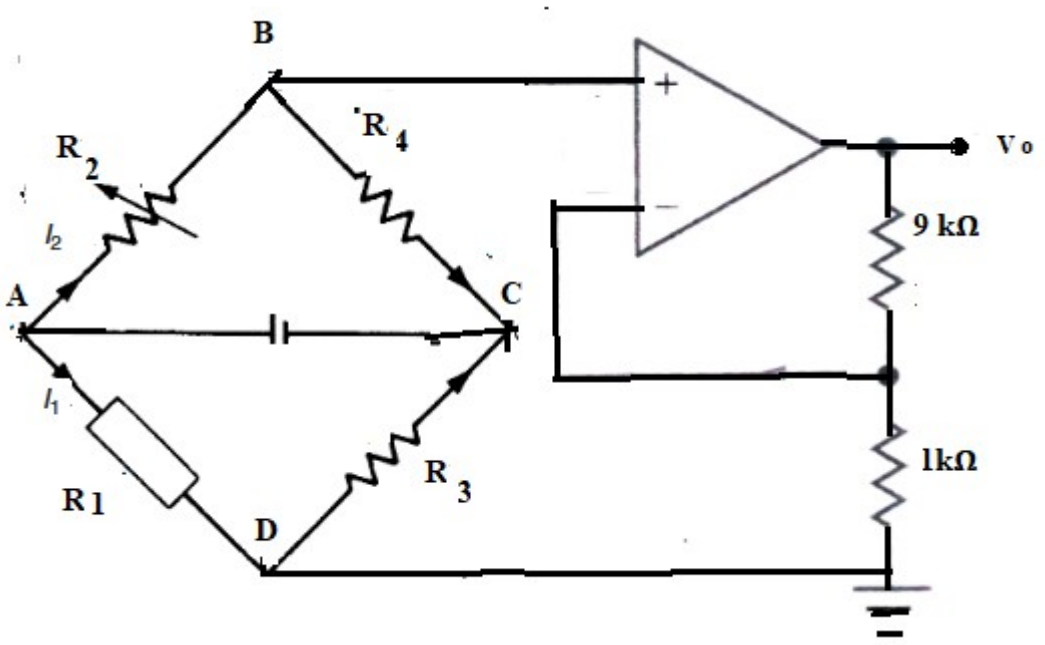

Figure Q3c

d) A strain gauge is made of material having a resistance temperature coefficient of 0.000012/°C. It has a resistance of 120Ω and a gauge factor of 2.It is connected in a bridge circuit having resistance of 120Ω each. The bridge is balanced at ambient temperature .Supposing there is a change of 20 °C in the temperature of the strain gauge. Determine;

i) the output voltage of the bridge if the supply voltage is 10V

ii) the equivalent strain represented by change in temperature **(5marks)**

Question FOUR

a) Draw a diagram of a Linear Variable Differential Transformer(LVDT) and explain its operation (**5marks)**

b) The output of an LVDT is connected to a 50V voltmeter through an amplifier whose amplification is 130. An output of 10mV appears across the output of the LVDT when the plunger moves through 1mm calculate the:-

i. Sensitivity of the LVDT

ii. Sensitivity of the whole set up.

iii) Resolution of the instrument if the voltmeter scale has 100 divisions and the scale can be read to $\frac{1}{10}$ of a division. **(5marks)**

c) The following data was obtained from the tensile test on a strain gauged rod.;

- Original resistance of gauge =450 Ω
- Final resistance of the gauge =451.35Ω
- Gauge factor =2
- Modulus of Elasticity of the rod = 230GN/m^2
- Diameter of rod = 14mm

Determine the tensile load applied on the strain gauge **(5 marks)**

d) Draw a circuit of a dc tachogenerator and explain its operation **(5 marks)**

Question FIVE

a) Explain any THREE advantages of electronic instrumentation systems over the their mechanical counterparts **(5 marks)**

b) A control valve has a linear variation of opening as the input voltage varies from 0-10V. A microcomputer outputs an 10 bit word to control valve opening using an 8 bit DAC to generate the valve voltage , ddetermine ;

i) the voltage required to obtain a full open valve
ii) the percentage of valve opening for a bit change in the input word. **(5 marks)**

c) An instrumentation system to measure bending moment on a wind tunnel fan blade consists of the following components and individual sensitivities and in the order shown in Table Q5c

TableQ5c

component	sensitivity
Bridge circuit composed of strain gauges	4μV/Nm
Operational Amplifier gain	180V/V
Power amplifier	20mA/V
Pen recorder	0.667mm/mA

I) Draw the block diagram of the complete system

II) Determine the overall sensitivity of the system

III) Determine the bending moment required to give a pen deflection of 24mm **(4marks)**

d) Draw a block diagram of a typical instrumentation system and explain the function of each block **(6 marks)**

Thermocouple tables

Temp. (°C)	*Type E*	*Type J*	*Type K*	*Type N*	*Type S*	*Type T*
-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		0.383
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		0.789
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		7.718
180	11.949	9.667	7.338	5.258		8.235
160	10.501	8.560	6.539	4.617		7.207
170	11.222	9.113	6.939	4.936		7.718
180	11.949	9.667	7.338	5.258	1.190	8.235