CS 692 — Systems | Capstone Exam (Fall 2025) | 3:00–4:30 pm

Full name: _____ **Net ID:** _____

Instructions (read before starting). Please avoid asking about items covered below.

1) You can write your answers on both sides of the paper. If you run out of space on the first page, continue your answer on the back of the page.

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 exam. Please do not detach it.

3) Do **NOT** detach the exam sheets. If at any point the papers get detached, raise your hand and request that they be stapled immediately.

4) You are **NOT** allowed to use a 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 front/back of the room.

6) Exam duration: 3:00–4:30 pm.

Choose two of the three questions. Please indicate *which two* you want graded (if not indicated, the first two attempted will be graded):

	Question #1	**Question #2**	**Question #3**
Select (check two):	☐	☐	☐

Full name: _____ **Net ID:** _____

1. (20 points) Suppose we have the following page accesses: 3 4 2 6 4 3 7 4 3 6 3 4 8 4 6 and that there are three frames within our system. (Detailed steps are required)

   (a) (10 points) Using the FIFO replacement algorithm, what is the number of page faults for the given reference string?

   (b) (10 points) Using the LRU replacement algorithm, what is the number of page faults for the given reference string?

Full name: _____ **Net ID:** _____

2. (20 points) Banker's Algorithm

	Allocation				**Max**				**Available**			
	A	B	C	D	A	B	C	D	A	B	C	D
P0	4	0	0	1	6	0	1	2				
P1	1	1	0	0	1	7	5	0				
P2	1	2	5	4	2	3	5	6				
P3	0	6	3	3	1	6	5	3				
P4	0	2	1	2	1	6	5	6	3	2	1	1

(a) (5 points) What is meant by a "safe state?"

(b) (7 points) Draw the Need Matrix

(c) (8 points) Is the system in safe state? If yes, show a safe state process sequence. If no, explain why.

Full name: _____ **Net ID:** _____

3. (20 points) Consider the following pseudo-code for the **Producer–Consumer problem** using semaphores mutex = 1, empty=N, full=0:

Listing 1: Producer

```
// Producer
while (true) {
    item = produce_item();
    wait(empty);
    wait(mutex);
    insert_item(item);
    signal(mutex);
    signal(full);
}
```

Listing 2: Consumer

```
// Consumer
while (true) {
    wait(full);
    wait(mutex);
    item = remove_item();
    signal(mutex);
    signal(empty);
    consume_item(item);
}
```

(a) (5 points) Explain how **mutual exclusion** is enforced in this solution.

(b) (7 points) Could **deadlock** occur in this system? Why or why not?

(c) (8 points) What would happen if the order of the `wait` operations in the producer were reversed (i.e., `wait(mutex)` before `wait(empty)`)?

Scratch Paper

This page (front and back) is for scratch work only. It will not be graded and should remain attached to the exam.