HW 10: Due 4/30/04

Electrostatic drives are used in MEMS devices as force actuators. The basic principle is that the force on the capacitor plates (the force required to keep them separate) is given by

$$F = -\frac{\partial}{\partial \Delta} W_e(\Delta, V)\,, \tag{1}$$

where Δ is the motion of the plates and W_e is the energy stored in the electric field $\int \frac{1}{2}\epsilon_o \boldsymbol{E}\cdot\boldsymbol{E}$.

There are two very basic types of drives the parallel plate drive and the comb drive. The parallel plate drive is the most obvious of these because of its simplicity but it suffers from a very non-linear force displacement relation which makes it hard to design with. Further it suffers from the pull-in phenomena where as the gap closes the force grow so rapidly that it over-powers the stiffness of the supports and the system electrically shorts. The comb drive on the other hand is supposed to have much better characteristics and is thus favored by most designers. Its force displacement relation is is supposedly independent of deflection and it is supposed to be essentially free from pull-in problems.

Using electrostatic analysis, confirm these statements. Namely, use electrostatic analysis to study

1. The force displacement characteristics of a comb drive
2. The force displacement characteristics of a parallel plate drive
3. Explain how the various geometric features of each of these devices affect their response.
4. What is the relation between voltage and force?

For a sense of dimensions, take a look at the following SEM picture:
`http://www.best.me.berkeley.edu/~raffi/SEMs/GA_SEM_18.jpg`.