PP I

TECHNICAL UNIVERSITY OF MOMBASA

School of Engineering & Technology

Department of Electrical & Electronic Engineering

UNIVERSITY EXAMINATION FOR:

BACHELOR OF SCIENCE (ELECTRICAL & ELECTRONIC ENGINEERING)

EEE 4317: SENSORS AND INSTRUMENTATION.

END OF SEMESTER EXAMINATION

SERIES: APRIL 2025

TIME: 2 HOURS

DATE: APRIL 2025

I0nstructions to Candidates

You should have the following for this examination
-Answer Booklet, examination pass and student ID
This paper consists of **five** Questions; Question ONE is compulsory. In addition attempt any Other TWO Questions.
Do not write on the question paper.

Question ONE (**Compulsory 30 marks**)

a) Distinguish between the following pairs of terms
(i) Repeatability and Reproducibility
(ii) Threshold and Resolution
(iii) Precision and Accuracy

[6 marks]

b) During a test run, measurements of temperature were made 100 times with variations in apparatus and procedures. After applying corrections for the known systematic errors, the following data were recorded:

[13 marks]

Temperature °C	**97**	**98**	**99**	**100**	**101**	**102**	**103**	**104**	**105**
Frequency of occurrence	**2**	**5**	**9**	**19**	**33**	**18**	**8**	**4**	**2**

Determine the
(i) arithmetic mean,
(ii) average deviation,
(iii) standard deviation,
(iv) variance and
(v) Probable error of the reading.

c) (i) Define the term calibration

(**ii**) Briefly explain the two calibration methods

(**iii**) Outline any four reasons for calibration

[11 marks]

Question TWO

a) With the aid of diagrams explain the following

(i) Hysteresis

(ii) Dead space

[8 marks]

b) A machine shop was assigned the task to manufacture 20,000 steel rods of a nominal length of 15 mm; the rod length was stipulated neither to exceed 15·25 mm and not to be smaller than 14.5 mm. When inspected for quality control, it was found that 2000 of the rods were too long to fit into a gauge set at 15·25 mm. Predict the number of remaining 18,000 rods which will conform to the specifications. Presume that the measurement data conforms to Gaussian normal distribution curve.

[12 marks]

Question THREE

a) With the aid of diagram explain the construction ad principle of operation of

(i) Bolometer

(ii) LVDT accelerometer

[8 marks]

b) In an LVDT accelerometer the outputs are 0.4 mV/mm with a ± 25 mm core displacement. The spring constant is 300 N/m and the mass of the core is 50 g. Determine the

(i) maximum measurable acceleration,

(ii) natural frequency

(iii) Sensitivity of the accelerometer.

[12 marks]

Question FOUR

a) The Schering bridge of **Figure Q4a** shows the circuit diagram of a Schering bridge. As seen from the diagram, a perfect capacitor C_1 in parallel with a resistance R_1, is to represent it as perfect capacitor C_X in series with resistance R_X

[12 marks]

b) The Schering Bridge shown in Figure Q4a has the following constants R_1 = 1.5 kW, C_1 = 0.4 mF, R_2 = 3 kW and C_3 = 0.4 mF at frequency 1 kHz. Determine the unknown resistance and capacitance of the bridge circuit and dissipation factor.

[8 marks]

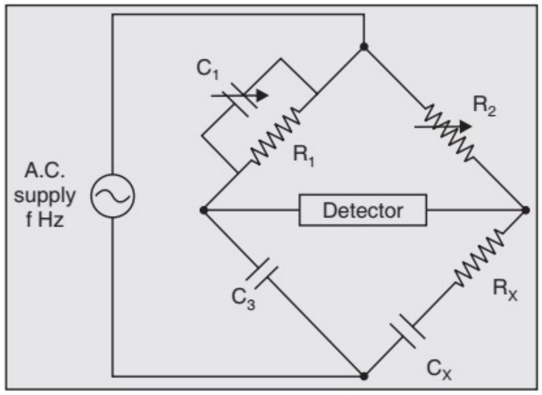

Figure Q4a

Question FIVE

a) Outline any four classes of errors in measurement systems

[8 marks]

b) Show that the change in capacitance **ΔC** in a single gap, parallel plate variable permittivity (dielectric constant) displacement is given by

$$\Delta C = \epsilon_o \frac{bx}{t}\left(\epsilon_{rm} - 1\right) \quad \text{farads}$$

Where

ϵ_o = permittivity of free space = 8.85 x 10^{-12} F/m

ϵ_{rm} = dielectric medium (other than air) which is displaced by the measurand by an amount x

b = width of the parallel plate

$t=$¿ distance between the parallel plates

x = distance moved by the dielectric in a direction parallel to the plane of the plates so that area of plates between which the dielectric lies changes

[12 marks]

Table 3.1 Probability tables

$z=\frac{\delta}{\sigma}$	0	0·01	0·02	0·03	0·04	0·05	0·06	0·07	0·08	0·09
0·0	0·0000	0·0040	0·0080	0·0120	0·0160	0·0199	0·0239	0·0279	0·0319	0·0359
0·1	0·0398	0·0438	0·0478	0·0517	0·0557	0·0596	0·0636	0·0675	0·0714	0·0754
0·2	0·0793	0·0832	0·0871	0·0910	0·0948	0·0987	0·1026	0·1064	0·1103	0·1141
0·3	0·1179	0·1217	0·1255	0·1293	0·1331	0·1368	0·1406	0·1443	0·1480	0·1517
0·4	0·1554	0·1591	0·1628	0·1664	0·1700	0·1736	0·1772	0·1808	0·1844	0·1879
0·5	0·1915	0·1950	0·1985	0·2019	0·2054	0·2088	0·2123	0·2157	0·2190	0·2224
0·6	0·2258	0·2291	0·2284	0·2357	0·2389	0·2422	0·2454	0·2486	0·2518	0·2549
0·7	0·2580	0·2621	0·2642	0·2673	0·2704	0·2734	0·2764	0·2794	0·2823	0·2852
0·8	0·2881	0·2910	0·2939	0·2967	0·2996	0·3023	0·3051	0·3079	0·3106	0·3133
0·9	0·3186	0·3186	0·3212	0·3238	0·3264	0·3289	0·3315	0·3340	0·3365	0·3389
1·0	0·3413	0·3159	0·3461	0·3485	0·3508	0·3531	0·3554	0·3577	0·3599	0·3621
1·1	0·3643	0·3665	0·3686	0·3708	0·3729	0·3749	0·3770	0·3790	0·3810	0·3830
1·2	0·3849	0·3869	0·3888	0·3907	0·3925	0·3944	0·3962	0·3980	0·3997	0·4015
1·3	0·4032	0·4049	0·4066	0·4082	0·4099	0·4115	0·4131	0·4147	0·4162	0·4177
1·4	0·4192	0·4207	0·4222	0·4236	0·4251	0·4265	0·4279	0·4292	0·4306	0·4319
1·5	0·4332	0·4345	0·4357	0·4370	0·4382	0·4394	0·4406	0·4418	0·4430	0·4441
1·6	0·4452	0·4462	0·4474	0·4485	0·4495	0·4505	0·4515	0·4526	0·4435	0·4545
1·7	0·4554	0·4564	0·4573	0·4582	0·4591	0·4599	0·4608	0·4616	0·4625	0·4633
1·8	0·4641	0·4649	0·4656	0·4664	0·4671	0·4678	0·4686	0·4693	0·4700	0·4706

Table 3 1. (*Contd*)

$z=\frac{\delta}{\sigma}$	0	0·01	0·02	0·03	0·04	0·05	0·06	0·07	0·08	0·09
1·9	0·4713	0·4719	0·4726	0·4732	0·4738	0·4744	0·4750	0·4756	0·4762	0·4767
2·0	0·4773	0·4778	0·4783	0·4788	0·4793	0·4798	0·4803	0·4808	0·4812	0·4817
2·1	0·4821	0·4826	0·4830	0·4834	0·4838	0·4842	0·4846	0·4850	0·4854	0·4857
2·2	0·4861	0·4865	0·4868	0·4871	0·4875	0·4878	0·4881	0·4884	0·4887	0·4890
2·3	0·4893	0·4896	0·4898	0·4901	0·4904	0·4906	0·4909	0·4911	0·4913	0·4916
2·4	0·4918	0·4920	0·4922	0·4925	0·4927	0·4929	0·4931	0·4932	0·4934	0·4936
2·5	0·4938	0·4940	0·4941	0·4943	0·4945	0·4946	0·4948	0·4949	0·4951	0·4952
2·6	0·4953	0·4955	0·4956	0·4957	0·4959	0·4960	0·4961	0·4962	0·4963	0·4964
2·7	0·4965	0·4966	0·4967	0·4968	0·4969	0·4070	0·4971	0·4972	0·4973	0·4974
2·8	0·4974	0·4975	0·4976	0·4577	0·4977	0·4978	0·4979	0·4980	0·4980	0·4981
2·9	0·4981	0·4982	0·4983	0·4983	0·4984	5·4984	0·4985	0·4985	0·4986	0·4986
3·0	0·4987	0·4987	0·4987	0·4987	0·4988	0·4989	0·4989	0·4989	0·4990	0·4990
3·1	0·4990	0·4991	0·4991	0·4991	0·4992	0·4992	0·4992	0·4992	0·4993	0·4993
3·2	0·4993	0·4993	0·4994	0·4994	0·4994	0·4994	0·4994	0·4995	0·4995	0·4995
3·3	0·4995	0·4995	0·4996	0·4996	0·4996	0·4996	0·4996	0·4996	0·4996	0·4997
3·4	0·4997	0·4997	0·4997	0·4997	0·3997	0·4997	0·4997	0·4997	0·4998	0·4998
3·5	0·4998	0·4998	0·4998	0·4998	0·4998	0·4998	0·4998	0·4998	0·4998	0·4998
3·6	0·4998	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999
3·7	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999
3·8	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·4999	0·5000	0·5000	0·5000