CS 692 Systems Capstone Exam, Fall 2023

Please read the following instructions before you start the exam. Please avoid asking a question that is addressed below:

1) You can write your answers on both sides of the paper. If you run out of space as you answer the questions on the front pages, continue your answer on the back of the page. Please do not ask the instructor whether you can write on the back side of the paper. The answer is YES YOU CAN.

2) You may use the last paper sheet (front and back) as scratch paper. It is also marked as scratch paper. Please note that the instructor will NOT grade the scratch paper. The scratch sheet stays with the instructor. Please do not detach it.

3) Do NOT detach the exam sheets. If at any point the papers got detached, raise your hand and request for them to be stapled immediately.

4) You are NOT allowed to use Calculator.

5) You are NOT allowed to have your cell phone, e-watch, or other electronic devices nearby (on the desk or inside your pocket). They should be turned off and stay inside your bag /backpack which will be placed in the back of the room.

6) Exam duration: 3:00 to 4:30 pm.

Choose two of the three questions. Please indicate the questions you have completed for grading below. If they are not indicated, we will assume that the first two questions that you attempted are to be graded.

□ Question #1
□ Question #2
□ Question #3

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Question 1) Parts a,b,c (20 points total)

1a. (5pts) What is the purpose of the "Banker's Algorithm?" Specifically, what does it mean for a system to be in a "safe" state? What does it mean for a system to be in an "unsafe" state?

1b. (10pts) Given the following Resources (A,B,C) with Quantity (10,5,7) for processes P0, P1, P2, P3, P4 and available (3, 3, 2), what is the state of the system? If there is a choice between two processes, the lower numbered process should be used. Please show your work for credit.

	Allocated	Max	Need
	A, B, C	A, B, C	
P0	0, 1, 0	7, 5, 3	
P1	2, 0, 0	3, 2, 2	
P2	3, 0, 2	9, 0, 2	
P3	2, 1, 1	2, 2, 2	
P4	0, 0, 2	4, 3, 3	

1c. (5pts) Show the Resource Allocation Graph (RAG) for the system described in 1b.

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Question 2 parts a,b (20 points total)

2.a (5pts) Which requirements must be satisfied for any solution to the critical section problem?

2.b (15pts) Does the code below satisfy these requirements? If a requirement is satisfied, explain why. If a requirement is not satisfied, explain why.

```
#define NUM_THREADS 2

bool flag[NUM_THREADS];
int turn;

void *process (void *id) {
  int i = *((int *) id);
  while (1) {
       flag[i] = true;
       turn = (i + 1) % NUM_THREADS;
       while (flag[(i + 1) % NUM_THREADS] && turn == (i + 1) % NUM_THREADS) ;
          // critical section
       printf("Thread %d in critical section\n", i);
       sleep(1);
       flag[i] = false;
       // non-critical section
  }
  return NULL;
}
int main() {
   pthread_t threads[NUM_THREADS];
   int thread_id[NUM_THREADS];
   for (int i = 0; i < NUM_THREADS; i++) {
       thread_id[i] = i;
       pthread_create(&threads[i], NULL, process, &thread_id[i]);
  }
  for (int i = 0; i < NUM_THREADS; i++) {
    pthread_join(threads[i], NULL);
  }
  return 0;
}
```

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Question 3 parts a,b,c (20 points total)

3a. (8pts) Given the following page requests (1, 2, 3, 4, 2, 5, 4, 6, 2, 5, 4, 7, 5, 4, 6) and a 4-frame page table, how many page faults will occur using the Least Recently Uses (LRU) algorithm? Please show your work for credit.

3b. (8pts) Given the same page requests as above (1, 2, 3, 4, 2, 5, 4, 6, 2, 5, 4, 7, 5, 4, 6) and a 4-frame page table, how many page faults will occur using the second chance (clock) algorithm? Please show your work for credit.

3c. (4pts) Which algorithm from a and b above has the fewest page faults? In terms of implementation, which algorithm is more complex to implement and why?

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Scratch Page- This page (front and back) will not be graded.

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