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Department of Computer Science

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Course	Operating system
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Lab No.	10 (After Mids.)

Lab No. 10 Operating system:

Counting Semaphores:

Task 1:

```
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>

sem_t parking_spaces;
void* car(void* arg) {
    int id = *(int*)arg;
    printf("Car %d is trying to park...\n", id);
    sem_wait(&parking_spaces); // Try to get a space
    printf("Car %d parked successfully!\n", id);
    sleep(2); // Stay parked for 2 seconds
    printf("Car %d is leaving.\n", id);
    sem_post(&parking_spaces); // Free the space
    return NULL;
}

int main() {
    pthread_t cars[10];
    int ids[10];
    // Initialize: 3 parking spaces available
    sem_init(&parking_spaces, 0, 3);
    // Create 10 cars (more than spaces!)
    for(int i = 0; i < 10; i++) {
        ids[i] = i + 1;
        pthread_create(&cars[i], NULL, car, &ids[i]);
    }
    // Wait for all cars
    for(int i = 0; i < 10; i++) {
        pthread_join(cars[i], NULL);
    }
    sem_destroy(&parking_spaces);
    return 0;
}
```

Output:

```
PROBLEMS    OUTPUT    DEBUG CONSOLE    TERMINAL    PORTS

● dawood@DESKTOP-V4SDVD9:~/Lab 10$ gcc Task1.c -o task1.out
● dawood@DESKTOP-V4SDVD9:~/Lab 10$ ./task1.out
Car 1 is trying to park...
Car 1 parked successfully!
Car 2 is trying to park...
Car 2 parked successfully!
Car 3 is trying to park...
Car 3 parked successfully!
Car 4 is trying to park...
Car 5 is trying to park...
Car 6 is trying to park...
Car 7 is trying to park...
Car 8 is trying to park...
Car 9 is trying to park...
Car 10 is trying to park...
Car 1 is leaving.
Car 2 is leaving.
Car 4 parked successfully!
Car 5 parked successfully!
Car 3 is leaving.
Car 6 parked successfully!
Car 4 is leaving.
Car 5 is leaving.
Car 7 parked successfully!
Car 8 parked successfully!
Car 6 is leaving.
Car 9 parked successfully!
Car 8 is leaving.
Car 9 is leaving.
Car 10 parked successfully!
Car 7 is leaving.
Car 10 is leaving.
dawood@DESKTOP-V4SDVD9:~/Lab 10$
```

Task 2:

```
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>

#define BUFFER_SIZE 5
int buffer[BUFFER_SIZE];
int in = 0; // Producer index
int out = 0; // Consumer index
sem_t empty; // Counts empty slots
sem_t full; // Counts full slots
pthread_mutex_t mutex;

void* producer(void* arg) {
    int id = *(int*)arg;
    for(int i = 0; i < 3; i++) { // Each producer makes 3 items
        int item = id * 100 + i; // 6 max values

        // TODO: Wait for empty slot
        sem_wait(&empty);
        // TODO: Lock the buffer
        pthread_mutex_lock(&mutex);
        // Add item to buffer
        buffer[in] = item;
        printf("Producer %d produced item %d at position %d\n",
               id, item, in);
        in = (in + 1) % BUFFER_SIZE;
        // TODO: Unlock the buffer
        pthread_mutex_unlock(&mutex);
        // TODO: Signal that buffer has a full slot
        sem_post(&full);
        sleep(1);
    }
    return NULL;
}
void* consumer(void* arg) {
    int id = *(int*)arg;
    for(int i = 0; i < 3; i++) {

        // TODO: Students complete this similar to producer
        sem_wait(&full);
```

```
pthread_mutex_lock(&mutex);
int item = buffer[out];
printf("Consumer %d consumed item %d from position %d\n",
id, item, out);
out = (out + 1) % BUFFER_SIZE;
pthread_mutex_unlock(&mutex);
sem_post(&empty);
sleep(2); // Consumers are slower
}
return NULL;
}
int main() {
    pthread_t prod[2], cons[2];
int ids[2] = {1, 2};
// Initialize semaphores
sem_init(&empty, 0, BUFFER_SIZE); // All slots empty initially
sem_init(&full, 0, 0); // No slots full initially
pthread_mutex_init(&mutex, NULL);
// Create producers and consumers
for(int i = 0; i < 2; i++) {
pthread_create(&prod[i], NULL, producer, &ids[i]);
pthread_create(&cons[i], NULL, consumer, &ids[i]);
}
// Wait for completion
for(int i = 0; i < 2; i++) {
pthread_join(prod[i], NULL);
pthread_join(cons[i], NULL);
}
// Cleanup
sem_destroy(&empty);
sem_destroy(&full);
pthread_mutex_destroy(&mutex);
return 0;
}
```

Output:

The screenshot shows a terminal window with the following content:

```
C Task1.c C Task2.c X
C Task2.c
48     out = (out + 1) % BUFFER_SIZE;
49     pthread_mutex_unlock(&mutex);
50     sem_post(&empty);
51     sleep(2); // Consumers are slower
52 }
53 return NULL;
54 }
55 int main() {
PROBLEMS OUTPUT DEBUG CONSOLE TERMINAL PORTS

● dawood@DESKTOP-V4SDVD9:~/Lab 10$ gcc Task2.c -o task2.out
● dawood@DESKTOP-V4SDVD9:~/Lab 10$ ./task2.out
Producer 1 produced item 100 at position 0
Producer 2 produced item 200 at position 1
Consumer 1 consumed item 100 from position 0
Consumer 2 consumed item 200 from position 1
Producer 2 produced item 201 at position 2
Producer 1 produced item 101 at position 3
Consumer 1 consumed item 201 from position 2
Consumer 2 consumed item 101 from position 3
Producer 2 produced item 202 at position 4
Producer 1 produced item 102 at position 0
Consumer 1 consumed item 202 from position 4
Consumer 2 consumed item 102 from position 0
dawood@DESKTOP-V4SDVD9:~/Lab 10$
```

Remarks:

In this code there are two Semaphores Empty and Full

- Empty Values has been initialized with buffer size which is 5
- While Full Values has been initialized with 0

So now, When the Producer will run, it will create 3 items [i], Then it will wait for empty slots, then it will lock buffer

Perform its task – that is critical section, after that it will unlock buffer, then it will increment the count of full slots by **Sem_post(&Full)**

Similarly, In Consumer, each consumer will create 4 items, then wait for the full slot and it will lock buffer then

After performing task or critical section it will unlock the buffer and after consuming it will increment empty slots by **Sem_post (&empty slots)**

Line **int item = id * 100 + i;** will make **6 Possible Values:**

$$\begin{aligned} \text{int item} &= \text{id} * 100 + [i] \\ 1 \times 100 + 0 &= 100 \\ 1 \times 100 + 1 &= 101 \\ 1 \times 100 + 2 &= 102 \\ 2 \times 100 + 0 &= 200 \\ 2 \times 100 + 1 &= 201 \\ 2 \times 100 + 2 &= 202 \end{aligned}$$

Each Has 5 Main Steps

Consumer

- sem_wait (&full) //decrement by 1
- mutex_lock()
- Critical Section
- mutex_unlock
- sem_post (&empty). //increment by 1
reserve the place.

Producer

- Sem_wait (&empty)
- mutex_lock()
- Critical section // work/condition
whatever will execute.
- mutex_unlock
- sem_post (&full).