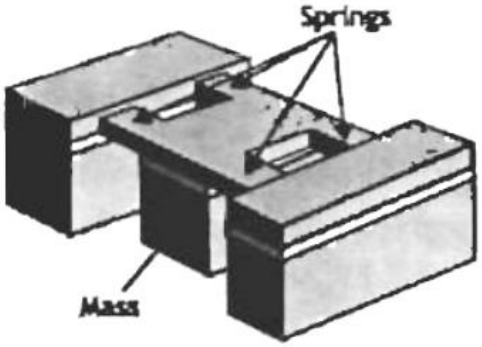
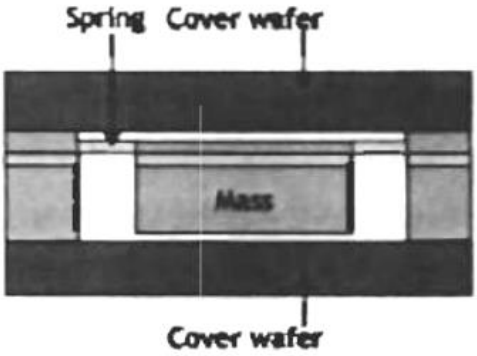
Project

1. A schematic of a bulk micromachined accelerometer is shown in figure below. The mass dimensions are 1200 µm x 1200 µm x 550 µm and the silicon density is 2330 Kg/m^3 while the young's modulus of silicon is 160 GPa. The spring is designed such that its stiffness is 40 N/m and the targeted quality factor Q is 0.2.

Calculate:

a. Sensor resonant frequency
b. Damping coefficient
c. Proof mass displacement due to 1 g, 5 g, and 10 g acceleration.





2. Design the beam suspension shown in figure. Using ANSYS as a finite element package, determine the following:
   a. Find the mass displacement due to the inertia loads mentioned in part "c".
   b. Hence determine the stiffness of the suspension.
   c. Compare the numerical results with the analytical results.
3. Now, in ANSYS go to Solution > Analysis Type > Sol'n Control and select "Large Displacement Static" in "Analysis Options" ➔ by doing this you have activated the nonlinear solver in ANSYS.
   a. Find the mass displacement due to the inertia loads mentioned in part 3 using ANSYS as a finite element package (with selecting Large Displacement Static for all three loads).
   b. Determine the stiffness of the suspension in this case.
   c. Compare the numerical results with the analytical results and numerical results found in part 2. Explain any discrepancies? Does the maximum stress in the suspension beams exceeds the rapture stress?, If yes, suggest methods or different geometries to reduce the maximum stress in beams.

Rapture stress is 3 GPa.

4. Using ANSYS modal analysis
    a. Determine the first three modes of the accelerometer and plot their shapes.
    b. Compare the estimated first mode with the natural frequency calculated analytically, numerically in part 2 and part 3. Justify any similarities or differences.

Bonus

5. Using ANSYS harmonic analysis
    a. Plot the frequency response of the system from $0.1f_n$ to $10f_n$ using the given quality factor.
    b. Repeat part (a) with quality factor values 0.02 and 0.8.
    c. Comment on the effect of the quality factor on the shape of the response.

The project should be submitted on the form of a report containing the previous points including clear figures for the solid model, meshed structure and any other relevant illustrating materials(figures, animations, …etc.).

DUE DATE: 7th of May