MASTER OF ELECTRICAL ENGINEERING
MASTER IN CONTROL SYSTEM ENGINEERING
FIRST YEAR SECOND SEMESTER
EXAMINATION, 2025

CYBER PHYSICAL SYSTEMS

Full Marks 100

Time: Three hours **(50 marks for each part)**

Use a separate Answer-Script for each part

PART I

Answers must be to the point and relevant to the specific question.

1. **A temperature sensor has a nominal resistance of 1 kΩ at 25°C. Its resistances at 40°C and 100°C are 1124 Ω and 1706 Ω respectively. It is to be used in an ohmmeter circuit, over 40°C to 100°C. Can you improve the linearity of the output voltage versus temperature characteristic by simply introducing an external resistance? If so, calculate the value of such resistance. Derive the expression used.**

   If the ohmmeter circuit is to be interfaced with a processor-based system, explain how the interfacing can be done to have immunity against variation in the excitation. Also point out, how a look-up table (LUT) is used for software based linearization. [CO2, K2] 9+7

OR

1. (a) **Bring out clearly the motivation for using AC supply for resistive strain gauge bridge circuits. Explain how AC excitation serves the purpose for which it is used. [CO2, K2]** 7

   (b) **A single resistive strain gauge is placed in a Wheatstone bridge circuit. Give an appropriate scheme for removing the nonlinearity introduced by the bridge circuit. Does it guarantee a linear relation between the output and the measured mechanical strain? [CO2, K2]** 4

   (c) **Explain very briefly , with sketches, the functioning of silicon piezoresistive accelerometers. [CO2, K2]** 5

2. (a) What role do the guard electrodes play in capacitive sensors? Elucidate. [CO4, K4] 6

(b) A capacitor microphone system has been developed using a series combination of the transducer (employs the principle of change of separation between the plates), a DC voltage source of 100 V and a resistance *R* of 10 MΩ. The output voltage is measured across *R*. 12

The initial separation between the capacitor plates is 1 mm, the overlapping area of two plates is 630 mm^2, and permittivity of free space is 8.854×10^{-12} F/m. Determine the steady state gain and the time constant of the system. What will be the low-frequency cut-off value of this system, considering a 5% tolerance band? How can this low-frequency cut-off value be brought down to 10Hz? *Derive the expressions used.* [CO4, K4]

OR

2.(a) Give a labelled sketch showing the mechanical structure of MEMS vibratory gyroscope. With relevant free hand sketches elaborate its working principle. [CO3, K3] 4+8

(b) "In an astable multivibrator circuit used for variable air-gap capacitive sensors, the deviation of the output frequency from its nominal value is linearly related with the displacement being measured". Justify or correct the statement with necessary explanation. [CO3, K3] 6

3. Write short notes on <u>any two</u> of the following.

(a) Synchronous demodulation arrangement for Capacitive transducers.

(b) Tactile and touch sensors. 8+8

(c) Digital linearization arrangement for NTC thermistors.

(d) Anderson's loop based digital strain measurement system.

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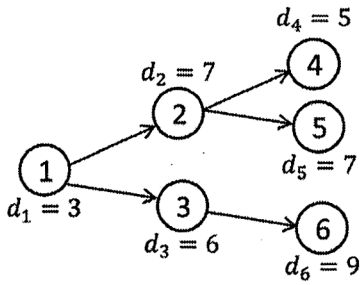
No. of Questions	PART- II	Marks
	Answer questions as per the directives associated.	
	Answer any ONE of question-1 and 2: [CO1-K1]	
1.	Draw a generalized schematic diagram of a typical Cyber Physical System (CPS). Point out all the elements and platforms necessary to construct such system. Explain the role of every elements in the system. Give example of a CPS.	12
2.	Draw a generalized schematic diagram of a conventional closed loop control system. How is the system modified to build a distributed embedded Cyber Physical System (CPS)? Explain the working principle of such CPS.	12
	Answer any ONE of question-3 and 4: [CO2-K2]	
3.	(a) What are the types of tasks and list of tasks the Compute Unit (CU) of embedded CPS has to execute? Name them.	3
	(b) What is a task scheduler? What are the different types of task scheduler available in CPS?	3
	(c) Define all the attributes of a task execution with appropriate diagram.	6
4.	Is the execution time of a processor fixed always? Explain.	12
	Answer question-5:	
5.	Explain in brief (any **FOUR**): [CO3-K3]	4x3=12
	(a) Mutex (b) Context Switch time (c) Semaphore	
	(d) Preemptive scheduling and its implementation (e) Memory Hierarchy	

	Answer any ONE of question-6 and 7: [CO4-K4]	
6.	Given a Directed Acyclic Graph, as mentioned in figure:  Present the schedule of all the tasks obtained after the application of (i) Earliest Deadline First (EDF) (ii) Latest Deadline First (LDF) (iii) EDF with precedence scheduling (EDF*)	14
7.	Write short notes on (any TWO): (a) Mutual exclusion and scheduling (b) RM Scheduling (c) Role of processors in task scheduling	7+7