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1. Consider a system that has 2 processes, Process1 and Process 2, and 2 classes of resources R1 and R2. The total number of resource units in these classes are 4 and 5 respectively. At time t0 the system has following state:

| | **Allocated Resources** | | **Maximum Required** | |
|---|---|---|---|---|
| | R1 | R2 | R1 | R2 |
| **Process1** | 1 | 3 | 2 | 5 |
| **Process2** | 2 | 1 | 3 | 2 |

Find out if the request could be immediately granted or not for the following independent requests separately. Show all the necessary steps and calculations for i), ii) and iii).

i) Process P2 requests (1,1) (2Marks)

ii) Process P1 requests (0,1) (1.5Marks)

iii) Process P1 requests (1,0) (1.5Marks)

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2. Suppose there are five processes P1, P2, P3, P4 and P5 that need to access a shared resource R. The access policy for R is as follows: P1 and P2 can access R concurrently, but no other process can access R when they are accessing it. P3, P4 and P5 can access R concurrently, but no other process can access R when they are accessing it. Design a solution using semaphores to implement this policy. Explain the logic behind your solution and write the pseudocode for each process.

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3. A system has 4 processes and 5 allocatable resource. The current allocation and maximum needs are as follows-

| Process | **Allocated** | | | | | **Maximum** | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| **A** | 1 | 0 | 2 | 1 | 1 | 1 | 1 | 2 | 1 | 3 |
| **B** | 2 | 0 | 1 | 1 | 0 | 2 | 2 | 2 | 1 | 0 |
| **C** | 1 | 1 | 0 | 1 | 1 | 2 | 1 | 3 | 1 | 1 |
| **D** | 1 | 1 | 1 | 1 | 0 | 1 | 1 | 2 | 2 | 0 |

If Available = [ 0 0 X 1 1 ], what is the smallest value of x for which this is a safe state?

4A. Consider the methods used by processes P1 and P2 for accessing their critical sections whenever needed, as given below. The initial values of shared boolean variables S1 and S2 are randomly assigned.

| **Method Used by P1** | **Method Used by P2** |
|---|---|
| while (S1 == S2) ;<br>Critica1 Section<br>S1 = S2; | while (S1 != S2) ;<br>Critica1 Section<br>S2 = not (S1); |

Which one of the following statements describes the properties achieved? Justify your answer. (3M)

(A) Mutual exclusion but not progress

(B) Progress but not mutual exclusion

(C) Neither mutual exclusion nor progress

(D) Both mutual exclusion and progress

4B. A counting semaphore was initialized to 7. Then 20 wait() operations and X signal() operations were completed on this semaphore. If the final value of semaphore is 5, then find the value of X?(2 M)

5. Consider the two functions incr and decr shown below.

```
incr(){                 decr(){
    wait(s);                wait(s);
    X = X+1;                X = X-1;
    signal(s);              signal(s);
}                       }
```

There are 5 threads each invoking incr once, and 3 threads each invoking decr once, on the same shared variable X. The initial value of X is 10, and s is a binary semaphore initialized to 1. What is the value of X, after the end of execution of all threads.

6. Consider the following threads, T1, T2, and T3 executing on a single processor, synchronized using three binary semaphore variables, S1, S2, and S3, operated upon using standard wait() and signal(). The threads can be context switched in any order and at any time.

| $T_1$ | $T_2$ | $T_3$ |
|---|---|---|
| while(true){<br>wait($S_3$);<br>print("C");<br>signal($S_2$); } | while(true){<br>wait($S_1$);<br>print("B");<br>signal($S_3$); } | while(true){<br>wait($S_2$);<br>print("A");<br>signal($S_1$); } |

Which initialization of the semaphores would print the sequence BCABCABCA....?

Pseudocode for wait and signal – 2marks

Working for each thread – 1 mark

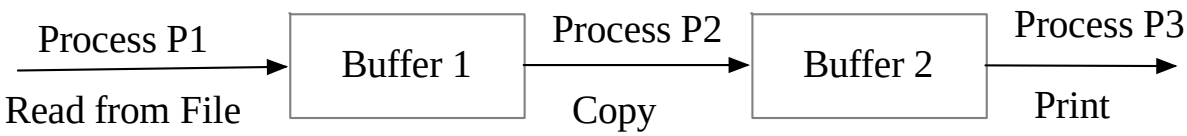
Semaphore values- 2 marks

7. Suppose there are four processes P0, P1, P2, P3 and P4 that need to access FOUR types of resources A, B C and D. The following table shows the current allocation, maximum demand and available resources for each process.

| **Process** | **Allocation** | **Maximum** | **Available** |
|---|---|---|---|
| | A B C D | A B C D | A B C D |
| P0 | 2 0 0 1 | 4 2 1 2 | 3 3 2 1 |
| P1 | 3 1 2 1 | 5 2 5 2 | |
| P2 | 2 1 0 3 | 2 3 1 6 | |
| P3 | 1 3 1 2 | 1 4 2 4 | |
| P4 | 1 4 3 2 | 3 6 6 5 | |

Using the Banker's Algorithm, determine if the system is in a safe state or not. If yes, show a safe sequence of processes. If no, explain why the system is unsafe.

8. Consider three processes (P1, P2, and P3) that are involved in printing a file (as shown below). Process P1 reads the data from the disc into Buffer 1, then Process P2 copies the data from Buffer 1 to Buffer 2, and finally Process P3 prints the data from Buffer 2. Assume all three processes operate on one file at a time, and buffers 1 and 2 have a capacity of 1 file/record. Design/propose a solution that uses semaphores to coordinate the three processes. To represent the operations executed in the crucial region, use the proper comment lines.



9. Consider the following snapshot of the resource allocation. Check whether the system is in safe state. If so, obtain the safe sequence by tracing safety algorithm and show the steps. Now, check whether the following requests are granted if P0 requests (0,1,1) and P4 requests an instance of Z. Justify your answer.

Number of instances of each resource type x=10, y=7,z=11.

| **Process** | **Allocation** | | | **Max Need** | | |
|---|---|---|---|---|---|---|
| | **X** | **Y** | **Z** | **X** | **Y** | **Z** |
| P0 | 3 | 1 | 3 | 3 | 2 | 4 |
| P1 | 2 | 1 | 3 | 3 | 2 | 4 |
| P2 | 1 | 1 | 3 | 2 | 2 | 3 |
| P3 | 2 | 2 | 1 | 2 | 2 | 1 |
| P4 | 1 | 1 | 1 | 1 | 1 | 2 |

10A) Consider the following code snippets that use a shared binary semaphore T. T is set to 0 before either process begins execution and X is set to 5. Write how many different values of X are possible after both processes finish executing and the final value of X. Write the sequence of execution of Process A and Process B. (2M)

10B) Does this snippet fulfill any criteria that solves critical section problem? Justify your answer (3M)

| **Process A** | **Process B** |
|---|---|
| int Y; | int Z; |
| A1: Y = X*2; | B1: wait(T); |
| A2: X = Y; | B2: Z = X+1; |
| signal(T); | X=Z; |