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 __________________		

Total of top 4 Lab Grades	________________	(400 max)
Total of top 4 Question Sections	________________	(100 max)
Lab Bonus	________________	
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 1999 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 __________ (36 max) 2 __________ (60 max) 3 _________ (104 max)

TOTAL __________ (200 max)

Initials ________________________

PROBLEM 1 (total 36 points):

Define the following terms:

1a. (6 points) Transition voltages of an analog-to-digital converter

1b. (6 points) Nyquist sampling theorem

1c. (6 points) Tri-state buffer

Initials ________________________

1d. (5 points) Infinite impulse response digital filter

1e. (6 points) Comparator circuit

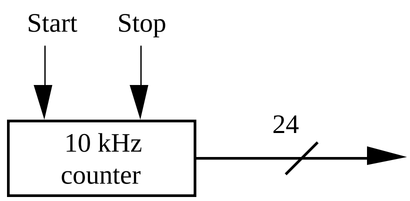
1f. (6 points) Sample-and-hold circuit

Initials ________________________

PROBLEM 2 (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 a “Start” input pulse, increases by one every 100 µs, and is stopped by 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.

a. (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.)

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

Initials ________________________

PROBLEM 3 (104 points)
Design a system for using a microcomputer and the FFT to sample and analyze the harmonic content of the periodic waveforms produced by certain musical instruments.

The requirements are:

- Waveforms are sampled to an accuracy of 0.1% in the 0 to 20,000 Hz range.
- Higher frequencies that alias into the 0 to 20,000 Hz range must be reduced in amplitude by a factor of 100.
- The signal is sampled at a frequency of 2^{16} Hz = 65,536 Hz for 2 s.
- Raised cosine (Hanning) window used to reduce spectral leakage.

You have available the following:

- A microphone and instrumentation amplifier capable of converting the music to an analog waveform with an amplitude of ±5 volts.
- A microcomputer with a 16-bit digital input and 16-bit digital output port. Reading and writing takes 1 µs.
- A circuit that produces 10 µs-wide pulses at 2^{16} Hz = 65,536 Hz.
- A 12-bit successive approximation A/D converter chip with a “start conversion” input and a “data available” output. The A/D input must be held constant during the 10 µs conversion time.
- Any components discussed in 145L that you may need.

3.a. (24 points) Sketch your design, showing and labeling all essential components and lines.

3.b (24 points) Design an anti-aliasing filter that meet the above requirements (determine the filter order n and the corner frequency f_c)

3.c (24 points) List the steps (hardware and software) involved in sampling the waveform and taking the FFT.

3.d (6 points) To what frequencies do the FFT coefficients H_0, H_1, $H_{65,536}$, and $H_{131,071}$ correspond?

(See equation sheet for powers-of-two table)

3.e (4 points) If the system input is a pure 1,000 Hz harmonic signal, how would it appear in the FFT coefficients?

3.f (6 points) How close in frequency can two harmonic signals of equal amplitude be and still appear as separate peaks in the FFT?

Initials ________________________

3.g (6 points) If the system input is the sum of two pure 20,000 Hz and 46,536 Hz harmonic signals of equal amplitude, how would they appear in the FFT coefficients?

3.h (4 points) For a musical instrument with a fundamental frequency of 100 Hz, at what Fourier amplitude H_n would expect the fundamental to occur? (give Fourier frequency index n).

3.i (6 points) At what Fourier amplitude H_n would expect the mth harmonic to occur?