CS 6901   Capstone Exam Systems Fall 2015: Choose any 2 problems.

1) a) Construct a circuit diagram for a 4x1 multiplexer.
b) Let $F(a, b, c, d) = a'b'c'd' + a'b\,c\,d + ab'c'd + a\,b\,c\,d$. Use a 16x1 multiplexer (as a block diagram) and no additional logic gates to implement F .

2) Given the following 3 processes and main body that access the common variable i :

```
int i = 0;
```

Processes:

P1:	P2:	P3:
`i = i + 3;`	`i = i - 4;`	`i = i + 5;`

Main body:
Start asynchronously P1, P2, P3
// After all 3 processes have finished
`Print i;`

a) What is the largest possible value of `i` that could be printed? Briefly explain how this can occur.
b) List all other possible values of `i` that might be printed? (No explanations needed for part b).)

3) Consider a system with 3 resources (A, B, C) in quantity (10, 6, 9). The Banker's Algorithm is used to allocate resources and it has the following SAFE state:

Available:	A	B	C
	3	2	1

Process	Allocation			Max			Need		
	A	B	C	A	B	C	A	B	C
P0	1	0	2	2	1	6	1	1	4
P1	0	2	2	0	5	3	0	3	1
P2	3	1	2	6	6	5	3	5	3
P3	0	1	0	2	2	1	2	1	1

a) Justify why the current state is safe.
b) If P0 requests an additional unit of resource B, will it be allowed? Justify your answer.
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CS 6901 Capstone Exam Data Structures and Algorithms Fall 2015

Choose any 2 of the 3 problems.

1) Write the function int CountInternal(treeNode *p) that counts the number of non-leaf nodes in the (possibly empty) binary tree with root p. Declare all data structures.

2) Given a (possibly empty) singly linked list of distinct integers, write a function that removes the node containing the integer x. The function returns true if x is found, false otherwise. The prototype is

bool remove_node(nodeptr & *head, int x) .

3) For each function with input argument *n*, determine the precise number of "fundamental operations" that will be executed. Your answer should be a function of n 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. Assume that $n \geq 1$ for all parts.

Note that `fc` is recursive.

a)

```
void fa(int n) {
  for(int i = 0; i <= n; i = i+2)
    Perform 1 fundamental operation;
  //endfor i
}
```

b)

```
void fb(int n) {
  for(int k = 2; k <= n; k++)
    for(int j = 1; j < n; j++)
      Perform 1 fundamental operation;
    //endfor j
  //endfor k
}
```

c)

```
void fc(int n) {
  if (n > 1) {
    Perform n-1 fundamental operations;
    fc(n-1);
  }//endif
}
```

Theory Exam

1. Give regular expressions describing each of the following languages over $\Sigma = \{0, 1\}$:
    a. $\{w : \text{the fourth symbol of } w \text{ is a } 0\}$
    b. $\{w : |w| \text{ is odd}\}$
    c. $\{w : w \text{ contains either substring } 000 \text{ or substring } 111\}$
    d. $\{w : \text{every } 0 \text{ in } w \text{ is immediately followed by a } 1\}$
    e. $\{w : |w| \neq 2\}$

2. Answer each of the following questions with only **YES** or **NO** to indicate whether or not the listed classes are closed under the indicated operations. *Do not guess if unsure, as wrong answers will lower your score!*
   Scoring: +2 points for correct answers; 0 points for no answers; -1 point for wrong answers
    a. regular languages under set difference
    b. regular languages under concatenation
    c. context-free languages under complement
    d. context-free languages under intersection
    e. decidable languages under union
    f. decidable languages under Kleene closure
    g. acceptable languages under complement
    h. acceptable languages under intersection
    i. co-acceptable languages under concatenation
    j. co-acceptable languages under set difference

3. A *clique* in an undirected graph is a subgraph wherein every two nodes are connected by an edge. Consider the language:

   CLIQUE = $\{G, k : G = (V, E) \text{ is an undirected graph containing a clique of size } k\}$

   Show that $3SAT \leq_p CLIQUE$