SYSTEMS EXAM
Fall 2019
90 minutes

Check which problems you are submitting:

☐ #1
☐ #2
☐ #3

How many pages total? ________
Please do not write on the back of any pages.

__________________________________________
(print name)

__________________________________________
(signature)

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(NetId)
Problem #1

a) (4pts) List the four conditions of deadlock:

b) (16pts) Below is a semaphore solution for the producer/consumer problem. The buffer can hold n items. Semaphores are X, Y, and Z.

// The buffer is initialized to be empty and is processed as a first in first out queue

// PRODUCER CODE

while (true)
{
    1. getItem();
    2. wait(X);
    3. wait(Z);
    4. addItemToBuffer();
    5. signal(Z);
    6. signal(Y);
}

// CONSUMER CODE

while(true)
{
    1. wait(Y);
    2. wait(Z);
    3. readItemFromBuffer();
    4. signal(Z);
    5. signal(X);
    6. processItem();
}

There is a problem with each of the semaphore initializations below. Give a sequence of statements showing how an error might occur.

For instance, can the Producer and Consumer be in their critical sections at the same time? Will deadlock occur?
Please note, for full credit, you must list a sequence of statements that lead to an error. You will not get credit for guessing.

1) \( X = 0, Y = 0, Z = 1 \)
2) \( X = n, Y = 0, Z = 0 \)
3) \( X = n, Y = 0, Z = 2 \)
4) \( X = 0, Y = n, Z = 1 \)

Problem #2 Resource Allocation Banker’s algorithm

(3pts) What is meant by a “safe state?”

(14pts) Show a safe state process sequence for the following:

Resources: \( X, Y, Z \) where available is \( X = 12, Y = 6, Z = 7 \)

<table>
<thead>
<tr>
<th></th>
<th>Allocated</th>
<th>Max</th>
<th>Available</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>X Y Z</td>
<td>X Y Z</td>
<td>X Y Z</td>
</tr>
<tr>
<td>P0</td>
<td>4 1 1</td>
<td>7 3 2</td>
<td>0 1 1</td>
</tr>
<tr>
<td>P1</td>
<td>3 1 2</td>
<td>5 2 7</td>
<td></td>
</tr>
<tr>
<td>P2</td>
<td>2 2 3</td>
<td>2 2 4</td>
<td></td>
</tr>
<tr>
<td>P3</td>
<td>2 2 0</td>
<td>4 4 1</td>
<td></td>
</tr>
</tbody>
</table>

(3pts) If a request for \( P2 \) arrives for \( (3,2,4) \) can it be granted? Why or why not?
#3 Memory Management Paging

a) (4pts) Given a 3 level page table with a Translation Lookaside Buffer (TLB) hit ratio of 95%, What is the effective access time given that a TLB access is 75ns and a memory access time is 100ns?

b) (4pts) Assume a 32 bit logical address space and 3 level paging system. The first 12 bits are for the 1st level page table, the next 8 bits are for the 2nd level page table, the next 6 bits are for the 3rd level page table and remaining 6 are for the offset. How much virtual memory can be accessed?

c) (12pts) Which page replacement strategy will work best with the following page references assuming there are 4 page frames? FIFO or LRU. Work must be shown for credit. Please show your work.

Reference sequence 1 2 3 4 1 2 5 1 2 3 4 5