ELECTRICAL AND COMPUTER ENGINEERING
PhD QUALIFYING EXAMINATION

Session2

August 21, 2007

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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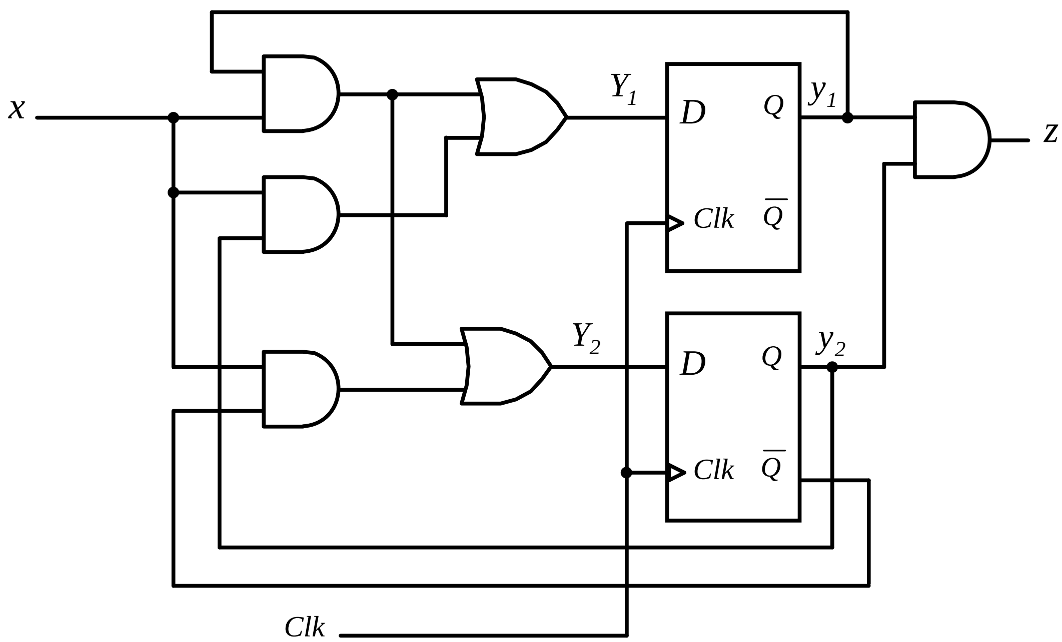
14

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

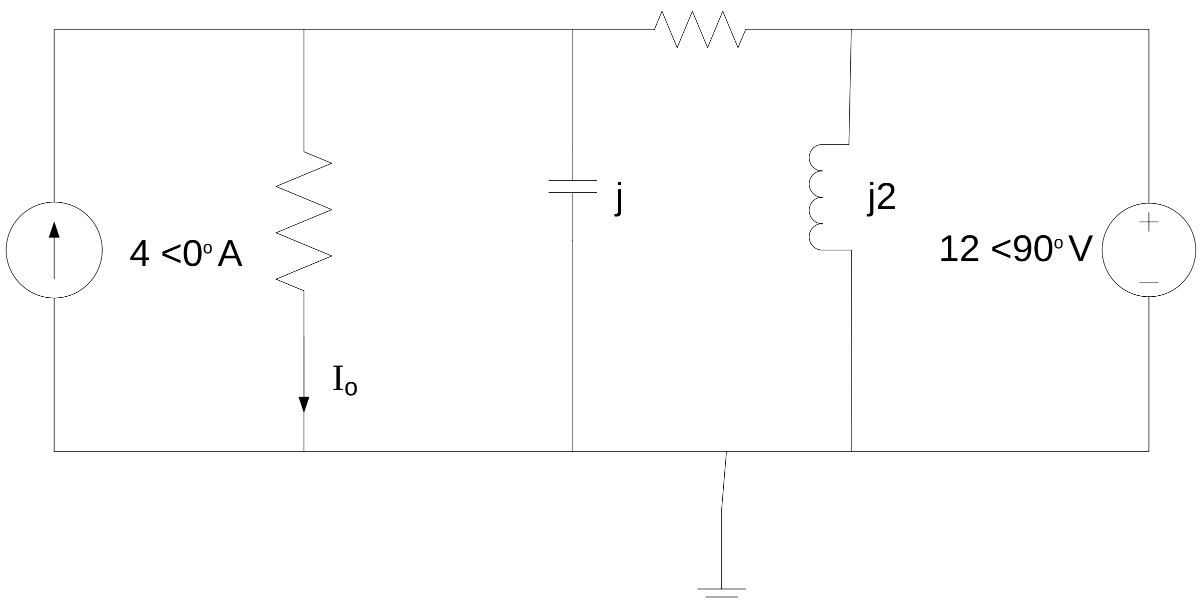
Problem 1-2 ID # ________________________

Determine the "State Table" of the finite state machine described by the following logic implementation.



Problem 2-2 ID # ____________________________

Find the value of I_o.



4Ω

Problem 3-2 ID # ____________________________

4. The N-point discrete Fourier transform is defined by $\mathrm{X}[k]=\sum_{n=0}^{N-1}\mathrm{x}[n]e^{-j2\pi kn/N}$. If $N=8$ and $\mathrm{x}[n]=\{0,1,0,-1,1,1,0,1\}$, $0\le n<8$

$$\left(\cos(\pi/4)=\sin(\pi/4)=1/\sqrt{2}\right)$$

(a) Find the numerical value of $\mathrm{X}[7]$.

(b) Find the numerical value of $\mathrm{X}[1]$.

(c) Find the numerical value of $\mathrm{X}[-39]$.

(d) Two of the values of $\mathrm{X}[k]$ in the range $0\le k<8$ must be real numbers. Which two are they?

Problem 4-2 ID # ______________________

Evaluate $\int_0^1 \int_x^1 \sin\left(y^2\right)\, dy\ dx$.

Problem 5-2 ID # ___________________________

Write a C++ function that computes the difference (positive or negative) between two times (each specified by 3 non-negative integers for hours, minutes, and seconds in 24-hour, or “military”, notation). The result is to be in seconds.

Problem 6-2 ID # ________________________

Consider the web-server system shown in figure 1. Requests arriving at the web-server pass through an admission control mechanism, which works as follows: Each arriving request is held for *H* units of time before possible admission. If, when a request is held, another request arrives, then the first request is dropped (not admitted) and the second request is held for *H* units of time, and so on.

- Assuming requests arrive according to a Bernoulli process with rate λ, what is the rate, λ_a, at which they are admitted? What is the rate, λ_d, at which they are dropped?
- Now support that *H* is geometrically distributed with parameter μ (mean holding time of $1/\mu$). The rest of the mechanism remains the same. What are the admission and dropping rates now?

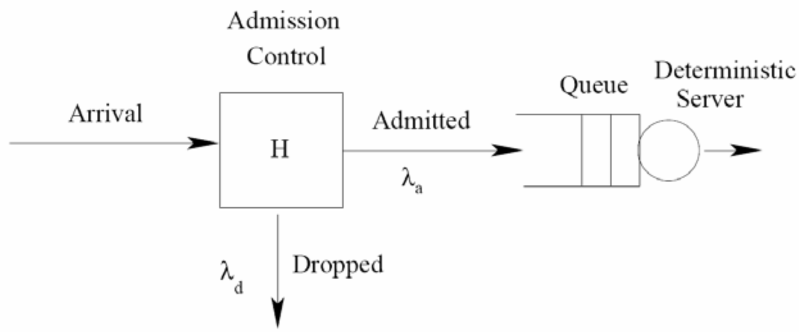


Figure 1: Web-server with admission control

Problem 7-2 ID # ____________________________

Consider four processors with different cache configurations:

- Cache 1: Direct-mapped with one-word blocks
- Cache 2: Direct-mapped with four-word blocks
- Cache 3: Two-way set associative with four-word blocks
- Cache 4: Four-way set associative with four-word blocks.

The following miss rate measurements have been made:

- Cache 1: Instruction miss rate is 5%; data miss rate is 7%
- Cache 2: Instruction miss rate is 3%; data miss rate is 4%
- Cache 3: Instruction miss rate is 2%; data miss rate is 4%
- Cache 4: Instruction miss rate is 2%; data miss rate is 3%

For these processors, 40% of the instructions contain a data reference. Assume that the cache miss penalty is 6 + Block size in words. The CPI for this workload was measured on a processor with cache 1 and was found to be 2.0. Determine which processor spends the most cycles on cache misses. Explain your answer.

Problem 8-2 ID # ____________________________

For each of the following program fragments, give the Big-Oh analysis of the running time. Order the fragments by growth rate.

```
// Fragment #1
for (int i=0; i<n; i++)
  sum++;

// Fragment #2
for (int i=0; i<n; i+=2)
  sum++;

// Fragment #3
for (int i=0; i<n; i++)
  for (int j=0; j<n; j++)
    sum++;

// Fragment #4
for (int i=0; i<n; i++)
  sum++;
for (int j=0; j<n; j++)
  sum++;

// Fragment #5
for (int i=0; i<n; i++)
  for (int j=0; j<n*n; j++)
    sum++;

// Fragment #6
for (int i=0; i<n; i++)
  for (int j=0; j<i; j++)
    sum++;

// Fragment #7
for (int i=0; i<n; i++)
  for (int j=0; j<n*n; j++)
    for (int k=0; k<j; k++)
      sum++;

// Fragment #8
for (int i=0; i<n; i=i*2)
  sum++;
```

Problem 9-2 ID # ______________________

Please write pseudocode to use the *`fork`* command to create a new process. The new process should execute a program called `child`. The parent process should do nothing but wait for the child process to finish and then print a message “child process exits”.

Problem 10-2 ID # ____________________________

Given a 3×3 matrix

$$A = \begin{bmatrix} 3 & -1 & -2 \\ 2 & 0 & -2 \\ 2 & 1 & -1 \end{bmatrix}$$

(a) Find the eigenvalues and corresponding eigenvectors of A.

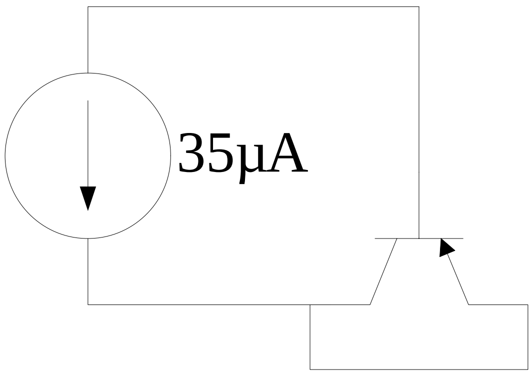
(b) Find a nonsingular matrix X and a diagonal matrix D such that

$$X^{-1}AX = D$$

(c) Confirm that $A = XDX^{-1}$

Problem 11-2 ID # ___________________________

For the transistor shown, $I_s = 2 \times 10^{-15}$ A, β_F=75, β_R=2.



Part A. Label the collector, base and emitter terminals of the transistor.

Part B. What is the transistor type?

Part C. Label the emitter-base and collector-base voltages, and label the normal direction for I_E, I_C, and I_B.

Part D. Write the simplified form of the transport model equations that apply to this particular circuit configuration. Write an expression for I_E/I_B. Write an expression for I_E/I_C.

Part E. Find the values of I_E, I_C, I_B, V_{CB}, and V_{EB}

Problem 12-2 ID # ___________________________

A three-phase, 460 $V_{line\text{-}line}$, 60 Hz induction motor has a no load speed of 900 rpm and a full load speed of 855 rpm. Neglect rotational losses.

(a) How many poles does the motor have?

(b) What is the slip at full load?

(c) What is the frequency of the rotor currents at full load?

(d) At full load, what is the speed (in rpm) of the rotor field relative to the stator rotating field?

(e) At full load, what is the speed (in rpm) of the rotor field relative to the rotor structure?

(f) At full load, what is the speed (in rpm) of the rotor field relative to the stator structure?

Problem 13-2 ID # ________________________

A 50 ohm transmission line is connected to an antenna with a load impedance Z_L=(25-j50) ohm.

Use a Smith Chart to: (please show all details and describe all your steps)

a) Find the complex reflection coefficient at the load
b) Find the VSWR along the line
c) Find location of the first VSWR minima along the line
d) Calculate the fraction of power delivered to the load
e) Find the position and length of a short-circuited shunt stub required to match the line.

Problem 14-2 ID # ________________________

An AM station with a message power of 0.7, carrier frequency of 200 MHz, modulation index of 0.9, and message bandwidth is 2 kHz transmits a signal to a destination 200 km away. The signal is received such that $(S/N)_D = 30$ dB. The transmitter power has $S_T = 50$ watts. We would like to change to FM in order to reduce the transmitter power, but yet still maintain the same signal-to-noise ratio. What would be the *new transmitter power* if we changed to FM with $f_\Delta = 16$ kHz? You may neglect threshold effects.

Problem _-_ ID # ___________________________