1. Go the Berkeley Nanolab web page, and click on the “Lab Manual” link. Of the seven sputtering systems, the Randex has the widest variety of targets.
   a. How many different metal and dielectric targets do we have?
   b. You’ll notice that for many tools the longest section of the user manual is on the vacuum system, often with arcane units. For the Randex the pressure at which the high-vacuum system takes over from the roughing pump is given in section 9.2 in microns of mercury in honor of Evangelista Torricelli. 1 mm of mercury is 1 Torr. At approximately what pressure does the high-vac pump take over, and how low does it need to go before the rest of the process can run?

2. Technics C is a simple plasma etcher. If you etch 1000 Angstroms of silicon nitride and want to stop on oxide, how much oxide will be etched if you do a 20% overetch of the nitride? What if the nitride were on bare silicon (how much overetch of silicon)?

3. In the polyMUMPS process, what cross section do you get if you draw a 10 um square of ANCHOR1 inside a 20um square of ANCHOR2, and nothing else? Assume that the poly2 overetch is 200%, all other overetches are 20%, and that the selectivity of both the poly RIE etch and oxide RIE etch to nitride is 10:1.

4. In reference [1]
   a. On slide 7, how does the etch rate of trenches change as the width decreases?
   b. On slide 7, how does the etch rate of trenches compare to the etch rate of holes? Why might that be so?
   c. Look at slide 15 and imagine crying when your wafer looks like this.
   d. On slide 16, how does the trench width affect sidewall angle? What must be happening on a cycle-by-cycle basis to cause this?

5. In Joey’s presentation
   a. On slide 61, label the SEM cross-section with: substrate, buried oxide, device layer, etch hole, footing. Label the remaining silicon at the bottom of the etch hole, and estimate how much more silicon needed to be etched.
   b. On slide 62, why did the springs in the yellow box disappear during the etch?

6. Look through the window into the ee143 lab on the 2nd floor of Cory Hall. What thin film systems do you see?

7. Which of the following process flows don’t work, and why?
   b. Deposit aluminum on silicon and pattern. Grow an LPCVD oxide at 450 C.
   c. Deposit aluminum on silicon dioxide and pattern. Cover with an LPCVD silicon nitride.
   d. Deposit aluminum on silicon dioxide. Cover with a PECVD silicon nitride (google it if you need to)
   e. Deposit aluminum on silicon dioxide and cover with LPCVD polysilicon.
   f. Deposit aluminum on silicon dioxide and cover with sputtered silicon.

8. The masks in the figure below are used to make a force-sensitive cantilever beam with a pointy end, using the following simplified process (missing all of the cleaning and rinsing processes, detail of lithography and etching, and detail of the depositions)
   a. grow 0.5um thermal oxide /TIP ; RIE oxide etch
   b. 30% KOH etch, 85C, 30 minutes
   c. LPCVD “low stress” silicon nitride, 1um
   d. LPCVD doped polysilicon, 0.2um /PLY ; RIE silicon etch
   e. LPCVD “low stress” silicon nitride, 0.2um /PIT ; RIE nitride + oxide to surface
   f. 30% KOH etch, 85C, 2 hours
Draw the cross section through AA after each process step

Figure 1  Layout view of problems 5 and 6.  Convention: draw conductors (PLY & MET) and holes in dielectrics.  Drawing is not to scale.  TIP mask consists of a single square 10um on a side.  Cantilever is 100um long.

9.  The polysilicon resistor in the structure with the process above is not connected to anything, and several masks are not used.  Using the tables in Kirt Williams’ etch rate paper http://microlab.berkeley.edu/labmanual/chap1/JMEMSEtchRates2(2003).pdf create two new versions of the process that let you run metal traces to the polysilicon resistor.  It is difficult to do lithography on the wafer after step F, so for this problem assume that is not allowed.  You might not need all masks in both versions.
   a.  version 1: Pick a metal that can be deposited and patterned between steps E and F (it must survive step F unprotected).  Write a new process flow including all necessary contact and mask steps.  Draw all process cross sections.
   b.  version 2: Using aluminum for metallization, find a material that can be used to protect the aluminum during step F.  How will you make contact to the aluminum?  Write a process flow including all necessary contact and mask steps.  Draw all process cross sections.
   c.  Will the final structure be flat?  How will it react to heating via the polysilicon resistor?  What will happen to the resistor if an external force pushes on the end of the cantilever?
   d.  Think about how you’d turn this into a useful tip for an atomic force microscope. (just think – no need to turn anything in)
   e.  Think about how you’d use one of your processes above, possibly modified, to make a pressure sensor, a microphone, or an accelerometer with a 400um thick proof mass.

10. [247A] Draw some cross-sections of the last two “think about” questions.