CS 6901 Capstone Exam Systems Spring 2017: Choose any 2 of the 3 problems.

1) Design a fully simplified 3-bit mod 6 down counter with your choice of T, JK, or D flip-flops. The circuit decrements at each clock pulse, going through the sequence

0, 5, 4, 3, 2, 1, 0, 5, 4, 3, … .

Show the circuit diagram.

2) Consider the following page replacement algorithms: FIFO (first in first out) and LRU (least recently used). Logical memory has 10 pages (pages 0 .. 9), while physical memory consists of 4 frames (frames 0 .. 3). The page reference string begins with 2, 6, 5, 7 to fill the four frames. Each part begins from this same initial point.

On your solution page, show the 2 frame traces for each part.

a) Continue the page reference string with at most 3 additional terms where LRU will result in strictly fewer page faults than FIFO.

```
ref. str.:  2   6   5   7    _   _   _
            ---------------------------
            2   2   2   2
                6   6   6                       LRU
                    5   5
                        7
            ---------------------------
            2   2   2   2
                6   6   6                       FIFO
                    5   5
                        7
```

b) Continue the page reference string with at most 3 additional terms where FIFO will result in strictly fewer page faults than LRU.

```
ref. str.:  2   6   5   7    _   _   _
            ---------------------------
            2   2   2   2
                6   6   6                       LRU
                    5   5
                        7
            ---------------------------
            2   2   2   2
                6   6   6                       FIFO
                    5   5
                        7
```

3) Consider the Readers/Writers problem with a single writer. Any number of readers can examine a file and the writer is only allowed access when there are no active readers. Consider the following incorrect solution. The common variables and their initializations are given by:

```
semaphore wrt=1;
int readcount=0;
```

Code for the writer and the readers:

```
writer()
{
  wait(wrt);
  //Do the writing
  signal(wrt);
}

reader()
{
  if(readcount==0)wait(wrt);
  readcount++;
  //Do the Reading
  readcount--;
  if(readcount==0)signal(wrt);
}
```

Give an execution sequence where a reader and the writer have access at the same time.

CS 6901 Capstone Exam Data Structures and Algorithms Spring 2017

Choose any 2 of the 3 problems.

1) Given a possibly empty binary tree containing character data, write a function that returns the number of left children in the tree. The prototype for your function should be

`int LeftCount(TreeNode *ptr).`

Global variables may not be used. Declare all data structures.

2) Given a possibly empty singly linked list, write a function that reverses the last 4 nodes of the list (without altering the earlier nodes). If the given list has fewer than 5 nodes, the entire list should be reversed. The prototype for your function should be

`void Reverse4(Nodetype *ptr).`

3) Solve the recurrence relation $T(n) = 2T(n/2) + (n-1)$ where $T(1) = 0$ and $n = 2^k$ for a nonnegative integer *k*. Your answer should be a precise function of n in closed form. An asymptotic answer is not acceptable. Justify your solution.

Theory Exam

Answer **ANY TWO** of the following three questions:

1. A certain programming language *P* defines a comment as delimited by /# and #/. Let the alphabet Σ = {a, b, /, #} and let *C* be the set of all comments that begin with /#, end with #/, and contain no intervening #/. The shortest legal string in *L* is therefore /##/.

    a. (10 points) Give a deterministic finite automaton (DFA) that recognizes legal comments *C* in the language *P*.
    b. (10 points) Write a context-free grammar (CFG) that generates legal comments *C* in the language *P*.

2. Consider the language *L* = {<*M*> | *M* is a Turing machine that accepts the string *w* = 0011}.

    a. (5 points) Is *L* decidable or undecidable?

    b. (15 points) Prove your answer above using reducibility. You may assume that the following languages are known to be undecidable:

        $HALT_{TM}$ = {<*M*, *w*> : *M* is a Turing machine that halts on *w*}
        A_{TM} = {<*M*, *w*> : *M* is a Turing machine that accepts *w*}

        You may not use Rice's Theorem.

3. For each decision problem listed below, answer:

    i. Is the problem in the class **NP**?

    ii. Is the problem **NP-complete**?

Scoring: each correct answer given is +2, each incorrect answers given is -1, no answer given is 0]
DO NOT GUESS!

    a. Given a graph *G*, does *G* contains a 3-clique?

        (a 3-clique is a subgraph of *G* that is fully connected or complete on 3 vertices)

    b. Given two integers *n* and *m*, are *n* and *m* relatively prime?

        (two integers are relatively prime if their greatest common divisor is 1)

c. Given a graph G and a number k, is the largest clique in G of size k?

(a clique is a subgraph of G that is a complete graph)

d. Given a Boolean expression E, are there are <u>exactly</u> two truth assignments that satisfy E?

(a Boolean expression is satisfiable if some assignment of variables makes it true)

e. Given a set of students $N = \{s_1, s_2, \ldots, s_{|N|}\}$, a set of final exams $M = \{e_1, e_2, \ldots, e_{|M|}\}$, a mapping $f: N \rightarrow P(M)$ showing the specific subset of exams each student is taking, and a number t of possible time slots for the exams, is it possible to schedule the exams into the t time slots such that no student has two of his or her exams assigned to the same time slot?