MANIPAL INSTITUTE OF TECHNOLOGY
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DEPARTMENT OF MECHATRONICS

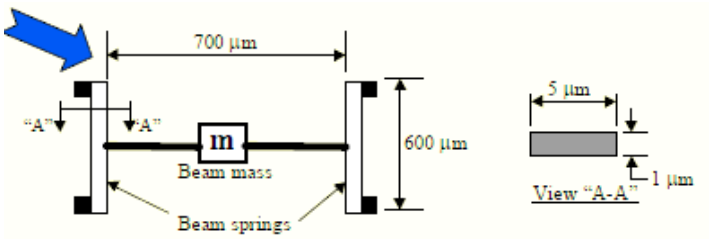
VII SEMESTER B. TECH

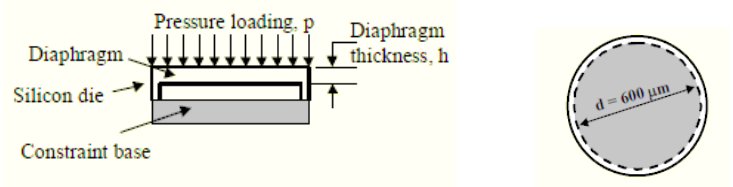
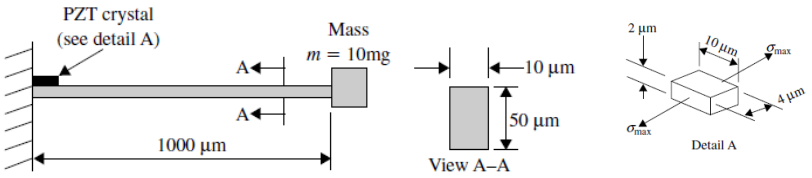
END SEM MAKE-UP EXAM, Dec. 2022- Jan. 2023

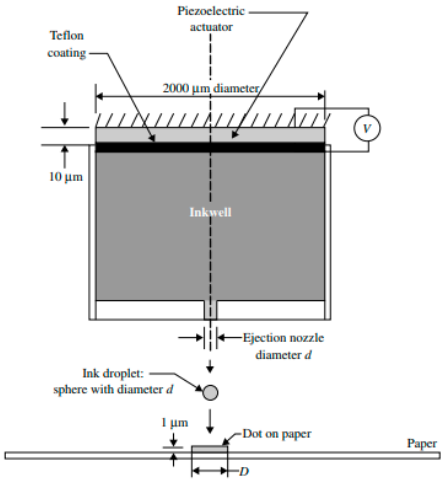
SUBJECT: Micro Electro Mechanical Systems Subject Code: MTE 4077

Date:29/12/2022 **Time: 2:30 PM TO 5:30 PM** **MAX. MARKS: 50**

- Answer **ALL** the questions.
- Missing data could be suitably assumed and justified.

Q. No.		M	CO	PO	BL
1A	Discuss the working phenomenon of micro-pressure sensors using the resistive transduction principle.	**4**	**CO1**	**PO1,2,3**	**Apply**
1B	Illustrate the working principle of MEMS biomedical sensor	**3**	**CO1**	**PO1,2,3**	**Understand**
1C	Calculate the natural frequency of a forced balanced micro accelerometer. The dimensions and direction of the beam movement are shown in Figure. 1. (E=190,000 MPa) Note: The spring constant of the beam is $k = \frac{48EI}{L^3}$  Figure. 1 Forced balanced micro accelerometer	**3**	**CO2**	**PO1,2,3,4,5**	**Analyze**
2A	Determine the minimum thickness and maximum deflection of the circular diaphragm of a micro pressure sensor made of silicon material is shown in Figure.2. The diameter of the circular diaphragm is d = 600 µm; the applied pressure is 20 MPa, the Yield strength of silicon σy = 7000 MPa, Modulus of Elasticity is 190,000 MPa and ν = 0.25.	**4**	**CO2**	**PO1,2,3,4,5**	**Creating**

	 Figure.2 Micro pressure sensor and Circular diaphragm Note: Refer to the maximum stress and deflection equations $(\sigma_{rr})_{max} = \frac{3W}{4\pi h^2}$ $w_{max} = -\frac{3W(m^2-1)a^2}{16\pi E m^2 h^3}$ $(m = 1/\nu)$				
2B	Explain the working principle of microsensors and mention the common conversion method used in microsensors.	**4**	**CO1**	**PO1,2,3**	**Apply**
2C	Determine the capacitance of the parallel plate capacitor. The two plates have identical dimensions of length 1000 µm and width 1000 µm and the gap between the electrode is 2 µm. The air acts as the dielectric medium between the two plates.	**2**	**CO2**	**PO1,2,3 ,4,5**	**Analyze**
3A	Calculate the maximum stress and strain produced by the proof mass of the micro accelerometer during the collision shown in Figure 3. The maximum deflection of the cantilever beam is related to stress on the beam and assumes that the maximum deflection of the cantilever beam of 3.74 µm at the free end in the accelerometer. Also, the strains on the beam related to a resistance change in the piezoresistors crystal. The modulus of the elasticity beam is 190,000 MPa and other dimensions are given in Figure. 3.  Figure. 3 Piezoresistive transducer of the micro-accelerometer Note: Refer to the force, stress, and strain equations. $F = \frac{3EIZ}{L^3}$ $\sigma_{max} = \frac{M_{max} C}{I}$ $\varepsilon_{max} = \frac{\sigma_{max}}{E}$	**4**	**CO2**	**PO1,2,3 ,4,5**	**Evaluate**
3B	Mention the advantages and disadvantages of microactuators used in microsystems.	**3**	**CO2**	**PO1,2,3 ,4,5**	**Apply**
3C	What is the importance of the scaling law? Write an equation for how scaling is related to stress.	**3**	**CO2**	**PO1,2,3 ,4,5**	**Analyze**
4A	Determine the required electric voltage for ejecting a droplet of ink from an inkjet printer head using PZT piezoelectric crystal as a pumping mechanism. The ejected ink will have a resolution of 300 dpi and The ink droplet is produce a dot with	**5**	**CO3**	**PO1,2,3 ,4,5**	**Evaluate**

	a film thickness of 1µm on the paper. The geometry and dimension of the printer head are shown in Figure 4. Assume that the ink droplet takes a shape of a sphere and the inkwell is always re-filled after ejection. Note: The piezoelectric coefficient of the PZT crystal is $d=480x10^{-12}$ m/v  Figure.4 Inkjet printer head				
4B	Sketch and explain the photolithography process used in the fabrication of the MEMS device.	**3**	**CO3**	**PO1,2**	**Apply**
4C	List the major deposition technique used in the microsystem.	**2**	**CO4**	**PO1,2,3,5,8**	**Apply**
5A	Discuss the general steps involved in chemical vapor deposition and mentions their advantages.	**4**	**CO4**	**PO1,2,3,5,8**	**Analyze**
5B	Distinguish the major differences between bulk and surface micromachining.	**4**	**CO4**	**PO1,2,3,5,8**	**Apply**
5C	Highlight the important consideration used in microsystem packaging.	**2**	**CO4**	**PO1,2,3,5,8**	**Apply**