

# CSSE 332 -- OPERATING SYSTEMS

## Introduction to Mutual Exclusion

Name: \_\_\_\_\_

**Question 1.** (5 points) In your own words, describe the main problem leading the sample code in `simple_example.c` to produce incorrect results.

**Question 2.** Consider the following code snippet:

```
1 struct metadata {
2     unsigned int id, length;
3     int *array;
4 };
5
6 void *thread_function(void *arg) {
7     struct metadata *ptr = (struct metadata*)arg;
8     printf("Thread %d started, processing array of length %d...", ptr->id,
9           ptr->length);
10
11     // swap_max_with_last is a function defined elsewhere that finds the
12     // maximum element in an array and swaps it with the last element in that
13     // array (the last element is specified by the argument end below).
14     // The signature for this function is the following:
15     // void swap_max_with_last(int *array, int start, int end);
16     // where:
17     // array: An array of integer.
18     // start: The starting index to access the array from.
19     // end:   The ending index to access the array.
20     swap_max_with_last(ptr->array, 0, ptr->length - ptr->id + 1)
21
22     printf("Thread %d done.\n", ptr->id);
23     return 0;
24 }
25
26 int main(int argc, char **argv) {
27     int *array = malloc((2<<20) * sizeof(int));
28     struct metadata all_meta[TOTAL_THREADS];
29     pthread_t threads[TOTAL_THREADS];
30     int i;
31
32     // defined elsewhere
33     initialize_array(array);
34     for(i = 0; i < TOTAL_THREADS; i++) {
35         all_meta[i].id = i + 1;
36         all_meta[i].length = 2<<20;
37         all_meta[i].array = array;
38         pthread_create(&threads[i], NULL, thread_function, &all_meta[i]);
39     }
40
41     for(i = 0; i < TOTAL_THREADS; i++) {
42         pthread_join(threads[i], NULL);
43     }
44     exit(0);
45 }
```

(a) (5 points) What do you think this piece of code is attempting to do?

- (b) (10 points) In the code listing above, identify any critical sections and possible race conditions. Feel free to add your notes to the code listing itself.

- (c) (5 points) At the end of the main, what do you expect the contents of array to be?

**Question 3.** (5 points) In the space below, write down the main API functions used to create and use mutex lock in the pthreads library.

**Question 4.** (10 points) The code listing below contains a major bug, identify it and suggest a way to fix it.

```
1 void *thread1(void *ignored) {
2     // some code
3     pthread_mutex_lock(&lock);
4
5     // do some stuff
6
7     pthread_mutex_unlock(&lock);
8     return 0;
9 }
10
11 void *thread2(void *ignored) {
12     // some initialization code
13
14     pthread_mutex_unlock(&lock);
15     pthread_mutex_lock(&lock);
16
17     // do some stuff
18
19     pthread_mutex_unlock(&lock);
20     return 0;
21 }
```

**Question 5.** (10 points) Please write down two **sentences** describing two new things that you learned in this session.

**Question 6.** (10 points) Please write down two things that you are still not very clear about, or any questions that you might have that the session did not go over or did not cover well.