NAME (please print) ____

STUDENT (SID) NUMBER ________________________

UNIVERSITY OF CALIFORNIA

College of Engineering
Electrical Engineering and Computer Sciences
Berkeley

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 2002 FINAL EXAM (May 17)

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 __________ (30 max) 2 __________ (25 max) 3 __________ (30 max)

4 __________ (15 max) 5 __________ (40 max) 6 __________ (60 max)

TOTAL __________ (200 max)

Initials ____

Problem 1 (total 30 points) Define the following terms (should take 20 words):

1a (5 points) Tri-state buffer

1b (5 points) Transition voltages of an A/D converter

1c (5 points) Digital filter

1d (5 points) Anti-aliasing filter

1e (5 points) Fourier frequency convolution theorem

1f (5 points) Nyquist sampling theorem

Initials ____

Problem 2 (25 points)
2a (10 points) If f = a + b, where a and b are two random numbers with standard deviations σ_a and σ_b, compute the standard deviation of the sum. (show work)

2b (15 points) If f is the average of N random numbers a_i, i = 1 to N, and they all have the same standard deviation σ_a, compute the standard deviation of the average. (show work)

Initials ____

Problem 3 (30 points)

In this course we studied several types of A/D converters:

TR Tracking

SA Successive Approximation

DS Dual Slope or Integrating

FL Flash

HF Half-flash

1B 1-bit (or delta-sigma)

3a (5 points) Which produce their output in a continuous manner?

3b (5 points) Which require a "start conversion" command?

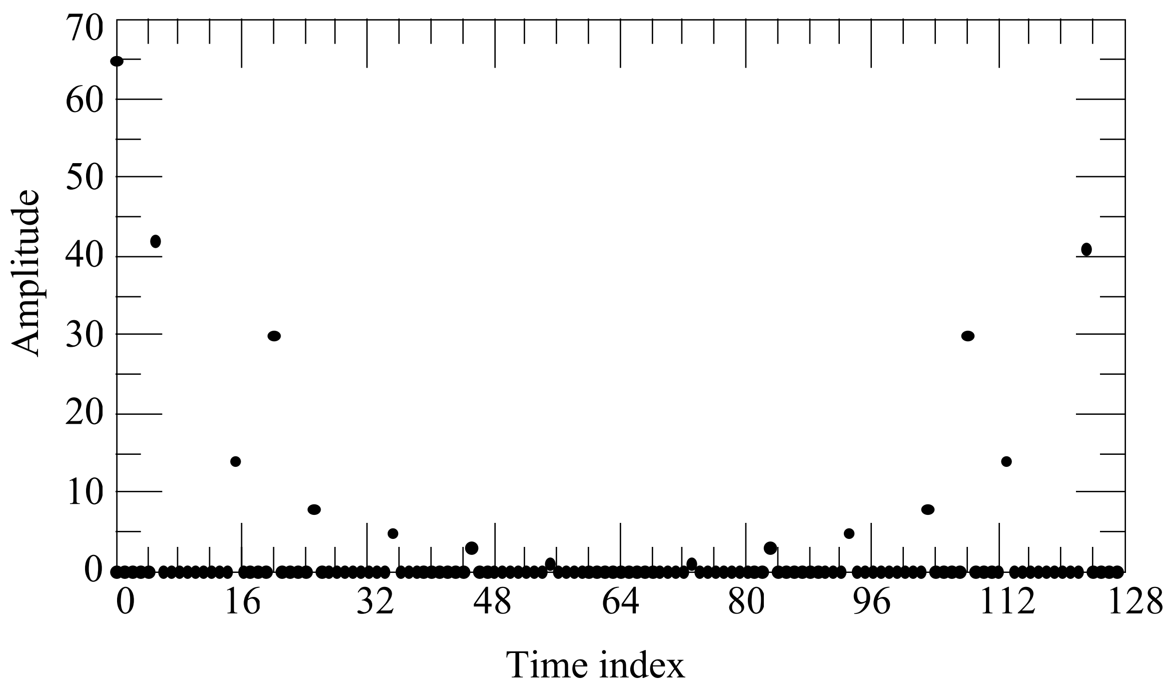
3c (5 points) Which can be used at very high rates (> 100 MHz) at moderate resolution (8 bits)?

3d (5 points) Which can provide high resolution (16 bits) at intermediate rates (<20 kHz)?

3e (5 points) Which have an accuracy that does not depend on the accuracy of internal resistors?

3f (5 points) Which require a sample-and-hold amplifier for full accuracy at their maximum conversion rate?

Problem 4 (15 points)
You sample exactly 5 cycles of a 15 Hz square wave (after anti-alias filtering) and compute the FFT. The magnitudes of your FFT coefficients are plotted in the figure below. Explain the non-zero values at n = 5, 15, 20, 25, 35, 45, 55, 73, 83, 93, 103, 108, 113, and 123. (You do not need to explain the amplitudes, just why they are non-zero.)



Initials ____

PROBLEM 5 (40 points)
A colleague has taken 16,348 (=2^{14}) samples of a bandwidth-limited nontrivial waveform for one second, takes the fast Fourier transform (FFT), ***and then deletes the data***. After informing you of this, you ask "Did you use a raised cosine window?". Your colleague replies "What is a raised cosine window?", tells you that it is not possible to take the data again, and asks whether you can fix the available FFT.

5a (10 points) How is your colleague's FFT related to the true frequency spectrum of the waveform?

5b (20 points) How can you use your colleague's FFT to compute the FFT that would have been produced if the data had first been windowed with a raised cosine?

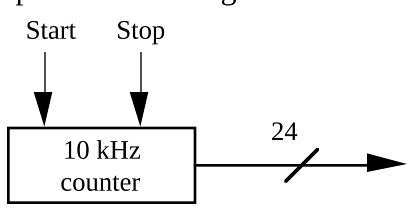
5c (10 points) How is the FFT computed in part 5b related to the true frequency spectrum of the waveform?

Initials ____

PROBLEM 6 (total 60 points):

You have been chosen to design a microcomputer system for timing the swimming events in the Summer Olympic Games.

- There are 12 swimmers and the pool has 12 lanes. Each swimmer starts at the one end of the pool and, at the sound of a gunshot, jumps in and swims to the opposite end of the pool in their own lane
- When they reach the opposite end of the pool, the swimmers make contact with a switch (called a "touch plate") mounted on the wall of the pool. When the switch is touched, the contacts stay closed until manually reset.
- The athletic event is started by the starter's pistol, which closes an electrical contact when the trigger is pulled
- Your computer system detects the contact closure and immediately sends a pre-recorded gunshot sound to 12 speakers, each located behind a swimmer. (this gives each swimmer a fair start and also avoids using chemical explosives).
- There is an external timing circuit mounted near each touch plate. Each has a 24-bit counter that is set to zero by the high-to-low edge of a "Start" input pulse, increases by one every 100 µs, and is stopped by the high-to-low edge of a "stop" input pulse. The start and stop input lines float high when disconnected and can be brought low by connecting to ground.



- Your microcomputer has three 16-bit input ports, two 16-bit output ports, and ***NO*** analog I/O. The input port lines float high when disconnected and can be brought low by connecting to ground.
- The gunshot sound is in a digital file and you have a software function that sends the digital data to one of the output ports at the correct speed.
- You have an external 12-bit D/A converter and a power amplifier, and any digital circuits described in 145L

The requirements for your design are:

- The system must record the time for every swimmer to an accuracy of 100 µs even if several swimmers touch their plates in the same 100 µs.
- The lane numbers and time for each swimmer (in units of s) are to be written to the computer display screen and to a file as soon as possible after the swimmer finishes.

6a (30 points) Sketch your design, showing and labeling all essential components and lines. (You only need to show two touch plate switches, timing circuits and speakers.)

6b (30 points) Describe the events (hardware and software) that must take place from the start of the race to after the last swimmer finishes.