Capstone Exam Spring 2021 Systems

1. General

3pts Name three (3) services that an Operating System provides.

2pts Where are temporary data such as function parameters, return addresses, and local variables stored?

2pts In an operating system, where is the list of processes waiting for a particular I/O device stored?

2pts A process that has terminated, but whose parent has not yet called wait(), is known as a ________ process.

3pts Define what is meant by the term race condition. What is a solution mechanism to solve race conditions?

8pts) Assume for the following that competition synchronization is NOT enabled.

The init = 2, process X has the statement: init = init + 2, and process Y has the statement: init = init * 3.

What are the four possible values of init after the X and Y processes finish?

Resource Allocation

4pts Give two (2) solutions for breaking deadlock among processes.

2pts What is meant by a "safe state?"

12pts Given the table below, show that the system is in a safe state.

Issue here with mAX go with need

Processes	Allocated	Max	Need	Available
	A, B, C	A, B, C		A, B, C
P0	0, 1, 0	1,1,1	1,2,1	0,1,0
P1	1,2,3	5,5,7	4,3,4	
P2	2,0,2	0,3,0	2,3,0	
P3	2,1,1,	2,2,1	0,1,0	
P4	0,0,2	4,3,3	4,3,1	

(2pts) Give a request that will leave the system in an unsafe state

CPU Scheduling

2pts What happens to the Round Robin CPU scheduling routine if the time quantum is too large?

2pts. Which CPU scheduling algorithm performs best in general and why?

Using the table below, calculate the **average wait time** for each of the CPU scheduling algorithms listed below the table. Please show your work with a Gantt chart.

	Arrival (secs)	Burst	Priority
P1	0	7	3
P2	3	3	2
P3	5	5	1
P4	6	2	4

5pts Round Robin with time quantum of 4 seconds

5pts Pre-emptive priority

6pts Pre-emptive Shortest job first

<u>CS 692   Capstone Exam   Algorithms   Spring 2021</u>: Choose any 2 of the 3 problems.

1) Given a (possibly empty) singly linked list of integers in nondecreasing order, write a function that creates another singly linked list that is a copy of the original list, but with all duplicate entries removed. This new list is to be in increasing order. Runtime must be linear.

2) Which of the following five statements correctly describes the relationship between the functions f and g defined in a)-d) below? Note that more than one of the five statements may be correct for each part. You do not need to explain your choices.

$f \in o(g)$ $f \in O(g)$ $f \in \theta(g)$ $g \in o(f)$ $g \in O(f)$

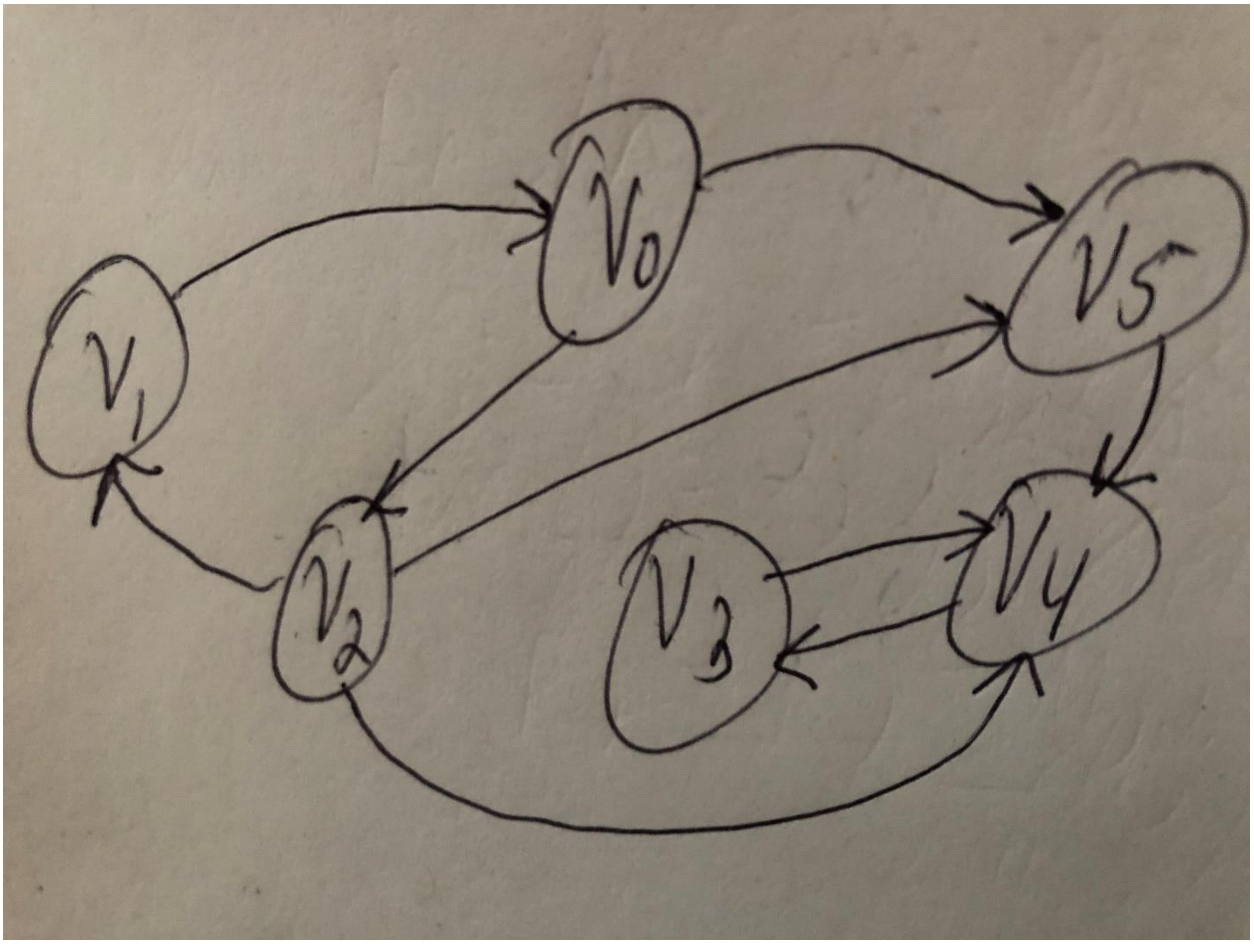
a) $f(n) = n!\,,\quad g(n) = (n+1)!$

b) $f(n) = n^2\,,\quad g(n) = n(log_2 n)^2 + 5$

c) $f(n) = 257n + 83\sqrt{n}\,,\quad g(n) = (log_2 n) + \frac{1}{6}n$

d) $f(n) = \begin{Bmatrix} n, & n \text{ odd} \\ n^2, & n \text{ even} \end{Bmatrix},\quad g(n) = \frac{1}{3}n^2$

3) Let G be a directed graph with vertices $v[0], \ldots, v[n\text{-}1]$ and m edges. The edges are stored using the adjacency matrix implementation.
a) Write an algorithm that prints the vertex number of each vertex that is a "grandchild" of $v[0]$. That is, print i if $v[0]$-$v[i]$ is not an edge of G, but there is a vertex u such that $v[0]$-u and u-$v[i]$ are both edges of G. Also, $v[0]$ is not considered to be its own grandchild. Your algorithm should only examine $v[0]$'s edges and the edges involving $v[0]$'s children. No vertex number should be printed more than once.
For any local data structure you use (such as stacks, queues, etc.), you may assume that the basic operations already exist (and so you don't need to write the code for pop, enqueue, etc.).
b) State in big-theta terms the worst case runtime of your routine as a function of n and/or m.
c) Suppose the graph had been given as adjacency lists. For this implementation, state in big-theta terms the worst case runtime of the routine as a function of n and/or m.
For the example on the following page, the grandchildren of v_0 are v_1 and v_4.


V0
V1
V2
V3
V4
V5

CS 692: Theory Exam
Spring 2021

Answer any **TWO** of the three problems listed below. If you attempt all three, only questions one and two will be graded. Please show all work.

Q1. Give context-free grammars generating the following languages over $\Sigma = \{0,1,2\}$ (10 points each).

a) $\{ 0^n 1^m 2^k \mid n, m, k \geq 0, \text{ and } n = m \text{ or } m = k \}$

b) $\{ 0^n 1^m 2^k \mid n, m, k \geq 0 \text{ and } n + m = k \}$

Q2. Consider $\Sigma = \{0,1\}$:

a. (5 points) State the Pumping Lemma for regular languages. Explain clearly and completely.

b. (15 points) Prove whether or not the following language is a regular language: $L = \{0^n 1^m \mid m < n\}$. If you choose to disprove, you need to apply the pumping lemma.

Q3. Answer the following questions. Please clearly explain each in detail and show all your work.

a) How do you prove, in general, that a Problem X is in NP? Please give the steps and explain (4 points).

b) Consider the problem Q defined below. Prove whether or not problem Q is in NP (10 points).

Problem Q:
INSTANCE: An undirected graph G(V,E) and a positive integer k.
QUESTION: Does graph G have a subset C of nodes such that |C| = k and there exists an edge in E between every pair of nodes in C?

c) How do you prove, in general, that a Problem Y is NP-complete? Please give the steps and explain (6 points).