(b) "Surface tension is a dominant factor in 'small' volume of liquids"- Explain. Determine the pressure required overcoming the surface tension of water in a small tube of 0.5 mm inside diameter. Assume that the water is at 20°C and surface tension coefficient of water γ = 0.073 N/m.

4 + (4 + 4) = 12

Group – E

8. (a) What are the mechanical aspects of micro-system design?

(b) Give a brief description of the Process design assembly strategy, methods, and testing used in packaging of micro-systems?

6 + 6 = 12

9. (a) Write two special microfluid flow techniques that are popular in bioMEMS. Explain any one of them with suitable diagram.

(b) What are the three major databases used in CAD (computer aided design) for micro-system design? How will you define the selection of CAD software for design of micro-systems?

(2 + 4) + (4 + 2) = 12

M.TECH/AEIE/3RD SEM/AEIE 6131/2019

MICRO-ELECTROMECHANICAL SYSTEM DESIGN
(AEIE 6131)

Time Allotted : 3 hrs **Full Marks : 70**

Figures out of the right margin indicate full marks.

Candidates are required to answer Group A and any 5 (five) from Group B to E, taking at least one from each group.

Candidates are required to give answer in their own words as far as practicable.

Group – A
(Multiple Choice Type Questions)

1. Choose the correct alternative for the following: **10 × 1 = 10**

(i) The design of micro-accelerometer is based on the principle of
(a) plate bending (b) mechanical vibration
(c) strength of material (d) both (a) & (c).

(ii) What does system-on-chip means?
(a) Performing experiment on a chip
(b) A combination of TTL and CMOS Logic
(c) An integration of micro sensors and actuators on a chip
(d) An integration of micro system and microelectronics on a chip.

(iii) The piezo-electric micro-actuators are work on the principle of
(a) Mechanical to electrical conversion (b) Electric heating
(c) Electrical to mechanical conversion (d) both (b) & (c).

(iv) The separation of bio-particle inside a micro fluidic channel because of
(a) coriolis force (b) electro-osmotic force
(c) buoyancy force (d) electrostatic force.

(v) The finite element method (FEM) is a viable analytical tool for micro-structures of
(a) simple geometry
(b) complex geometry and loading/boundary conditions
(c) complex loading and boundary conditions
(d) simple loading with boundary conditions.

(vi) Striction is a common drawback in
(a) surface micromachining (b) bulk micromachining
(c) LIGA (d) DRIE.

(vii) For micro-fluidic devices Laminar flow normally takes place with Reynolds number in the range of
(a) 0 - 10 (b) 10 - 100
(c) 100 - 1000 (d) 1000 - 10000.

(viii) The momentum equation is used to evaluate
(a) volumetric flow rate
(b) relationship between motion and driving forces
(c) the induced forces in a moving field
(d) mass flow rate.

(ix) In early stage of design of MEMS products, packaging needs to be considered to ensure
(a) low surface area (b) high customer demand
(c) acceptable product appearance (d) low packaging cost.

(x) In micro-fabrication, the most common thermal and electrical insulation material is
(a) silicon oxide (b) silicon nitride
(c) silicon carbide (d) boron nitride.

Group – B

2. (a) How will you distinguish MEMS based Microsystems and IC based Microelectronics technologies from the design/ fabrication point of view?

(b) Why does "Miniaturization" happen in each and every modern industry? Describe the working principle of different types of MEMS based pressure sensors used in modern automobile systems.

5 + (3 + 4) = 12

3. (a) Explain what do you understand by intrinsic stress/strain in a microfabrication processes? State the possible sources of intrinsic stress/strain in a micro structure.

(b) Determine the maximum stress and deflection in a circular plate made of silicon when is subjected to a pressure loading, p = 20 MPa. The plate has diameter of 532μm and a thickness, h = 13.887μm. Assume E = 190,000 MPa.

(3 + 3) + (3 + 3) = 12

Group – C

4. (a) State the reasons of choosing square shaped thin plates compared to circular thin plates (by assuming that the plates are made of silicon with same surface area and thickness subjecting with same applied force).

(b) A rectangular diaphragm, 14.5 μm thick has the plane dimensions as shown in the fig.1. The diaphragm is made of silicon. Determine the maximum stress and deflection when it is subjected to a normal pressure, P = 20 MPa. All 4 edges of the diaphragm are fixed. Assume E = 190,000 MPa, α = 0.0277 and β = 0.4974.

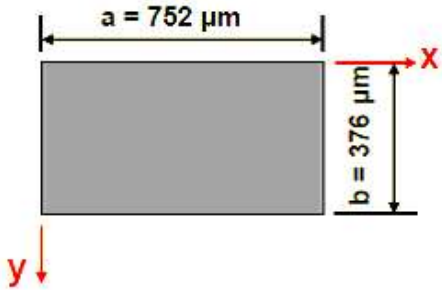

Fig.1

5 + 7 = 12

5. (a) What are the constraints of micro-system design?

(b) Estimate the damping coefficient in a balanced-force micro-accelerometer as illustrated in Fig. 2, with (i) air, and (ii) silicone oil as damping media. The sensor operates at 20°C. Assume the dynamic viscosities for air and silicone oil at 20°C to be: $\mu_{air} = 18.75\times10^{-6}$ N-s/m², and $\mu_{si} = 740\times10^{-6}$ N-s/m².

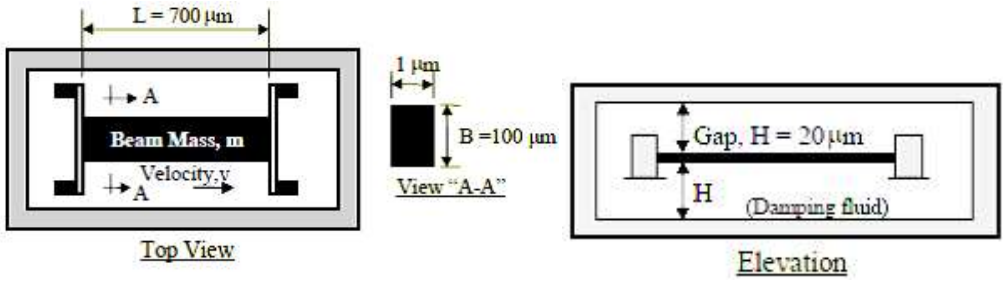

Fig. 2

5 + 7 = 12

Group – D

6. (a) State input information to a Finite Element analysis.

(b) What do you understand by thermal-actuated relay? Design a thermal-actuated relay using bi-layer beams in MEMS structure.

4 + (3 + 5) = 12

7. (a) State the Newton's cooling law of heat flow in fluids.