ECE 110
Professors Brunet and Loui **November 17, 2008**

HOUR EXAMINATION #3

1) Write your:

Last Name (use capital letters):_____
First Name (use capital letters):_____
Signature:_____

2) Write your name and section at the back of the test.

DO NOT TURN THIS PAGE UNTIL YOU ARE TOLD

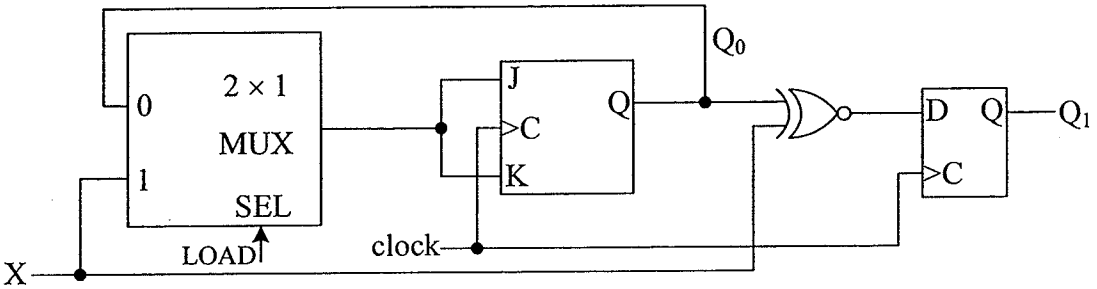
Make sure to write your name AGAIN at the top of every page of your exam.

A. Write or print clearly. Answer each problem on the exam itself. If you need extra paper, there is an extra sheet at the end of this exam. Clearly identify the problem number on any additional pages. The decimal/ binary/ hexadecimal table, the Flip-flop characteristic tables, the ASCII Code, the Morse Code alphabet, the USPS Code, and numbers and properties for log base 2 are also attached to the exam.

B. In order to receive partial or full credit, **you must show all your work**, e.g., your solution process, the equation(s) that you use, the values of the variables used in the equation(s), etc. You must also include the unit of measurement in each answer.

Students caught cheating on this exam will earn a grade of F for the entire course. Other penalties may include suspension and/or dismissal from the university.

Problem 1 *(20 points)*



a) *[14 pts.]* Complete the table for the given circuit.

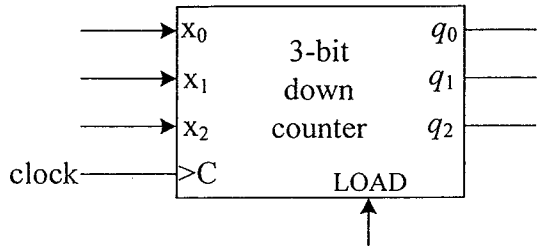
LOAD	Q_0	X	J	K	Q_0^+	Q_1^+
0	0	0				
0	0	1				
0	1	0				
0	1	1				
1	0	0				
1	0	1				
1	1	0				
1	1	1				

b) *[6 pts.]* Using your results in **a)** and assuming LOAD = 1, fill out the table below for consecutive clock pulses. Initially $Q_0(0) = 0$ and $Q_1(0) = 0$.

clock pulse	0	1	2	3
Q_0	0			
Q_1	0			
X	1	1	0	0

Problem 2 *(15 points)* You will design and analyze a mod-6 counter whose state sequence is $(q_2\ q_1\ q_0) = 101, 100, 011, 010, 001, 000, 101, 100, \ldots$

a) *[8 pts.]* Using a 3-bit down-counter with LOAD function, introduce one or more gates and constant inputs (0 or 1) to produce the specified counting sequence.



b) *[7 pts.]* Suppose the clock period is 3 ms. What are the periods of q_0, q_1, and q_2?

Period of q_0 = [ ] Period of q_1 = [ ] Period of q_2 = [ ]

Problem 3 *(15 points)* Define $g(t) = \cos(6\ \pi\ t)$ and $h(t) = \cos(14\ \pi\ t)$, where t is in seconds. The frequency of $g(t)$ is 3 Hz, and the frequency of $h(t)$ is 7 Hz.

a) *[4 pts.]* Find a sampling frequency f_{s1} such that $f_{s1} > 7$ Hz for which $h(t)$ aliases to $g(t)$.

b) *[5 pts.]* Find a cosine whose frequency is higher than 7 Hz that also aliases to $g(t)$ when sampled at the frequency f_{s1}.

c) *[6 pts.]* Find **two** sampling frequencies f_{s2} such that 3 Hz $< f_{s2} <$ 7 Hz for which $h(t)$ aliases to $g(t)$. Justify your answers briefly.

Problem 4 *(20 points)* A **prefix-free** code was designed for four symbols A, B, C and R. The codeword for C has been lost, but you know that the average length of the code is between 1.5 and 2.5 bits.

Symbol	A	B	C	R
Codeword	10	0	?	1101
Relative frequency	3/16	1/4	1/2	1/16

a) *[5 pts.]* Give the encoding for the name BARB

b) *[8pts.]* Let x be the length of the codeword for C. Using the average length of the code, determine the possible values for x. Show your work.

c) *[7 pts.]* Determine the codeword for C. **Explain your reasoning in words**.

Problem 5 *(15 points)* A facsimile (fax) machine digitizes an image using pixels that are 1/8 mm wide and 1/4 mm high. Each pixel color is quantized with one bit, white (1) or black (0).

a) *[6 pts.]* Determine the time, in seconds, required to fax a document that is 8.5 inches wide and 11 inches high, without data compression, over a telephone line that allows digital data to be transmitted at 30,000 bits per second. Use the conversion factor 1 inch = 25.4 mm. (**Hint**: The width is 1728 pixels.)

Time = [ ]

b) *[5 pts.]* Suppose a run-length code is used in which the length of a run from one to seven is represented in binary with 3 bits, preceded by the color bit. For instance, a run of five black pixels is encoded 0 1 0 1. A run of twelve black pixels is encoded as consecutive runs of lengths seven and five: 0 1 1 1 0 1 0 1. Determine the compression ratio for an 8.5 inch row of pixels that all have the same color.

Compression ratio = [ ]

c) *[4 pts.]* Propose a modification to the run-length code to increase the compression ratio for long runs of the same color. (**Hint**: What could code words 0 0 0 0 and 1 0 0 0 mean?)

Problem 6 *(15 points)*

For easy error detection and correction, it was decided to send a message of two ASCII symbols three times. The message below was received. There is one error.

1 0 0 0 1 1 0 0 1 1 0 0 1 0 1 0 0 0 1 1 0 0 1 1 1 0 1 0 1 0 0 0 1 1 0 0 1 1 0 0 1 0

a) *[5 pts.]* Indicate which bit is wrong (circle it). Show your work.

b) *[6 pts.]* Give the 14-bit message that was intended to be sent (**sequence of bits**).

c) *[4 pts.]* Give the two **symbols** that were intended to be sent.