NAME (please print) ____

STUDENT (SID) NUMBER ______________________________

UNIVERSITY OF CALIFORNIA, BERKELEY

College of Engineering
Electrical Engineering and Computer Sciences

EECS 145M: Microcomputer Interfacing Lab

LAB REPORTS:

1 ________________	2 ________________	3 ________________
8 ________________	9 ________________	10 ________________
21 ________________	22 ________________	23 ________________
24 ________________	26 ________________	

Total of top 4 Lab Grades	______________	(400 max)
Total of top 4 Question Sections	______________	(100 max)
Lab Participation	______________	(100 max)
Mid-Term #1	______________	(100 max)
Mid-Term #2	______________	(100 max)
Final Exam	______________	(200 max)
Total Course Grade	______________	(1000 max)

COURSE LETTER GRADE

Spring 2004 FINAL EXAM (May 21)

Answer the questions on the following pages completely, but as concisely as possible. The exam is to be taken ***closed book***. Use the reverse side of the exam sheets if you need more space. Calculators are OK. **In answering the problems, you are not limited to the particular equipment you used in the laboratory exercises.**

Partial credit can only be given if you show your work.

FINAL EXAM GRADE :

1 __________ (52 max) 2 __________ (20 max) 3 __________ (70 max)

4 __________ (58 max)

TOTAL __________ (200 max)

Initials ____

Problem 1 (total 52 points)

1a (10 points) List the essential handshaking steps for the reliable transfer of data from one circuit or computer to another.

1b (6 points) Briefly describe the operation of the tri-state driver.

1c (6 points) Briefly describe the cause of glitches in the output of the D/A converter.

1d (10 points) Describe how you would determine whether the averages of two sets of measurements are statistically different (include formulas).

1e (10 points) Using the Fourier frequency convolution theorem, describe the spectral leakage that results from using a rectangular sampling window.

1f (10 points) Describe how you would use a sensor, a difference amplifier, and an actuator to implement proportional control of a physical quantity.

Initials ____

PROBLEM 2 (20 points)

2a (10 points) Sketch the successive approximation analog to digital conversion circuit. Label each component and data line. (For example, a D/A would be drawn as a single labeled box with labeled I/O lines.) Use part 2b below to describe any complex operations.

2b (10 points) Describe the operation of the successive approximation analog to digital converter. You may use words or a flow chart, provided that you describe its operation clearly.

Problem 3. (70 points) Design a **computer-controlled** system for the assembly line testing of **eight** units of a new type of 12-bit A/D converter.

You are provided with the following:

- eight sample A/D converters (to be tested eight at a time)
- eight 16-bit tri-state drivers
- a microcomputer with the following:
  - a 16-bit D/A converter with 1/2 LSB absolute accuracy and 10 μs settling time
  - two 16-bit parallel input ports
  - two 16-bit parallel output ports

You may assume the following:

- The 16-bit parallel output port is in "transparent" mode (no handshaking). New data can be written to the port every 2 μs.
- You have a timer function wait(N), that can delay program execution for N μs.
- The A/D converter requires a "start conversion" low-to-high edge signal and after conversion provides an "output data available" low-to-high edge. The A/D converter sets "output data available" low and resets all internal functions when "start conversion" goes low.
- For highest possible reliability, you must wait until the A/D has signaled that its data are ready before reading its output.

Hint: Think about Laboratory Exercise 9 (A/D converters) and how you would automate the measurement and data analysis procedures.

3a (20 points) Draw a block diagram of the major components, including two of the eight A/D converters being tested. Show and label all essential data and control lines.

3b (10 points) List the steps your program must do to measure the first transition voltage V(0,1) of the first A/D converter (pseudocode is OK, so long as the logic is clear).

3c (10 points) How would you determine the maximum absolute accuracy error of the A/D? (Explain the procedure in steps or with a flow diagram.)

3d (10 points) How would you determine the maximum linearity error?

3e (10 points) How would you determine the maximum differential linearity error?

3f (10 points) With what accuracy could this system measure the quantities in parts **3c**, **3d**, and **3e** in units of 1 LSB of the A/D?

Problem 4 (58 points)
You have a data acquisition computer for measuring the frequency content of musical instruments:

- The sampling frequency is 2^{16} = 65,536 Hz.
- The low-pass Butterworth anti-aliasing filter has gain = 0.99 at 20 kHz, 0.16 at 32 kHz, and 0.01 at 45 kHz.
- You use a raised cosine window and apply the fast Fourier transform (fft) to determine the frequency content

Experiment 1: You sample a pure harmonic tone of frequency 440 Hz (the note middle A) for 0.5 seconds and take the fft

4a (6 points) What is the lowest frequency index and what frequency does it correspond to?

4b (8 points) What is the highest frequency index and what frequency does it correspond to?

4c (8 points) What is the highest frequency and what is the corresponding frequency index?

4d (8 points) Which Fourier coefficients are non-zero?

Experiment 2: You sample a musical instrument that is rich in harmonics (even beyond the Nyquist limit) for 0.5 seconds and take the fft. The instrument is playing middle A.

4e (6 points) What is the highest harmonic that you can easily detect?

4f (6 points) What is the highest harmonic whose amplitude can be easily determined to an accuracy of 1%

4g (8 points) How accurately could you determine the frequency of the fundamental note that the instrument is playing? (Assume that it may be out of tune and that all harmonics occur at integer multiples of the fundamental frequency.)

4h (8 points) What is the corner frequency and order of the low pass filter?