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

1) Rewrite $F(a, b, c, d) = \sum(0, 3, 4, 8, 10, 11)$ in fully simplified product-of-sums form.

2) Consider the following page reference string for a virtual memory system in which physical memory has exactly 3 frames:

2, 4, 6 4, 2, 7, 4, 3, 7, 2, 3

For each of the following page replacement algorithms, show which references will cause page faults and show the contents of the 3 frames at the time of each fault. Assume that the frames are initially empty. You do not need to show the first 3 faults that are caused by demand paging.

a) Least Recently Used
b) Second Chance

3) There are 3 standard goals to the 2-process mutual exclusion problem.
Goal 1: Mutual exclusion is guaranteed
Goal 2: Deadlock cannot occur.
Goal 3: Indefinite postponement cannot occur.

Attempted Solution: common variable: lock (initially false)
Assume the existence of an atomic (non-interruptible) test_and_set function that both returns the value of its boolean argument and sets the argument to true.

```
   Process 1                                   Process 2
while (true) {                              while (true) {
  while (test_and_set(lock));                 while (test_and_set(lock));
  Critical section;                           Critical section;
  lock = false;                               lock = false;
  Noncritical section;                        Noncritical section;
}                                           }
```

For the above solution,
a) Select one goal that is not satisfied and provide an execution sequence that violates the goal.
b) Select one goal that is satisfied and give a brief explanation that justifies why the goal is met for all possible execution sequences.

CS 6901 Capstone Exam Data Structures and Algorithms Fall 2017

Choose any 2 of the 3 problems.

1) Given a possibly empty binary tree, write a function that returns the number of nodes in the tree that have a right child, but no left child. The prototype for your function is

```
  int RightNoLeft(TreeNode *ptr).
```

Global variables may not be used. No additional functions may be defined. Declare all data structures.

2) Given an array of n nonzero real numbers a[0]…a[n-1], write a function to partition the array (not sort) so that all its negative elements come before all its positive elements. Your algorithm should have O(n) time complexity. The function prototype is

```
  void negpospartition(float a[], int n) .
```

3) Count the precise number of "fundamental/basic operations" executed in the following code. Your answer should be a function of n $(n \geq 1)$ in closed form. Note that “closed form” means that you must resolve all $\sum$’s and $\cdots$’s. An asymptotic answer (such as one that uses big-oh, big-theta, etc.) is not acceptable.

```
for(int k = 1; k < n; k++) {
  Perform 1 fundamental/basic operation;
  for (int j = k; j <= n; j++)
    Perform 1 fundamental/basic operation;
  //endfor j
}//endfor k
```

Theory Exam

1. Give regular expressions describing each of the following languages over $\Sigma = \{0, 1\}$:

    a. {*w* : *w* contains the substring 101}
    b. {*w* : *w* contains at least three 0's}
    c. {*w* : *w* contains at most three 1's}
    d. {*w* : $|w| \geq 3$}
    e. {*w* : $|w| \leq 3$}
    f. {*w* : *w* starts and ends with different symbols}
    g. {*w* : every odd position of *w* is 0}
    h. {*w* : *w* does not contain exactly two 1's}
    i. {*w* : every 0 in *w* is followed by two 1's}
    j. {*w* : w starts with the substring 011 and contains the substring 110}

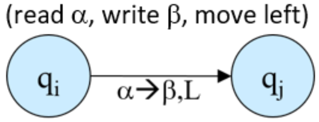
    Each question is worth 2 points. No partial credit will be given.

2. Give the state diagram for a Turing machine that decides the following language over $\Sigma = \{0, 1\}$:

    L = {*w* : *w* contains an even number of occurrences of the substring 011 and $|w|$ is odd}

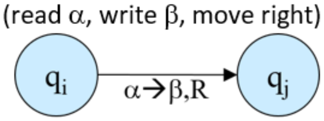
    Use the following notation to label each of your machine's transitions:

    (read α, write β, move left)



OR

(read α, write β, move right)



3. A *coloring* of a graph is an assignment of colors to its nodes so that no two adjacent vertices have the same colors.

    Let ***COLOR*** = {*G*, *k* : *G* = (*V*, *E*) is a graph that can be colored by *k* colors}.

    Provide a polynomial verifier to prove that ***COLOR*** $\in$ NP.