INFORMATION ABOUT THE FINAL EXAM

Extra Office Hours:

Prof. Nguyen will be traveling over most of the days leading up to the Final Exam. He, however, will be in town on Wednesday, Dec. 12, on which he will hold office hours from 3-5:30 p.m. (The morning of this day is presently reserved for course project out-briefs.)

Other than the above, you will need to rely on your TA's for office hours. The TA's will hold their regular office hours during the period leading up to the exam. In addition, during the week of Dec. 3, your TA's will be holding discussion sections during the 9:30-11 a.m. lecture period in 3108 Etcheverry, where they will be going more slowly through lecture material Prof. Nguyen had to present quickly on noise topics. You will also be able to ask questions about the last homework assignment during these periods. During the week of Dec. 3, the Friday discussion sections will become TA office hours.

Date of Exam:

Exam Group 7: Saturday, Dec. 15, 8-11 a.m. (sharp)

Place:

277 Cory Hall

General Information:

The exam will be open book and open notes. Bring a calculator to the exam. You will be provided with exam sheets with enough space to put all your work on these sheets. You should show and include all your work on the exam sheets. The exam will consist of a few problems, each with a number of parts.

Material to be Covered:

Reading in Senturia, class lecture notes, handouts, and homeworks. The exam is meant to include all material covered in the class, with stronger emphasis on material covered after the Midterm Exam. A summary of important topics that might be covered on the Final Exam can be listed as follows:

1. Basic MEMS fabrication process modules, including oxidation, film deposition, lithography, etching, ion implantation, diffusion, and bonding. You should especially have a good understanding of MEMS-centric etching and what influences selectivity and the degree of anisotropy.
2. Physics of stiction and bending/warping due to residual or thermal stresses and other phenomena. Be able to quantitatively determine whether a particular structure is warped or stuck down, or the degree to which its frequency has shifted from a designed value due to stress or other phenomena.
3. MEMS process flow design and layout. Be prepared to design your own process flow and layout for some arbitrary cross-section or 3D structure. Also, be able to make decisions on

what choices of process steps make most sense when integrating MEMS structures together with transistors onto a single-chip.

4. Surface micromachining, including its basic process flow, release issues (e.g., stiction), material choices, residual stress, stringers and methods for eliminating them.
5. Bulk micromachining, including selective wet etch methods, deep reactive ion etching, and bonding methods.
6. Mechanics of materials for MEMS, including stress, strain, material properties, and on-chip measurement & characterization of mechanical properties.
7. Microstructural elements, including bending moment and strain, flexural rigidity, residual stress analysis, boundary conditions, and spring combinations.
8. Energy methods for determination of deflection functions and resonance frequencies.
9. The pros and cons of scaling.
10. Input/output transducer modeling, including energy methods and construction of equivalent circuits. Here, you should understand first and second order effects for both parallel-plate and comb-capacitive transducers, including electrical stiffness and levitation.
11. Sensing circuits, including topologies that minimize parasitics and limitations imposed by non-ideal op amp characteristics. Be able to analyze circuit topologies and make the right choice of which circuit to use to grab a desired output variable.
12. Gyroscope and accelerometer operation and scale factor.
13. Noise in both electrical and mechanical systems.
14. Methods for determining the resolution of a sensor that include the ability to determine a sensor's scale factor, to generate a complete equivalent circuit for an electromechanical system, to determine the noise sources important for a given sensor circuit, and to finally obtain the resolution of a given sensor.