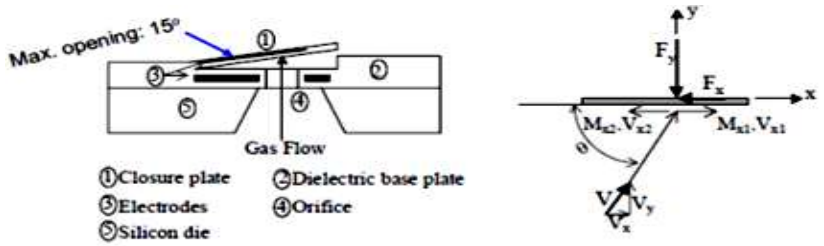

Fig. 2

4 + 8 = 12

7. (a) State the governing equations of heat transfer in MEMS Structure.

   (b) Show the differential equation and the appropriate initial and boundary conditions for a thermally actuated micro beam as illustrated below in fig.3. A thin copper film is attached to the top surface of the silicon beam used as a resistant heater. The actuator is initially at 20°C. Consider two cases for the contacting air at the bottom surface of the beam: (a) still air, (b) the air has a bulk temperature of 20°C but has a heat transfer coefficient of 10^{-4} W/m²°C.

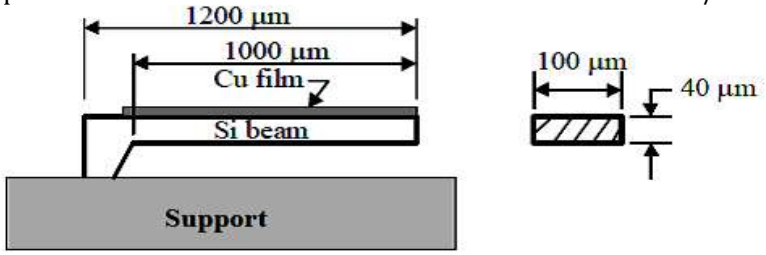

Fig. 3

4 + 8 = 12

Group - E

8. (a) What are the principal sources of intrinsic stresses induced in micro structures?

   (b) Explain the working principle of electrophoresis with a suitable diagram.

6 + 6 = 12

9. (a) State the unique forces required to design MEMS and Microsystems.

   (b) Explain the general structure of CAD (computer aided design) for micro-system design with suitable diagram.

4 + 8 = 12

MICRO-ELECTROMECHANICAL SYSTEM DESIGN
(AEIE 6131)

Time Allotted: 3 hrs **Full Mark**

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 a practicable.

Group – A
(Multiple Choice Type Questions)

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

(i) "Laboratory on-chip" means:
(a) performing experiment on a chip
(b) combination of TTL and CMOS Logic
(c) integration of micro sensors and actuators on a chip
(d) integration of micro system and microelectronics on a chip.

(ii) The most challenging issue facing Microsystems technology is:
(a) the small size of the products (b) lack of practical applicatio
(c) its multi-disciplinary nature (d) none of the above.

(iii) The theory of thin plate bending can be used to assess:
(a) the deflection only (b) the stress only
(c) both deflection and stress (d) none of the above.

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

(v) The movement of the beam mass in forced balanced r accelerometers is usually measured by:
(a) piezo-resistor (b) piezo-electric
(c) capacitance changes (d) frequency changes.

(vi) Reynolds number is proportional to:
(a) the travelling distance (b) the velocity
(c) the pressure of a fluid (d) the density of the fluid.

(vii) To access the fluid induced forces on micro-system components, we use:
(a) continuity equation (b) momentum equation
(c) equation of motion (d) both (a) & (b).

(viii) A serious drawback of a capacitance transducer is:
(a) its bulky size (b) non-linear i/o relationship
(c) low sensitivity (d) none of the above.

(ix) Micro-system packaging needs to be considered in early stage of design to ensure:
(a) low packaging cost (b) high customer demand
(c) acceptable product appearance (d) low surface area.

(x) Capillary electrophoresis on a chip is primarily used in:
(a) micro- fluidic actuator (b) micro- pressure measurement
(c) biomedical analysis (d) automobile application.

Group - B

2. (a) Give three examples of the objects that you personally recognised to be of the size of approximately one millimetre. What are the most obvious distinction between Microsystems and Microelectronics technologies?

(b) Why micro electronics technology cannot be adopted in the design and packaging of MEMS and micro-systems products? Define the safety applications of micro-sensors in modern semi-automated cars.

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

3. (a) What do you mean by "intelligent micro-systems"? Describe it with suitable block diagram.

(b) What are the different types of micromachining used in MEMS? State the applications of micro-systems in health care and aerospace industries.

(2 + 4) + (1 + 5) = 12

Group - C

4. (a) Compare the geometry of circular, square and rectangular plates in terms of maximum deflection and stresses by assuming that the plates are made of silicon with same surface area and thickness subjected to same applied force.

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

6 + 6 = 12

5. (a) What are the different steps that must be followed in the des appropriate microaccelerometer for a specific application?

(b) Determine the amplitude and frequency of vibration of a 10-mg attached to two springs as shown in the Fig.1. The mass can vibrate without friction between the rollers and the supporting floor. A that the springs have same spring constant k1 = k2 = k = 6 × 10^{-5} N both tension and compression. The vibration begins with the mass pulled to the right with an amount of δst = 5 μm. (as induc acceleration or deceleration).

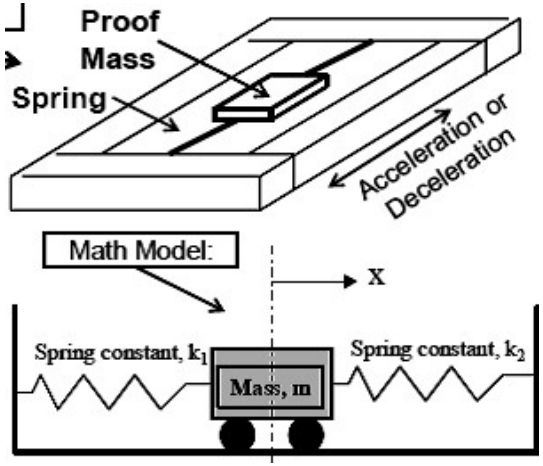

Fig. 1

6 + 6

Group - D

6. (a) Explain the characteristics of moving fluids.

(b) A micromachined silicon valve utilizing electrostatic actuati constructed. The valve is illustrated below by fig.2.
The thin closure plate is used as the valve with a dimension of 3(wide x400 μm long x 4 μm thick. The plate is bent to open or cl electrostatic actuation to regulate the hydrogen gas flow maximum opening of the closure plate is 15-degree tilt fro horizontal closed position.
Determine the force induced by the flow of the gas at a velocity cm/min and a volumetric rate of 30000 cm3/min. Also, calcula split of mass flow over the lower surface of the plate.