Exam Date & Time: 19-May-2022 (10:00 AM - 01:00 PM)





# **MANIPAL ACADEMY OF HIGHER EDUCATION**

# SIXTH SEMESTER B.TECH END SEMESTER EXAMINATIONS, MAY 2022 **MICRO ELECTRO MECHANICAL SYSTEMS [ICE 4056]**

Marks: 50

#### **Duration: 180 mins.**

(2)

(3)

### Α

## Answer all the questions.

Instructions to Candidates: Answer ALL questions Missing data may be suitably assumed

- 1) Discuss the mechanical properties of materials with increase in temperature with necessary graph.
  - A)

B) For the spring assemblage with arbitrarily numbered nodes shown in Figure, evaluate the unknown displacements. A force of 1000 N is applied at node 3 in the negative x direction. The spring constants are k1=500N/m, k2=1000N/m, k3=1500N/m and k4=2000N/m. Node 1, 4 and node 5 are fixed.



	C)	Write a note on micro chemical sensors	(3)
	D)	Draw the flowchart of engineering design of microsystems and explain.	(2)
2)		Calculate the electrostatic force between a parallel plate capacitor with a supply voltage of 10V, gap of 1 $\mu$ m and the diameter of the plate is 600 $\mu$ m.	(2)
	A)		
	B)	Draw the cross section of a CMOS inverter and explain its working.	(3)
	C)	A bi-layer strip is subjected to a uniform temperature rise, T as given in Figure. Calculate the deflection at the free end for a temperature range of 0 - 40°C and the maximum deflection. Consider $E_{SiO2} = 385$ GPA, $E_{Si} = 190$ GPA, $\alpha_{SiO2} = 0.5 \times 10^{-6}$ / °C and $\alpha_{Si} = 2.33 \times 10^{-6}$ / °C.	(5)

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Calculate the stiffness of a silicon cantilever beam with length 1000µm, breath 50 µm and width 25µm. Assume other parameters as required. (2)

A)

3)

B) Find the necessary voltage supply for the comb drive structure given in Figure to provide a 3 μm movements at the free end of each of the two arms.



- C) Calculate and compare the maximum deflection and stress of a circular and square diaphragm pressure sensor with an area of 196250  $\mu$ m<sup>2</sup> and thickness of 60  $\mu$ m for an applied pressure of 50MPa. Consider Young's modulus of silicon as 131 GPa and Poison's (4) ratio as 0.27.
- 4) Estimate the change of resistance in silicon piezoresistors attached to the diaphragm of a (4) pressure sensor as given below for an applied pressure of 50MPa. Also calculate the output of the Wheatstone bridge with a supply voltage of 10V. Consider E as 190GPa,  $\pi_{44} = 138.1$

A)  $x 10^{-11}$  Pa<sup>-1</sup>, and initial resistance as 2.5 K $\Omega$ .

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B) The mass attached to the beam is 2 g. The equivalent beam spring constant keq is 9120 N/m. The mass is pulled down by 3 μm, calculate the natural frequency and acceleration of the mass in the y-direction.





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