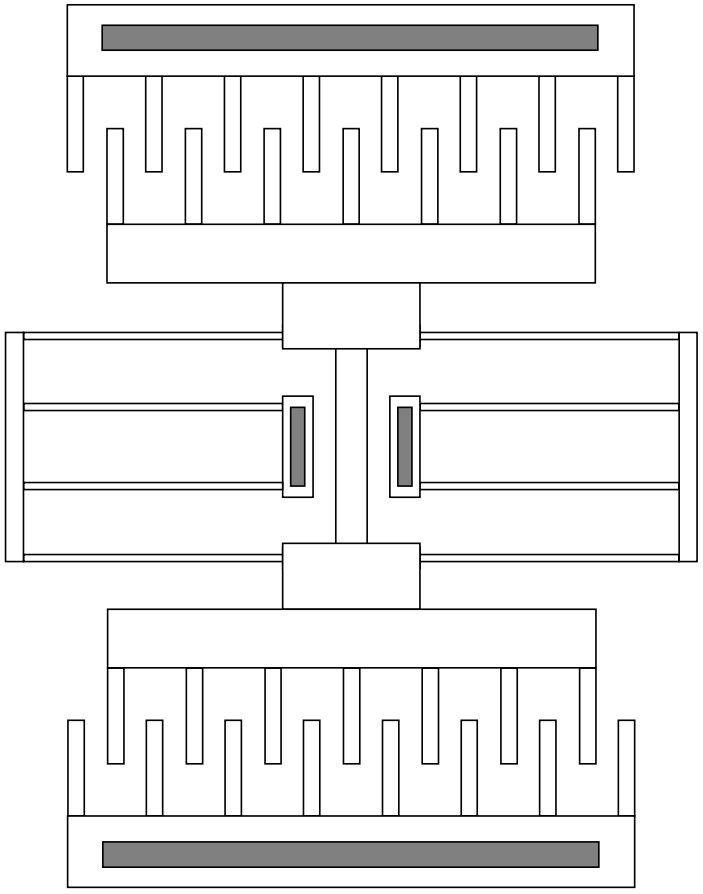
**EE 245 / NEEM 6441: Introduction to MEMS Design**
Homework 4

**Foundry Services and Design Practice**

1. Below is a typical comb-drive resonator. Design, using your CAD tool of choice, an array of comb-drive resonators using layer poly1 in the MCNC/MUMPS process.



- Design a design-rule-correct bonding bad with a metal square 100 microns on a side.
- Create a folded spring suspension and turn it into a pcell (parameterized cell) parameterized by the length of the beams.
- Create a comb drive unit cell that can be tiled as an array of instances.
- Create a 3x3 array of resonators, varying the beam length from 100 to 300 microns, and varying the number of comb teeth from 10 to 30.
- Make sure that all electrical connections to the array are made from bonding pads on the perimeter. Share pads when it makes sense.
- Remember to include grounding planes under moving, biased objects

   a. Print (or take a screen capture) of your top level design.
   b. Calculate the spring constant of the biggest and the smallest resonator support of your array assuming that the end beams are perfectly stiff.
   c. Calculate the mass of the whole structure for the biggest and the smallest resonator using the dimensions you chose in your design.
   d. Calculate the expected static deflection, resonant frequency, and resonant amplitude of the biggest and the smallest resonators of your array. Assume a 45V DC bias and a 5V AC excitation. Feel free to check your calculations with SUGAR although this is not required.

2. (Bonus) Design an electrostatic actuator in one of the given foundry processes with a deflection of 30 μm at 15 V. Try to minimize the size of your actuator. Print your design and provide some analysis to show it will work.