1. You know that the constant-voltage electrostatic force between two conductive parallel plates is $\frac{1}{2} \varepsilon V^2 A/g^2$. Using the fact that $Q=CV$ and $E=V/g$,
   a. write the force in terms of charge, not voltage
   b. write the force in terms of electric field
   c. write the force per unit area in terms of electric field

2. Estimate the electric field between two socks which stick together when you pull them out of the dryer. Assume that the socks are parallel plates separated by some small gap, $g$, with a friction-induced charge (triboelectric effect) on each side. If the mass of a sock per unit area is 1kg/m²
   a. estimate the electric field between the socks
   b. if the distance between the charges on the socks is 100 um, what is the voltage between them?

3. If you have two flat conductors separated by a gap of 1 um with a potential of 150V between them,
   a. how much area is needed to support your weight? (if you prefer not to reveal your weight, you may use a mass of 50kg, or a weight of 500N).
   b. if the gap is 10um and the voltage is 1.5V, what area is needed? How much did the field change? What was the ratio of your answers to a and b? How is that related to the field?

4. Here’s a picture of the ADXL50, the first commercial surface micromachined MEMS device.

   a. Label the spring supports (4 of them), anchors (also 4) and proof mass.
   b. If the gaps are 1.2um, estimate the no-acceleration capacitance to either of the differential capacitor outputs.

Note the 100um scale bar at the bottom.
5. These are pictures of the ADXL202. Die photo (CMOS+MEMS), SEM of the MEMS device, detail SEM, and simulation of response to a vertical acceleration.
   a. Using the scale bar, estimate the size of the proof mass, and the overall chip.
   b. In the detailed SEM, identify the proof mass, support springs, proof mass anchor, over-acceleration mechanical stops, differential sense capacitors, actuation capacitors.
6. In the document “Introduction to prototyping using polyMUMPS” document linked on the course website, the text describing the DIMPLE etch is not consistent with the cross section as shown on slide 18. What is inconsistent?

7. In the polyMUMPs process, list the thin film layers that will be present on the substrate (starting at the substrate and working up, in order) before the release etch, in regions with the following masking layers
   a. POLY0, POLY1, POLY2
   b. POLY0, ANCHOR1, POLY1, P1P2VIA, POLY2
   c. ANCHOR1, POLY1
   d. POLY2, METAL
   e. METAL
   f. DIMPLE

8. The layout below is run in the polyMUMPS process. Contacts are 2um square. Draw the cross-section AA of the resulting structure.

9. [EE247A] In a three mask process (POLY0, CONT, POLY1) with only one structural polysilicon (POLY0 for wiring, and POLY1 for structures), design a 3 axis capacitive accelerometer. Can you do it with a single proof mass? Will the response be linear in all directions?