

CS 6901 Capstone Exam Systems Fall 2014: Choose any 2 of the 3 problems.

1) Design a fully simplified 3-bit mod 7 down counter with your choice of JK, D, or T flip-flops. The circuit decrements at each clock pulse, going through the sequence

0, 6, 5, 4, 3, 2, 1, 0, 6, 5, 4, 3, ... .

Show the circuit diagram.

2) a) Consider a Round-Robin CPU scheduling algorithms for a single CPU with a time quantum of 3. Assume that no time is lost during context switching. Given four processes with arrival times and expected CPU time as listed below, draw a Gantt chart to show when each process executes. Of course, assume that the expected time turns out to be the actual time.

Process	Arrival Time	Expected CPU Time
P1	0	5
P2	2	7
P3	4	6
P4	7	2

b) Suppose that  $n$  processes ( $n \geq 2$ ) are sharing the CPU using Round-Robin. Assume that each context switch takes  $S$  time units and that each time quantum takes  $Q$  time units. Also assume that processes never block and instead simply switch between the CPU and the ready queue. Find the maximum value of  $Q$  such that no process will ever go more than  $T$  time units between executing instructions. Your answer should be a function of  $n$ ,  $S$ , and  $T$ .

3) Consider the semaphore solution to solve the readers/writers problem where any number of readers can examine a file, but only one writer at a time can update the file. A writer is only allowed access when there are no active readers. Write the basic code for readers and writers. Declare and initialize all semaphores.

CS 6901 Capstone Exam Data Structures and Algorithms Fall 2014  
Choose any 2 of the 3 problems.

1) a) Give a precise definition of  $f \in O(g)$  (“big-oh”).

b) Use the definition to prove that  $f \in O(n)$ , where

$$f(n) = \begin{cases} n^2 - n, & n \leq 23 \\ 5n + 7, & n > 23 \text{ and } n \text{ odd} \\ 4n, & n > 23 \text{ and } n \text{ even} \end{cases}.$$

2) Implement a FIFO queue of integers using a circular array  $a[0] \dots a[n-1]$ , where  $n$  is a constant. Declare the data structure and give code for the following operations:

a) initialize\_to\_empty

b) insert\_at\_rear

c) remove\_from\_front

d) is\_full (return true if the queue is full; false otherwise)

3) Write the function

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int CountKey(treeptr *p, int keyval);
```

that is given a (possibly empty) binary tree and returns the number of times a particular integer key (keyval) occurs *as a leaf node*. Declare all data structures.

# Theory Exam

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

1. Provide a context-free grammar that generates the following language over  $\Sigma = \{0,1\}$ :

$$\{w = 0^*1^* : |w| \text{ is odd}\}$$

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

$$\mathbf{3CLIQUE} = \{V, E : G = (V, E) \text{ is an undirected graph that contains a clique of size 3}\}$$

Show that **3CLIQUE** is decidable.

3. Answer the following:
  - a. Define the class **NP**.
  - b. Show that the class **NP** is closed under concatenation.