Department of Computer Science

Subject:

OPERATING SYSTEM

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ASSIGNMENT:

AFTERMID(H.W)

Semester:

5^{TH}

<u>Part 1: Semaphore theory</u>

1. A counting semaphore is initialized to 7. If 10 wait() and 4 signal() operations are performed, find the final value of the semaphore.

Initial value = 7

- 10 wait() → 7 − 10 = **−3**
- 4 signal() → −3 + 4 = **1**
- Semaphore value is 1

2. A semaphore starts with value 3. If 5 wait() and 6 signal() operations occur, calculate the resulting semaphore value.

Initial value = 3

- 5 wait() → 3 − 5 = **−2**
- 6 signal() → −2 + 6 = **4**
- Final semaphore value **= 4**

3. A semaphore is initialized to 0. If 8 signal() followed by 3 wait() operations are executed, find the final value.

Initial value = 0

- 8 signal() → 0 + 8 = **8**
- 3 wait() → 8 − 3 = **5**
- Final semaphore value **= 5**

4. A semaphore is initialized to 2. If 5 wait() operations are executed:

Initial value = 2

5 wait() operations

a) How many processes enter the critical section?

Only **2** processes can enter (value becomes 0)

b) How many processes are blocked?

Remaining waits = 5 − 2 = **3 blocked**

Answer:

- Enter CS = **2**
- Blocked = **3**

5. A semaphore starts at 1. If 3 wait() and 1 signal() operations are performed:

Initial value = 1

- 3 wait() → 1 − 3 = **−2**
- 1 signal() → −2 + 1 = **−1**

a) Processes blocked

Semaphore −1 → **1 process blocked**

b) Final value

Final semaphore value = −1

6.

semaphore S = 3;

wait
(S)=
1
sign
al(S)
=2
wait
(S)=
1
wait
(S)=
0

a) How many processes enter the critical section?

- Semaphore never goes negative → **5 processes enter** **B) What**

is the final value of S?

- S=0

7.

semaphore S = 1;

S = 1
wait(S) → 0 wait(S) → -1
(blocked) signal(S) → 0
(one wakes) signal(S) →
1

a) **How many processes are blocked?**
Only one

b) **What is the final value of S?**
One (s=1)

8.
A binary semaphore is initialized to 1. Five wait() operations are executed without any signal(). How many processes enter the critical section and how many are blocked?

Binary semaphore = 1

- 5 wait() without signal
- 1 process enters CS
- Remaining 4 are blocked

Answer:

- Enter CS = **1**
- Blocked = **4**

9.A counting semaphore is initialized to 4. If 6 processes execute wait() simultaneously, how many proceed and how many are blocked?

Initial value = 4

- 6 wait() simultaneously
- 4 proceed
- 6 − 4 = **2 blocked**

Answer:

- Proceed = **4**
- Blocked = **2**

10.A semaphore S is initialized to 2.

a) **Track the semaphore value after each operation.**

- wait(S)=1
- wait(S)=0
- wait(S)=-1 (blocked)
- signal(S)=0
- signal(S)=1 wait(S)=0

b) **How many processes were blocked at any time?**

One process was blocked

11. A semaphore is initialized to 0. Three processes execute wait() before any signal(). Later, 5 signal() operations are executed.

Initial value = 0

3 processes wait() → **3 blocked**
5 signal() operations

a) How many processes wake up?
3 processes wake up
b) What is the final semaphore value? Semaphore value=2

Part 2: Semaphore coding

Consider the Producer–Consumer problem using semaphores as implemented in Lab-10 (Lab-plan attached). Rewrite the program in your own coding style, compile and execute it successfully, and explain the working of the code in your own words.

Submission Requirements:

- **Your rewritten source code**
- **A brief description of how the code works**
- **Screenshots of the program output showing successful execution.**

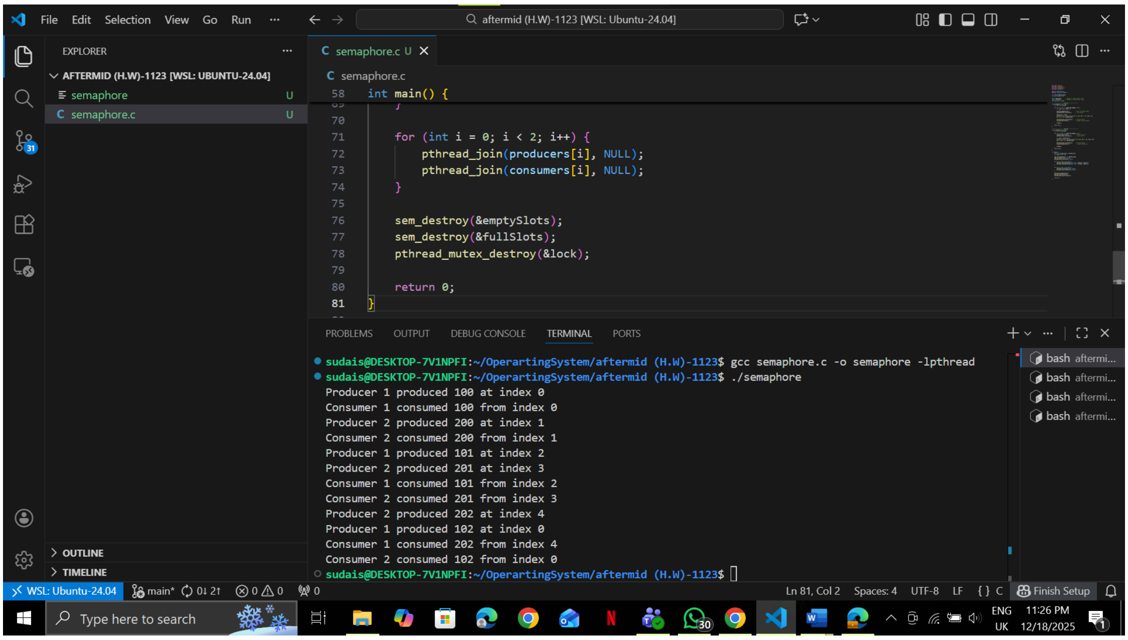
Code:

```
    #include <stdio.h>

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

```c
#define BUFFER_SIZE 5
#define ITEMS_PER_THREAD 3

int buffer[BUFFER_SIZE];
int in = 0, out = 0;

sem_t emptySlots;      // Number of empty buffer slots
sem_t fullSlots;       // Number of filled buffer slots
pthread_mutex_t lock;

// ---------------- PRODUCER ----------------
void* producer(void* arg) {
    int id = *(int*)arg;

    for (int i = 0; i < ITEMS_PER_THREAD; i++) {
        int item = id * 100 + i;

        sem_wait(&emptySlots);           // Wait for empty space
        pthread_mutex_lock(&lock);       // Lock buffer

        buffer[in] = item;
        printf("Producer %d produced %d at index %d\n", id, item, in);
        in = (in + 1) % BUFFER_SIZE;

        pthread_mutex_unlock(&lock);     // Unlock buffer
        sem_post(&fullSlots);            // Signal item available

        sleep(1);
    }
    return NULL;
}

// ---------------- CONSUMER ----------------
void* consumer(void* arg) {
    int id = *(int*)arg;

    for (int i = 0; i < ITEMS_PER_THREAD; i++) {
        sem_wait(&fullSlots);             // Wait for item
        pthread_mutex_lock(&lock);        // Lock buffer

        int item = buffer[out];
        printf("Consumer %d consumed %d from index %d\n", id, item,
out);
        out = (out + 1) % BUFFER_SIZE;

        pthread_mutex_unlock(&lock);      // Unlock buffer
        sem_post(&emptySlots);            // Signal empty slot
```

```
        sleep(2);
    }
    return NULL;
}

int main() {
    pthread_t producers[2], consumers[2];
    int ids[2] = {1, 2};

    sem_init(&emptySlots, 0, BUFFER_SIZE);
    sem_init(&fullSlots, 0, 0);
    pthread_mutex_init(&lock, NULL);

    for (int i = 0; i < 2; i++) {
        pthread_create(&producers[i], NULL, producer, &ids[i]);
        pthread_create(&consumers[i], NULL, consumer, &ids[i]);
    }

    for (int i = 0; i < 2; i++) {
        pthread_join(producers[i], NULL);
        pthread_join(consumers[i], NULL);
    }

    sem_destroy(&emptySlots);
    sem_destroy(&fullSlots);
    pthread_mutex_destroy(&lock);

    return 0;
}
```

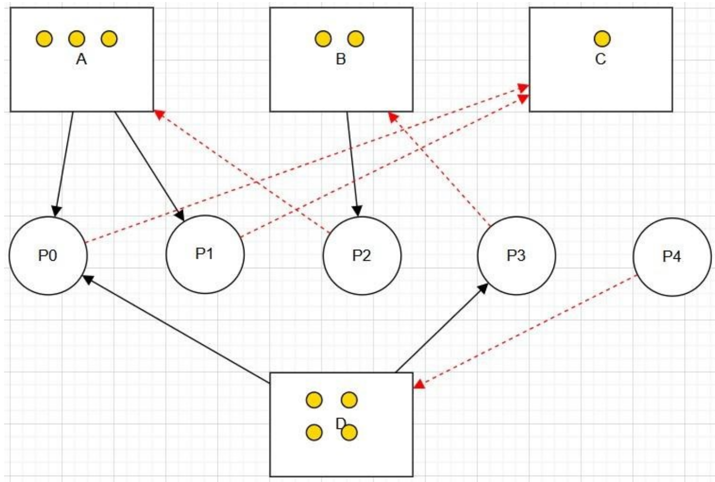
Output:



Remarks:

This program correctly implements the Producer–Consumer problem using semaphores and a mutex.It ensures proper synchronization, prevents race conditions, and safely manages shared buffer access between multiple threads.

Part 3: RAG (Recourse Allocation Graph)



a) Allocation matrix

Process	A	B	C	D
P0	1	0	0	1
P1	1	0	0	0
P2	0	1	0	0

P3	0	0	1	1
P4	0	0	0	0

b) Request matrix

Process	A	B	C	D
P0	0	0	0	0
P1	1	0	1	0
P2	1	0	1	0
P3	0	1	0	0
P4	0	0	0	1

Part 4: Banker's Algorithm

System Description:

- **The system comprises five processes (P0–P3) and four resources (A,B,C,D).**

Total Existing Resources:

Total			
A	B	C	D
6	4	4	2

- **Snapshot at the initial time stage:**

	Allocation				Max				Need			
	A	B	C	D	A	B	C	D	A	B	C	D
P0	2	0	1	1	3	2	1	1				
P1	1	1	0	0	1	2	0	2				
P2	1	0	1	0	3	2	1	0				
P3	0	1	0	1	2	1	0	1				

Questions:

1. Compute the Available Vector:

• Calculate the available resources for each type of resource.

Total resources:

A=0,B=4,C=4,D=2

a) Available matrix

Total allocated:

- A: 2 + 1 + 1 + 0 = 4
- B: 0 + 1 + 0 + 1 = 2
- C: 1 + 0 + 1 + 0 = 2
- D: 1 + 0 + 0 + 1 = 2

Total - total allocated

- A: 6 - 4 = 2
- B: 4 - 2 = 2
- C: 4 - 2 = 2
- D: 2 - 2 = 0

Available Vector: [2,2,2,0]

2. Compute the Need Matrix:

• Determine the need matrix by subtracting the allocation matrix from the maximum matrix.

The Need Matrix is calculated using the formula: Need = Max - Allocation.

Process	Max (A B C D)	Allocation (A B C D)	Need (A B C D)
P0	3 2 1 1	2 0 1 1	1 2 0 0
P1	1 2 0 2	1 1 0 0	0 1 0 2
P2	3 2 1 0	1 0 1 0	2 2 0 0

Step	Process	Need	Available (Work)	Can it run?	New Available (Work + Allocation)
1	P0	[1, 2, 0, 0]	[2, 2, 2, 0]	Yes	[2,2,2,0] + [2,0,1,1]={[4, 2, 3, 1]}
2	P2	[2, 2, 0, 0]	[4, 2, 3, 1]	Yes	[4,2,3,1] + [1,0,1,0]={[5, 2, 4, 1]}
3	P3	[2, 0, 0, 0]	[5, 2, 4, 1]	Yes	[5,2,4,1] + [0,1,0,1]={[5, 3, 4, 2]}
4	P1	[0, 1, 0, 2]	[5, 3, 4, 2]	Yes	[5,3,4,2] + [1,1,0,0] ={[6, 4, 4, 2]}

P3	2 1 0 1	0 1 0 1	2 0 0 0

3. Safety Check:

- **Determine if the current allocation state is safe. If so, provide a safe sequence of the processes.**
- **Show how the Available (working array) changes as each process terminates.**

To determine if the state is safe, we find a sequence where each process's Need <= Available.
Once a process finishes, it releases its Allocation back to the Available pool.
Yes. Safe Sequence: {P0, P2, P3, P1}