ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION

Session 2

August 19, 2008

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

4

5

6

7

8

9

10

11

12

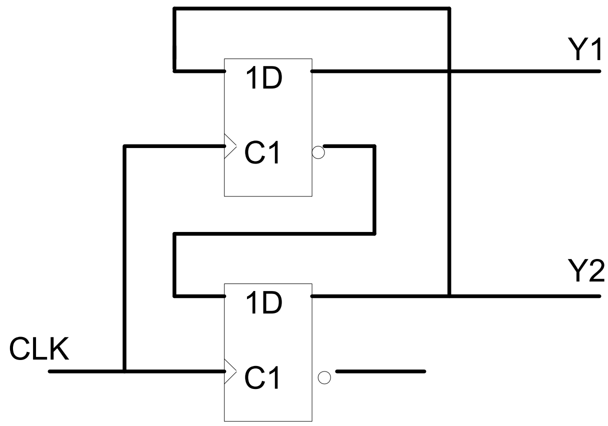
13

14

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

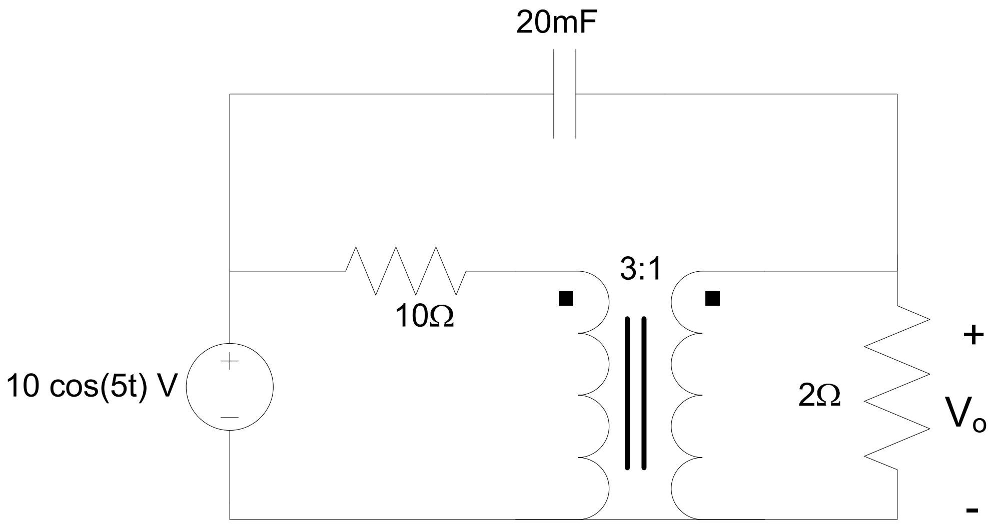
Problem 1-2 ID # ________________________

Analyze the following synchronous state machine to determine its functionality by obtaining the next-state equations, the present state/next state table, and the state diagram. Does the state machine have any illegal states?



Problem 2-2 ID # ________________________

Find the phasor for V_o. (The expression given for the voltage source is PEAK, not RMS.) Show your steps clearly.



Problem 3-2 ID # ________________________

A sinusoid $x(t) = 10\sin(24\pi t)$ is sampled at 10 samples/second to form a discrete-time signal $x_s[n]$. The discrete-time signal is then the input signal to a digital-to-analog converter (DAC) which converts each value of the discrete-time signal (with no time delay) into an output analog signal of the same value and holds that value constant until the next sample occurs.

(a) What is the fundamental period T_0 of the signal from the DAC?

(b) The output signal from the DAC is a periodic analog signal which could be represented as a linear combination of phase-shifted sine functions at the fundamental frequency and integer multiples of the fundamental frequency. What is the phase-shift in radians of the fundamental sine wave in this representation?

Problem 4-2 ID # ____________________________

Suppose a function $y = f(x)$ is defined by the following equation in the neighborhood of $x = 0$:

$$\log_2(x+y) + xy + 1 = 0$$

Then, find $\left.\dfrac{dy}{dx}\right|_{x=0}$

Problem 5-2 (Page1) ID # ________________________

For the following program, give the output as shown in the second page of this problem

```
#include <iostream>
using std::cout;
using std::endl;
void function1( void );
void function2( void );
void function3( void );
int x = 16;
int main()
{
   int x = 11;
   cout << "x in main function is " << x << endl;
   function1();
   function2();
   function3();
   function3();
   function2();
   function1();
   cout << "x in main function is " << x << endl;
   {
      int x = 18;
      cout << "\nx in main function is " << x << endl;
   }
   cout << "x in end of main is " << x << endl;
   return 0;
} // end main

void function1( void )
{
   int x = 11;
   cout << "\nx is " << x << " on entering function1" << endl;
   x++;
   cout << "x is " << x << " on exiting function1" << endl;
} // end function

void function2( void )
{
   static int x = 25;
   cout << "\nx is " << x << " on entering function2" << endl;
   x++;
   cout << "x is " << x << " on exiting function2" << endl;
} // end function

void function3( void )
{
   cout << "\nx is " << x << " on entering function3" << endl;
   x *= 10;
   cout << "x is " << x << " on exiting function3" << endl;
} // end function
```

Problem 5-2 (Page 2)   ID # ________________________

The output of the program is:

x in main function is ____
x is ____ on entering function1
x is ____ on exiting function1
x is ____ on entering function2
x is ____ on exiting function2
x is ____ on entering function3
x is ____ on exiting function3
x is ____ on entering function3
x is ____ on exiting function3
x is ____ on entering function2
x is ____ on exiting function2
x is ____ on entering function1
x is ____ on exiting function1
x in main function is ____
x in main function is ____
x in end of main is ____

Problem 6-2 ID # ______________________

We transmit a bit of information which is 0 with probability $1-p$ and 1 with p. Because of noise on the channel, each transmitted bit is received correctly with probability $1-\epsilon$.

(a) Suppose we observe a "1" at the output. Find the conditional probability p_1 that the transmitted bit is a "1".

Problem 7-2 ID # ________________________

A system implements a paged virtual address space for each process using a one level page table. The maximum size of virtual address space is 16MB. The page table for the running process includes the following valid entries (the -> notation indicates that a virtual page maps to the given page frame, that is, it is located in that frame):

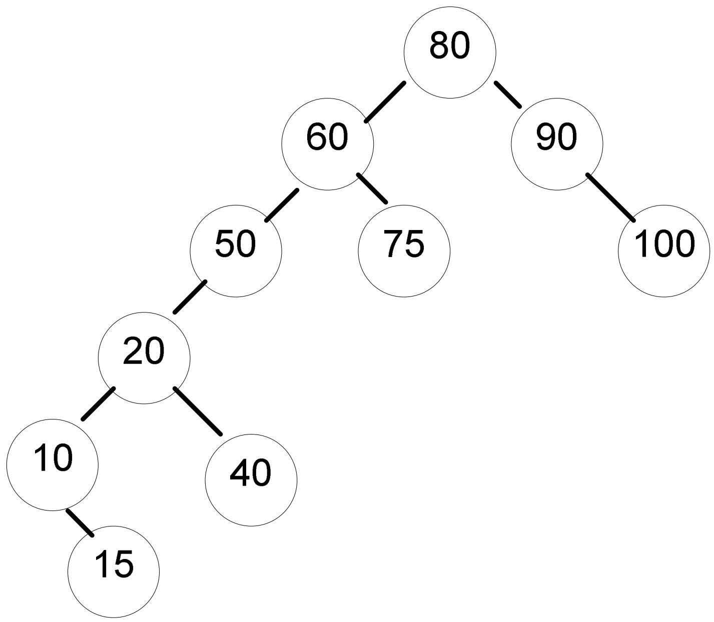
Virtual Page 2 -> Page Frame 4
Virtual Page 1 -> Page Frame 2
Virtual Page 0 -> Page Frame 1
Virtual Page 4 -> Page Frame 9
Virtual Page 4 -> Page Frame 16

The page size is 1024 bytes and the maximum physical memory size of the machine is 2MB.

a. How many bits are required for each virtual address?
b. How many bits are required for each physical address?
c. What is the maximum number of entries in a page table?
d. To which physical address will the virtual address 1524_{10} translate?
e. Which virtual address will translate to physical address 1024_{10}?

Problem 8-2 ID # ________________________

Consider the splay tree illustrated below. Show the result of the tree after a splay operation at 50.



Problem 9-2 ID # ________________________

What is an i-node and how does it relate to operating systems and storage? Assuming a typical operating system (e.g., Unix, Windows), explain the steps for creating files, deleting files, and listing directory contents. Explain how i-nodes are involved in this process. Explain how an "undelete" program can work, particularly with respect to i-nodes.

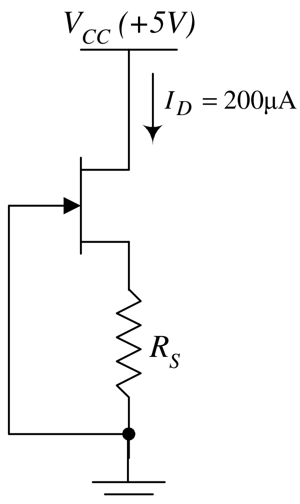
Problem 10-2 ID # ____________________________

Use LU decomposition and back substitution to solve the equation $Ax = b$ for x,

where $A = \begin{bmatrix} 1 & 1 & -1 & 1 \\ 0 & 3 & 2 & -1 \\ -1 & 8 & 2 & 1 \\ 3 & 4 & 1 & 5 \end{bmatrix}$ and $b = \begin{bmatrix} 2 \\ 4 \\ 15 \\ 21 \end{bmatrix}$. Show all work.

Problem 11-2 ID # ________________________

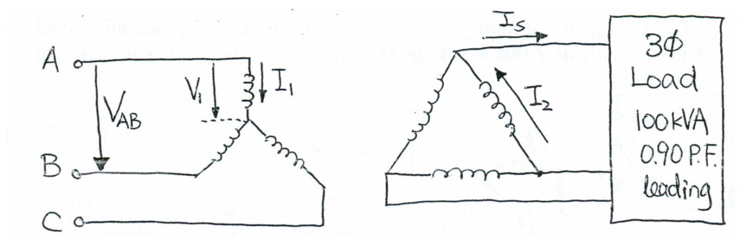
Consider the n-channel JFET circuit shown below. Determine the value of R_S needed to set I_D to 200 µA. For this JFET, $V_P = -1\text{V}$ and $I_{DSS} = 2$ mA. Assume the JFET is operating in the "pinch-off" or saturation region. You may neglect channel-length modulation. Thus, $I_D = I_{DSS}[1 - (V_{GS} / V_P)]^2$.



Problem 12-2 ID # ________________________

Three 1ϕ, 100kVA, 2300/230 V, 60Hz transformers are connected to form a 3ϕ, 4000/230 V (i.e., Y-Δ) transformer bank. The equivalent impedance of each transformer referred to low voltage is 0.01+j0.02 Ω. The 3ϕ transformer supplies a 3ϕ, 100kVA, 230V, 0.90 PF (leading) load at the low-voltage (LV) side.

1) Determine the transformer winding current (magnitude only) at the high-voltage (HV) side.
2) Determine the HV side line-to-line voltage (magnitude only) required to supply the specified load.
3) Determine the voltage regulation.



Problem 13-2 ID # ________________________

Consider a dielectric slab with 0.1 λ thickness and a dielectric constant of 4. This slab is backed by a semi-infinite metal with perfect conductivity; find the reflection coefficient at the air-dielectric slab interface for a normal TEM wave incidence.

a) if the metal has a conductivity of $2\text{x}10^7$ ohm/m and the operating frequency is 1GHz, find the skin depth, the surface impedance, and the effective reflection coefficient at the air-dielectric interface for this finite conductivity case.

Problem 14-2 ID # ________________________

Answer, explain or describe the following. Be complete but not wordy.

a. What type of detector would you use for weak signal AM reception?

b. List all types of analog modulation that are suitable for transmitting a signal with DC and/or low frequency content.

c. What is a direct conversion receiver?

d. What method of modulation would you employ if battery life was important and bandwidth was not costly? Why?

e. What physical phenomena will cause radio signals to be attenuated when traveling through free space?

f. What two mathematical models are used to describe bandpass signals?

g. What is the primary disadvantage of AM for transmitting voice information?

h. Given a system where the power spectral density of the noise cannot be changed, and where the path attenuation is fixed. List and briefly describe all possible ways to increase the destination's signal-to-noise ratio.

i. You are listening to a 990 kHz AM radio signal and someone starts transmitting a weaker sinusoidal signal at 992 kHz. How do you know that this "jamming" signal is occurring (i.e. what will you hear out of the loudspeaker)?

j. Describe two methods of generating a SSB signal.

Problem _-_ ID # ________________________