ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION
Session 1
Monday, January 5, 2009

Be sure to put your ID number on each sheet that has material to be graded. Do not put your name on any sheet.

There are 14 equally weighted problems. You are to SELECT ANY EIGHT of these to answer. You must make it very clear which eight that you choose. (If it is not clear, then the first eight problems that you attempt will be graded.) Indicate your selections in two ways:

1. Circle below which eight problems that you want graded.

2. If you write anything other than your ID number on the page of a question that you do not graded, the cross out that page with a large X from corner to corner.

Circle the eight questions that you want graded:

1

2

3

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14

Do all work on the paper supplied to you. Do not write on the back of any page.

Problem 1-1 ID# ____________________

Design a synchronous sequential state machine using DFFs to detect the following overlapping binary sequences: **{111, 101, 000}**.

a. Write the state table in the following format:

Present State (y_1 y_0)	X=0	X=1

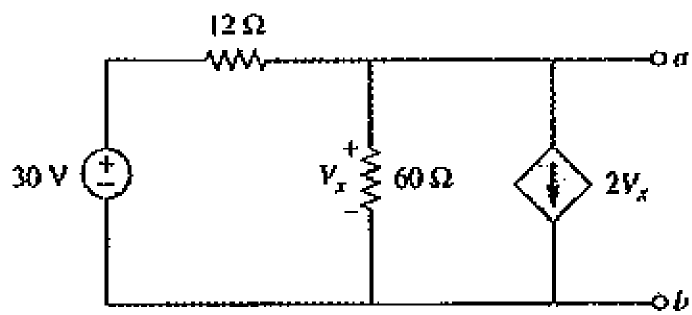
b. Find the inputs to the flip flops

c. Find the output (use Z as the variable)

d. Draw the circuit

Problem 2-1 ID# ______________________

Compute the Thevenin's equivalent circuit of the following circuit with respect to terminals a and b.



Let system stability of a linear, time-invariant system be defined by the criterion that to be stable a system must have a bounded response (output signal) to any arbitrary bounded excitation (input signal). Also let marginal stability for continuous-time systems be defined as having an impulse response that is bounded but not absolutely integrable. That is, for marginal stability

$$|h(t)| \text{ is finite for all } t \quad \text{and} \quad \int_{-\infty}^{\infty} |h(t)|\,dt \text{ does not converge .}$$

For discrete-time systems marginal stability is defined by having an impulse response that is bounded but not absolutely summable. That is, for marginal stability

$$|h[n]| \text{ is finite for all } n \quad \text{and} \quad \sum_{n=-\infty}^{\infty} |h[n]| \text{ does not converge .}$$

For each system below state whether the system is stable or unstable and give your reasons. A correct answer of "stable" or "unstable" gets no credit without a valid reason. If the system is unstable, state whether or not it is also marginally stable. Also, if the system is marginally stable, give an example of a bounded excitation that would produce an unbounded response.

(a) Impulse response is $h(t) = \cos(t)u(t)$.

(b) Transfer function is $H(s) = \dfrac{e^{-3s}}{s+5}$, $\text{Re}(s) > -5$.

(c) Transfer function is $H(z) = \dfrac{z}{z-1}$, $|z| > 1$.

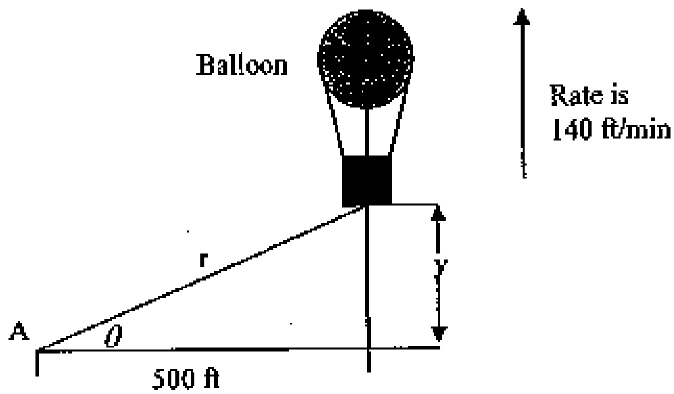
(d) Impulse response is $h[n] = (0.9)^n \cos(2\pi n/16)u[n]$.

(e) Transfer function is $H(s) = \dfrac{1}{(s^2+1)^2}$, $\text{Re}(s) > 0$.

(f) Transfer function is $H(z) = \dfrac{z+2}{z-0.8}$, $|z| > 0.8$.

Problem 4-1 ID# ____________________

A balloon rising from the ground at 140 (feet) ft/min is tracked by a rangefinder at a point A, located 500 ft from the point of liftoff (see the figure below). Find the rate at which the angle at A, θ, and the range r are changing when the balloon is 500 ft above the ground.



Problem 5-1 ID# ______________________

a) What is the output of the following segment?

```
int main()
{
      double array[] = {0.1, 0.45, -0.25, 0.19, 1.1, -2.1};
      double *arrayPtr;

      arrayPtr = array;

      cout << "arrayPtr[0] = " << arrayPtr[0] << '\n';
      cout << "arrayPtr[1] = " << arrayPtr[1] << '\n';
      cout << "arrayPtr[2] = " << arrayPtr[2] << '\n';
      cout << "arrayPtr[3] = " << arrayPtr[3] << '\n';

      cout << "*arrayPtr++ = " << *arrayPtr++ << '\n';
      cout << "*++arrayPtr = " << *++arrayPtr << '\n';
      cout << "*(arrayPtr+2) = " << *(arrayPtr+2) << '\n';
      cout << "arrayPtr[4] = " << arrayPtr[4] << '\n';

      return 0;
}
```

b) What is the output of the following code segment? Explain the function of this code.

```
int main()
{
    int *p, i, tmpValue, tmpIndex;
    int vector[5] = {9, 3, 2, 10, -9};

    p = vector;
    tmpValue = p[0];
    tmpIndex = 0;

    for (i=1; i<5; i++) {
        if (p[i] < tmpValue) {
            tmpValue = p[i];
            tmpIndex = i;
        }
    }

    cout << tmpValue << endl;
    cout << tmpIndex << endl;
}
```

Problem 6-1 ID# ____________________

A random variable X has a probability density function (pdf), $f_X(\cdot)$ where

$$f_X(x) = \begin{cases} cx(1-x), & \text{if } 0 \leq x \leq 1; \\ 0, & \text{otherwise.} \end{cases}$$

a. *Find* c;

b. *Find* $P(\frac{1}{2} < X \leq \frac{3}{4})$;

Problem 7-1 (Page 1) ID# ______________________

a) Answer, explain or describe the following:

i. What are the approximate distance or distances that multipath interference can cause more than a 3 dB loss for a signal operating at 3 MHz?

ii. How does a superhet receiver differ from a direct conversion receiver?

iii. What layer in the ionosphere absorbs radio signals that are below 5 MHz?

iv. What type(s) of voice modulation can use an envelope detector?

v. List two (2) applications for the phase locked loop.

b) Express the following signal in quadrature-carrier form.

$$x_c(t) = 2\cos 3t \cos[1000t + \pi/4]$$

c) Write the analytical expression for an FM signal whose carrier amplitude is 10 volts, carrier frequency is 100 kHz, has a frequency deviation constant of 1 kHz, and has an arbitrary message x(t) with unity amplitude.

d) Repeat problem c) from above, except for a suppressed carrier AM signal (DSB).

Problem 8-1 ID# ______________________

We have a computer system with byte-addressable memory. Virtual memory size is 64 GB, main memory size is 256 MB, and memory page size is 64 KB. The system has a 2-way set associative cache of total size 8 KB with cache line size of 256 B. The page table includes the following entries (the -> notation indicates that a virtual page is located in the given page frame):

Virtual page 7 -> Page Frame 5
Virtual page 2 -> Page Frame 0
Virtual page 1 -> Page Frame 2
Virtual page 0 -> Page Frame 1

a) How many bits are required for virtual addresses?
b) How many bits are required for main memory addresses?
c) In what main memory address will the contents of virtual address 0x000001A24 be found?
d) What virtual address is located in main memory address 0x0020F41 ?

Problem 9-1 ID# ____________________

A deadlock is a situation wherein two or more competing actions are waiting for the other to finish, and thus neither ever does. In the computing world, deadlock refers to a specific condition when two or more processes are each waiting for another to release a resource, or more than two processes are waiting for resources in a circular chain. There are four necessary conditions for a deadlock to occur, known as the Coffman conditions.

Please write down the four conditions and discuss how to prevent each of them.

Problem 10-1 ID# ____________________

You are given a sequence of *n* positive integers, for example, [32, 13, 23, ... 120]. Please consider an algorithmic solution that can divide them into 3 piles, and the sum of the numbers in each pile should be as close as they can be or equal.

a) Under what circumstances there can be an exact solution, in other words, the sum of each pile of numbers are equal

b) In the case of exact solution, design an algorithm to implement it and give worst case analysis.

c) If you are only required to provide an approximate solution, i.e., the sum of each pile is approximately equal to each other, design an algorithm and give worst case analysis.

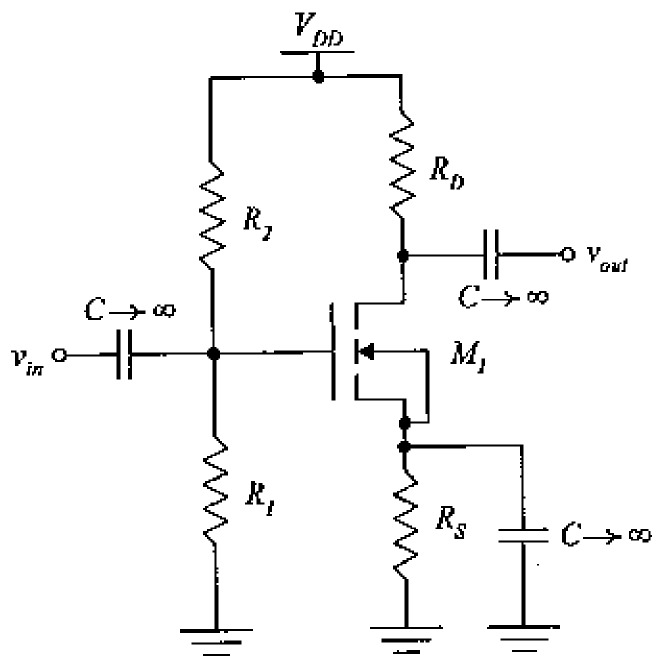
Problem 11-1 ID# ____________________

A lossless 50-Ω transmission line of 0.85λ is connected to a 10V-generator with an internal resistance of 50 Ω, and is terminated in a load with $Z_L = (25+j50)$ Ω. Find the following:

a) The reflection coefficient at the load Γ_L
b) The standing wave ratio VSWR
c) The shortest line length for which the input impedance is purely resistive
d) The position of the first voltage maximum from the load
e) Z_{in} at the generator side
f) The input voltage v_{in} and the input current i_{in} at the input side
g) The input real power to the transmission line and the load
h) The incident voltage wave V^+, and the incident current wave I^+
i) The incident power
j) The complex reflection coefficient at the input side $\Gamma(l)$
k) The reflected power
l) The load voltage V_L
m) The load current I_L
n) The power dissipated in the load.
o) Determine the location (d/λ) and the length of the stub (l_s/λ) required to have a perfect match at the input side.
(Hint: Use Smith Chart)

Problem 12-1 ID# ____________

Provide an expression for the midband small-signal voltage gain v_{out}/v_{in} for the n-channel MOSFET common-source amplifier shown below. Your analysis should include drawing the small-signal equivalent (AC) circuit (including the small-signal model for the MOSFET) at midband. You may assume v_{in} is provided by an ideal voltage source.



$\frac{v_{out}}{v_{in}} =$

Problem 13-1 ID# ____________________

Compute the sum and product of the two eigenvalues of the following 2X2 matrix:

$$\begin{pmatrix} 2 & 4 \\ 1 & 5 \end{pmatrix}$$

Problem 14-1 ID# ____________________

A single phase 2200V /220V transformer has the following test data:

Short circuit test (low voltage side shorted): V=150 volts, I=4.55 amps, P=215 watts

Open circuit test (high voltage side open): V=220 volts, I=2.5 amps, P=100 watts

a) What are the winding resistance (R_{eq}) and leakage reactance (X_{eq}) parameters referred to the low voltage side?

b) What are the core impedance parameters R_c and X_m referred to the high voltage side?