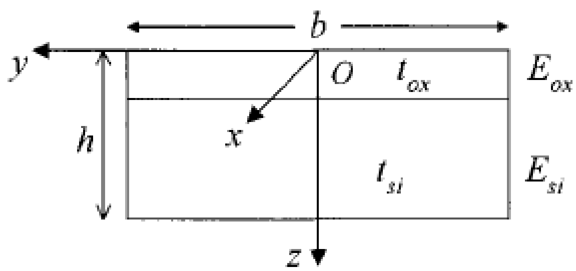
Assignment 2

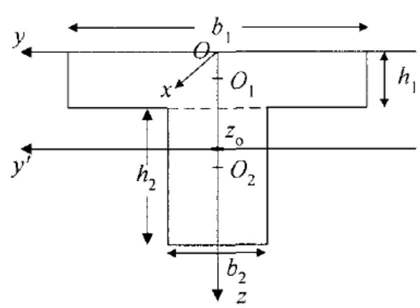
Problem 1:

The cross section of a composite beam consisting of two layers is shown in the figure below. The top layer of the composite beam is SiO_2 and the substrate is silicon. Find the position of the neutral plane for free bending. ($E_{ox} = 7 \times 10^{10} Pa,\ E_{si} = 1.7 \times 10^{11} Pa,\ t_{ox} = 0.5\mu m\ and\ t_{si} = 2\mu m$)



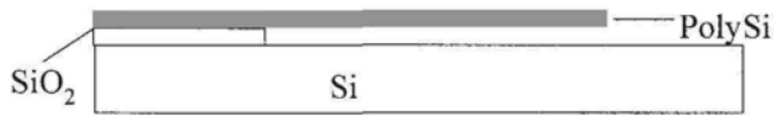
Problem 2:

Consider a beam with a T-shaped cross-section as shown in the figure below. The cross section can be divided into two rectangles. The top one has a width of b_1 and a thickness of h_1, while the lower one has a width of b_2 and a thickness of h_2. (The centers of the two rectangles are O_1 and O_2 in the figure.). Find the position of the neutral plane z_o for pure bending and the moment of inertia against the neutral plane.



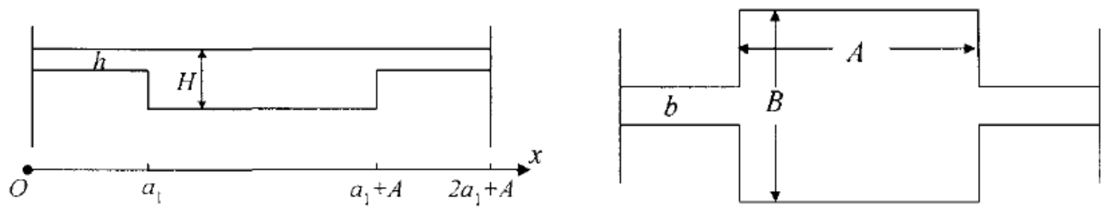
Problem 3:

A polysilicon cantilever beam overhangs over a silicon substrate as shown in the figure below. The thickness of the beam is $2\mu m$ and the original distance between the beam and the substrate is $2\mu m$. Find the maximum length the cantilever beam may have without contacting the substrate due to the displacement caused by its own weight. (Note: the Young's modulus of polysilicon is $E = 1.7 \times 10^{11} Pa$, $\rho = 2330 kg/m^3$.)



Problem 4:

A double-supported beam-mass silicon structure is shown in the figure below, where $a_1 = 500\mu m, b = 50\mu m,\ h = 10\mu m,\ A = B = 4mm$ and $H = 300\mu m$. Find (1) the displacement of the mass under its own weight, (2) the maximum stress on the beam surface.



(a) cross sectional view (b) top biew

Problem 5:

For the same double-supported beam-mass silicon structure as shown in problem 4 above, find the maximum acceleration in the normal direction the structure can tolerate without rupture (assuming the rupture stress for silicon is $T_R = 3 \times 10^9\ Pa$).

Problem 6:

A silicon structure as shown in problem 4, where $a_1 = 500\mu m, b = 50\mu m,\ h = 20\mu m,\ A = B = 4mm$ and $H = 300\mu m$. If the mass of the beam and the bending of the mass are negligible, find the vibration frequencies of the following vibration mode: (1) the vibration normal to the mass plane; (2) the lateral vibration in the mass plane.