

5. [C01] 1.a) Answer the following question: **[3 Marks]**

3 points

In a busy computer lab during finals week at a university, many students need access to a limited number of computers for their assignments and exams. To ensure fair and efficient resource allocation, which concept of operating system can be employed to address the issue? Explain how this method can solve the problem and mention the benefits it offers.

6. [C01] 1.b) Answer the following question: **[2 Marks]**

2 points

What specific problem(s) of the monolithic structure were addressed through the adoption of a layered structure, and how were they resolved?

7. [C01] 1.c) Find the output of the following code snippet. You need to type the answer in this form (as a response to this question) and show your working / tracing on paper. **Your output should exactly match with the original output. [3 Marks]** 3 points

```
int main(){|
    int a=9;
    int b=3;
    i=fork();
    if(i<0){
        printf("fork failed\n");
    }
    else if(i==0){
        j=fork();
        if(j<0){
            printf("fork failed\n");
        }
        else if(j==0){
            a=a*b;
            b=a/b;
        }
        else{
            wait();
            a=a+b;
            b=b-a;
        }
    }
    else{
        wait();
        a=a-b;
        b=b+a;
    }
    printf("value of a: %d\n",a);
    printf("value of b: %d\n",b);

    return 0;
}
```

8. [C01] 1.d) Answer the following question: **[3 Marks]**

3 points

In a Google Classroom, there are two types of users: teachers and students. Teachers create assignments with instructions and attached problem files, resulting in assignment slots in the classroom. Each slot contains instructions, the attached file, and individual placeholders for students to submit their assignments. Students can access instructions and problems from the attached files within these slots. When students submit assignments, they use designated placeholders within the assignment slots. Teachers review student assignments by accessing the files from these placeholders.

Logically explain what type of communication method was used in the above given scenario.

9. [C02] 2.a) Type the average waiting time and turnaround time in this form (as a response to this question) and show your calculation on paper : **[5 Marks]** 5 points

Draw a Gantt chart and illustrate the execution of the process using the **Round Robin** scheduling algorithm (**time quantum = 5 units**). **Calculate** the **average waiting** and **turnaround time**.

Process ID	Burst Time	Arrival Time	Priority
P1	5	2	1
P2	6	6	5
P3	13	6	4
P4	15	10	222222
P5	9	12	3

10. [C02] 2.b) Answer the following question: **[2 Marks]** 2 points

Due to a calculation error, P4 has received an abnormally high priority value compared to other processes. Describe the problem this situation might cause by providing a scenario illustrating the issue, and suggest how to address it.

11. [CO3] 3.a) Type the answer in this form (as a response to this question) and show your calculation on paper : **[3 Marks]** 3 points

A system has processes to execute of which are 86% parallel. The number of cores currently available is 2. Calculate the number of cores required in order to increase the speedup approximately 2 times.

12. [CO3] 3.b) Answer the following question: **[2 Marks]** 2 points

Imagine you have a text editor that is running on multiple threads and has a python code execution feature. To achieve the code execution, the editor creates a child process and loads the python interpreter as a separate program. In this scenario, should the child process be a single-threaded or multi-threaded program? State your reasons.

13. [CO3] 3.c) Answer the following question: **[2 Marks]** 2 points

Suppose an organization has a million employees. They preserve both HR management data including their demographic data. At an annual meeting on 31st December the CEO of the company wanted to pay a 20% bonus to employees whose age is more than 50 and achieved 90% KPI on 1st January. As the time is limited the data analyst used many nodes to make the search and generate the result. **Identify** which parallelism technique can be applicable here?

5. [C01] 1.a) Answer the following question: **[3 Marks]**

3 points

A call center for a telecommunications company handles a constant flow of customer calls and inquiries. Due to a limited number of service providers, most of the calls are dropped unanswered. To solve this problem they implemented a waiting lobby when all the lines are busy. Customers can wait till someone from the company picks up their call. Which concept of the Operating system has been employed in this scenario? Explain how it works in the context of the operating system.

6. [C01] 1.b) Answer the following question: **[2 Marks]**

2 points

What specific problem(s) of the layered structure were addressed through the adoption of a microkernel structure, and how were they resolved?

7. [C01] 1.c) Find the output of the following code snippet. You need to type the answer in this form (as a response to this question) and show your working / tracing on paper. **Your output should exactly match with the original output. [3 Marks]** 3 points

```
int main(){
    int x=15;
    int y=5;
    i=fork();
    if(i<0){
        printf("fork failed\n");
    }
    else if(i==0){
        x=y-x;
        y=x+y;
    }
    else{
        wait();
        j=fork();
        if(j<0){
            printf("fork failed\n");
        }
        else if(j==0){
            x=x/y;
            y=x*y;
        }
        else{
            wait();
            x=x-y;
            y=x+y;
        }
    }
    printf("value of x: %d\n",x);
    printf("value of y: %d\n",y);

    return 0;
}
```

8. [C01] 1.d) Answer the following question: **[3 Marks]**

3 points

In a Google Classroom, there are two types of users: teachers and students. Teachers create assignments with instructions and attached problem files, resulting in assignment slots in the classroom. Each slot contains instructions, the attached file, and individual placeholders for students to submit their assignments. Students can read instructions and problems from the attached file from that particular assignment slot. When a teacher creates an assignment, notification gets distributed to every teacher and student of the classroom. If a student submits an assignment every teacher of the classroom gets acknowledgement by a notification.

Logically explain what type of communication method was used in the above given scenario.

9. [CO2] 2.a) Type the average waiting time and turnaround time in this form (as a response to this question) and show your calculation on paper : **[5 Marks]** 5 points

Draw a Gantt chart and illustrate the execution of the process using the **Round Robin** scheduling algorithm (**time quantum = 6 units**). **Calculate** the **average waiting** and **turnaround time**.

Process ID	Burst Time	Arrival Time	Priority
P1	9	5	1
P2	13	6	5
P3	7	11	4
P4	11	9	222222
P5	11	17	3

10. [CO2] 2.b) Answer the following question: **[2 Marks]** 2 points

Due to a calculation error, P4 has received an abnormally high priority value compared to other processes. Describe the problem this situation might cause by providing a scenario illustrating the issue, and suggest how to address it.

11. [CO3] 3.a) Type the answer in this form (as a response to this question) and show your calculation on paper : **[3 Marks]** 3 points

A system has processes to execute of which are 82% parallel. The number of cores currently available is 3. Calculate the number of cores required in order to increase the speedup approximately 1.5 times.

12. [CO3] 3.b) Answer the following question: **[2 Marks]** 2 points

Imagine you have a text editor that is running on multiple threads and has a python code execution feature. To achieve the code execution, the editor creates a child process and loads the python interpreter as a separate program. In this scenario, should the child process be a single-threaded or multi-threaded program? State your reasons.

13. [CO3] 3.c) Answer the following question: **[2 Marks]** 2 points

In a University, students, department, admin everyone share the same data structure. Students use it for registering their course, the admin office approves the course and the account department confirms their registration, and the department assigns a faculty for coordinating everything about the student. **Identify** which parallelism technique can be applicable here?

5. [C01] 1.a) Answer the following question: **[3 Marks]**

3 points

John, a college student, received a designing task on a project management software. To complete it, he used the windows operating system to open adobe illustrator. While he was reading the requirements from a microsoft doc, he received a prompt from an antivirus software. - Identify different types of softwares used by the user in this scenario and mention a few differences between them.

6. [C01] 1.b) Answer the following question: **[2 Marks]**

2 points

What specific problem(s) of the monolithic structure were addressed through the adoption of a microkernel structure, and how were they resolved?

7. [C01] 1.c) Find the output of the following code snippet. You need to type the answer in this form (as a response to this question) and show your working / tracing on paper. **Your output should exactly match with the original output. [3 Marks]** 3 points

```
int main(){
    int p=8;
    int q=4;
    i=fork();
    if(i<0){
        printf("fork failed\n");
    }
    else if(i==0){
        p=p+q;
        q=p-q;
    }
    else{
        wait();
        j=fork();
        if(j<0){
            printf("fork failed\n");
        }
        else if(j==0){
            q=p*q;
            p=q/p;
        }
        else{
            wait();
            p=q-p;
            q=p+q;
        }
    }
    printf("value of p: %d\n",p);
    printf("value of q: %d\n",q);

    return 0;
}
```

8. [C01] 1.d) Answer the following question: **[3 Marks]**

3 points

In a significant research initiative addressing climate change, two pivotal groups play key roles: dedicated researchers who meticulously gather data from diverse sources, and skilled analysts responsible for employing advanced statistical models to derive actionable insights from this extensive dataset. To facilitate their collaboration, they have devised an effective approach for fluidly exchanging data and analysis instructions, thus enabling multiple analysts to work concurrently on this critical project.

Logically explain what type of communication method was used in the above given scenario.

9. [CO2] 2.a) Type the average waiting time and turnaround time in this form (as a response to this question) and show your calculation on paper : **[5 Marks]** 5 points

Draw a Gantt chart and illustrate the execution of the process using the **Round Robin** scheduling algorithm (**time quantum = 5 units**). Calculate the **average waiting** and **turnaround time**.

Process ID	Burst Time	Arrival Time	Priority
P1	11	5	1
P2	10	3	5
P3	5	9	4
P4	14	11	222222
P5	6	15	3

10. [CO2] 2.b) Answer the following question: **[2 Marks]** 2 points

Due to a calculation error, P4 has received an abnormally high priority value compared to other processes. Describe the problem this situation might cause by providing a scenario illustrating the issue, and suggest how to address it.

11. [CO3] 3.a) Type the answer in this form (as a response to this question) and show your calculation on paper : **[3 Marks]** 3 points

A system has processes to execute of which are 92% parallel. The number of cores currently available is 3. Calculate the number of cores required in order to increase the speedup approximately 2.25 times.

12. [CO3] 3.b) Answer the following question: **[2 Marks]** 2 points

Imagine you have a text editor that is running on multiple threads and has a python code execution feature. To achieve the code execution, the editor creates a child process and loads the python interpreter as a separate program. In this scenario, should the child process be a single-threaded or multi-threaded program? State your reasons.

13. [CO3] 3.c) Answer the following question: **[2 Marks]** 2 points

In a manufacturing facility, raw materials are received and undergo multiple processes, including quality control, production, and packaging. All these processes rely on a shared database to track inventory and production progress. **Identify** which parallelism technique can be applicable here?

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Department of Computer Science and Engineering
Final Examination Fall 2023
CSE 321: Operating Systems



Duration: 1 Hour 45 Minutes

Total Marks: 40

Answer the following questions.
Figures in the right margin indicate marks.

1. **CO4** a) A super shop has launched year-end sales on all their products. To avail the offer so many customers went there and purchased products as per their preferences. The issue occurred when they started the procedure of bill payment. There are 3 counters for paying bills but the number of customers waiting for completing payment is 50. [3]
- Explain** with proper logic, what issue has been raised in the above scenario and what will be the approach to provide proper synchronization to the issue according to the problem statement.
- b) For the upcoming PMCO finals team “xyz” has arranged training sessions for players. In a training session a player needs to use a set of headphones and a mobile device together. The team can only facilitate a set of headphones and a mobile device to players for training. In a particular session 1 hour left for 2 players Alex and Zyll. Each will get a 30 mins slot. But somehow Alex has captured the device and Zyll has captured headphones at the same time and that is why nobody is able to make any progress in the training session. [2]
- Logically explain** what issue has occurred in the above scenario
- c) In a system, following conditions are present.
- There are 3 processes: P1, P2 and P3.
 - There is a semaphore, $s=2$.
 - Ready queue is in the following order, [P1, P2, P3].
 - CPU allocation is managed by round robin scheduling algorithm with the time quantum of 6 ms.
 - Each statement takes 2 ms to execute.
 - Critical section contains 3 statements.
 - Remainder section contains 2 statements.

The structure of process P_i in solution using Semaphore:

<pre>wait(s){ while(s<=0) ;//busy wait s--; } signal(s){ s++; }</pre>	<pre>do{ wait(s); //critical section signal(s); //remainder section }while(true);</pre>
---	---

Complete the table given below for processes P1, P2 and P3 using semaphore.

[5]

Process 1	Process 2	Process 3



2. a) We have various ways to overcome deadlock in a system. Among these approaches is the strategy of ignoring it and relying on system restarts to resolve the deadlock. Despite the need for restarting the system, this method remains popular. **Discuss** why this strategy is commonly employed and **mention** the type of system that may utilize this method

[3]

CO4

- b) Suppose, in a workplace, we have a set of resource types, $R = \{R1, R2, R3, R4\}$ and a set of processes, $P = \{P1, P2, P3, P4\}$. **R1, R2, R3, and R4** have **2, 2, 2, and 2** instances respectively.

- P1 is holding 1 instance of R4
- P2 is holding 1 instance of R1
- P3 is holding 1 instance of R1
- P4 is holding 1 instance of R4
- P4 holding 1 instance of R2
- P2 requests 1 instance of R3
- P2 is holding 1 instance of R2
- P1 is requests 1 instance of R1
- P3 is holding 1 instance of R3
- P4 is holding 1 instance of R3
- P3 requests 1 instance of R4
- P4 requests 2 instances of R1

Construct a resource allocation graph for the above scenario and **identify the cycle (if any) and decide** whether there is a deadlock or not.

[4]

3. a) Arrays are stored in contiguous memory locations to optimize access to array elements, yet allocating processes in contiguous memory locations is discouraged. **Explain** why this is not recommended in terms of space complexity.

[3]

CO5

b) A system with an associative lookup time of 7ns, and memory access time of 59ns, what should be the approximate hit ratio to achieve Effective Access Time of 92ns? [3]

c) Assume that, page size of a process is **8 bytes** and size of the main memory is **72 bytes**. Logical memory and page table of the process are given below.

Logical Memory		PMT		Main memory
Page #	Data	Page #	Frame #	
P0	ab	P0	2	
P1	bc	P1	6	
P2	cd	P2	7	
P3	de	P3	13	
P4	ef	P4	11	
P5	fi	P5	5	

- How** can the user's view of memory be mapped into the main memory? [1]
- Find out** corresponding physical addresses of the following logical addresses – **18(10010), 44(101100) and 27(11011)** [3]

d) If the page size is **9 KB**, **how many** frames will be needed in Main memory for a process size of **83,645 Bytes**? Is there any **internal fragmentation**? - If yes, **calculate** the value. [1 KB = 1024 Bytes] [2]

e) In a particular time, the snapshot of Main memory given below for dynamic partitioning where gray portions of the memory are representing occupied spaces. Apply worst fit and first fit algorithms to place processes with the space requirement of **P1=600k, P2=400k, P3=348k, P4=200k, P5=52k, P6= 100k and P7=72k** (in order). Explain which algorithm makes the most effective use of memory? [5]

800K	600K	120K	100K	400K	522K
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- 4.** **a)** Consider a computer with a main memory that has 3 frames and page reference string of 0-7 page **[0, 1, 6, 6, 4, 0, 0, 5, 5, 4]**. The page reference string represents the order in which the pages are accessed by a program. **Apply LRU & OPT** algorithm to **simulate** the page replacement that occurs when the main memory can hold at most 3 pages at a time. **Record** the number of **page faults** and compare the result. **Mention** which algorithm performs better in this scenario. [6]
- CO5**

Department of Computer Science and Engineering
Final Examination Fall 2023
CSE 321: Operating Systems

B

Duration: 1 Hour 45 Minutes

Total Marks: 40

Answer the following questions.
Figures in the right margin indicate marks.

-
1. **CO4** a) In an office there are 10 employees. All the computers of the offices are connected to the internet by wired connectivity. But due to the limitation of bandwidth, office authorities allow only 5 devices to be connected with the wifi at the same time. On a particular day, 2 devices are already connected to the wifi and 6 more employees are trying to connect their devices to the wifi at the same time. **Explain** with proper logic, what issue has been raised in the above scenario and what will be the approach to provide proper synchronization to the issue according to the problem statement. [3]
- b) For the upcoming PMCO finals team "xyz" has arranged training sessions for players. In a training session a player needs to use a set of headphones and a mobile device together. The team can only facilitate a set of headphones and a mobile device to players for training. In a particular session a 30 mins slot has been allotted for each player. 4 players of the team have arrived for the session and a queue has been fixed based on the ascending order of their arrival times. According to the criteria mentioned above the order of the players in the queue is Action, Top, Icy and Nirzed. But they were called for the training according to the following order: Nirzed, Icy, Top and Action. Therefore, after waiting for a long period Action left the training arena out of annoyance. **Logically explain** what issue has occurred in the above scenario. [2]
- c) In a system, following conditions are present.
- There are 3 processes: P1, P2 and P3.
 - There is a semaphore, $s=2$.
 - Ready queue is in the following order, [P2, P3, P1].
 - CPU allocation is managed by round robin scheduling algorithm with the time quantum of 9 ms.
 - Each statement takes 3 ms to execute.
 - Critical section contains 2 statements.
 - Remainder section contains 3 statements.

The structure of process P_i in solution using Semaphore:

<pre>wait(s){ while(s<=0) ;//busy wait s--; } signal(s){ s++; }</pre>	<pre>do{ wait(s); //critical section signal(s); //remainder section }while(true);</pre>
---	---

Complete the table given below for processes P1, P2 and P3 using semaphore.

[5]

Process 1	Process 2	Process 3



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2. a) We have various ways to overcome deadlock in a system. Among these approaches is the strategy of ignoring it and relying on system restarts to resolve the deadlock. Despite the need for restarting the system, this method remains popular. **Discuss** why this strategy is commonly employed and **mention** the type of system that may utilize this method

[3]

CO4

b) Suppose, in a workplace, we have a set of resource types, $R = \{R1, R2, R3, R4\}$ and a set of processes, $P = \{P1, P2, P3, P4\}$. **R1, R2, R3, and R4** have **2, 3, 2, and 3** instances respectively.

- P1 is holding 1 instance of R2
- P2 is holding 2 instances of R2
- P3 is holding 1 instance of R1
- P3 requests 1 instance of R2
- P4 holding 2 instances of R4
- P2 holding 1 instance of R1
- P1 requests 1 instance of R1
- P4 requests 1 instance of R3
- P3 holding 1 instance of R3
- P1 holding 1 instance of R3
- P3 holding 1 instance of R4

Construct a resource allocation graph for the above scenario and **identify the cycle (if any) and decide** whether there is a deadlock or not.

[4]

3. **a)** Arrays are stored in contiguous memory locations to optimize access to array elements, yet allocating processes in contiguous memory locations is discouraged. **Explain** why this is not recommended in terms of space complexity. [3]

CO5

b) A system with an associative lookup time of 2ns, and memory access time of 72ns, what should be the approximate hit ratio to achieve Effective Access Time of 95ns? [3]

c) Assume that, page size of a process is **8 bytes** and size of the main memory is **72 bytes**. Logical memory and page table of the process are given below.

Logical Memory		PMT		Main memory
Page #	Data	Page #	Frame #	
P0	ij	P0	5	
P1	jk	P1	16	
P2	kl	P2	7	
P3	lm	P3	3	
P4	mn	P4	6	
P5	no	P5	12	

i. **How** can the user's view of memory be mapped into the main memory? [1]

ii. **Find out** corresponding physical addresses of the following logical addresses – **25(11001), 37(100101) and 23(10111)** [3]

d) If the page size is **10 KB**, how many frames will be needed in Main memory for a process size of **31,110 Bytes**? Is there any internal fragmentation? - If yes, **calculate** the value. [1 KB = 1024 Bytes] [2]

e) In a particular time, the snapshot of Main memory given below for dynamic partitioning where gray portions of the memory are representing occupied spaces. Apply worst fit and first fit algorithms to place processes with the space requirement of **P1=600k, P2=400k, P3=298k, P4=292k, P5=200k, P6= 100k, P7=44k and P8=58k** (in order). Explain which algorithm makes the most effective use of memory? [5]

800K	600K	320K	100K	400K	522K
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4. a) Consider a computer with a main memory that has 3 frames and page reference string of 0-7 page [5, 5, 3, 1, 7, 3, 3, 5, 2, 0]. The page reference string represents the order in which the pages are accessed by a program. **Apply LRU & OPT** algorithm to **simulate** the page replacement that occurs when the main memory can hold at most 3 pages at a time. **Record** the number of **page faults** and compare the result. **Mention** which algorithm performs better in this scenario.

[6]

Department of Computer Science and Engineering
Final Examination Fall 2023
CSE 321: Operating Systems

C

Duration: 1 Hour 45 Minutes

Total Marks: 40

Answer the following questions.
Figures in the right margin indicate marks.

1. **a)** In the research lab of a university there is a high-performing computer which can be used for research works on parallel computing. In a particular semester, four research groups are working on separate projects on parallel computing. One day four groups came together at the lab and were willing to use the high-performing computer at the same time. [3]
- CO4 Explain** with proper logic, what issue has been raised in the above scenario and what will be the approach to provide proper synchronization to the issue according to the problem statement.
- b)** In a certain match of PMCO two players from team “xyz” Action and Top started a debate over the sniping role of the team. Both of them are good in long range and in the match, Top found out a sniper weapon but he has no scopes. As a result, he is unable to use the sniper for the long range. On the contrary, Action has an 8x scope but he does not have any sniper weapon. Which means he is unable to use the scope. Both of them are willing to play as a sniper and for that Top is demanding the scope from Action and Action is demanding the sniper weapon from Top. But nobody is willing to make the compromise. Therefore, neither of them can play as a sniper. [2]
- Logically explain** what issue has occurred in the above scenario.
- c)** In a system, following conditions are present.
- There are 3 processes: P1, P2 and P3.
 - There is a mutex lock, available=true.
 - Ready queue is in the following order, [P3, P1, P2].
 - CPU allocation is managed by round robin scheduling algorithm with the time quantum of 12 ms.
 - Each statement takes 4 ms to execute.
 - Critical section contains 3 statements.
 - Remainder section contains 2 statements.

The structure of process Pi in solution using mutex lock:

<pre>acquire() { while(!available) ; //busy wait available=false; } release() { available=true; }</pre>	<pre>do{ acquire(); //critical section release(); //remainder section }while(true);</pre>
--	---

Complete the table given below for processes P1, P2 and P3 using mutex lock.

[5]

Process 1	Process 2	Process 3



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2. a) We have various ways to overcome deadlock in a system. Among these approaches is the strategy of ignoring it and relying on system restarts to resolve the deadlock. Despite the need for restarting the system, this method remains popular. **Discuss** why this strategy is commonly employed and **mention** the type of system that may utilize this method

[3]

CO4

b) Suppose, in a workplace, we have a set of resource types, $R = \{R1, R2, R3, R4\}$ and a set of processes, $P = \{P1, P2, P3, P4, P5\}$. **R1, R2, R3, and R4** have **3, 2, 4, and 2** instances respectively.

- P1 is holding 2 instances of R1
- P2 is holding 1 instance of R3
- P3 is holding 1 instance of R4
- P5 requests 2 instances of R3
- P4 is holding 1 instance of R4
- P3 requests 1 instance of R2
- P2 requests 1 instance of R1
- P2 is holding 1 instance of R2
- P1 is requesting 1 instance of R4
- P3 is holding 1 instance of R3
- P4 is holding 1 instance of R3
- P5 holding 1 instance of R2

Construct a resource allocation graph for the above scenario and **identify the cycle (if any) and decide** whether there is a deadlock or not.

[4]

3. a) Arrays are stored in contiguous memory locations to optimize access to array elements, yet allocating processes in contiguous memory locations is discouraged. **Explain** why this is not recommended in terms of space complexity.

[3]

CO5

b) A system with an associative lookup time of 5ns, and memory access time of 85ns, what should be the approximate hit ratio to achieve Effective Access Time of 146ns? [3]

c) Assume that, page size of a process is **8 bytes** and size of the main memory is **72 bytes**. Logical memory and page table of the process are given below.

Logical Memory		PMT		Main memory
Page #	Data	Page #	Frame #	
P0	op	P0	10	
P1	pq	P1	2	
P2	qr	P2	4	
P3	rs	P3	11	
P4	st	P4	8	
P5	tu	P5	3	

i. **How** can the user's view of memory be mapped into the main memory? [1]

ii. **Find out** corresponding physical addresses of the following logical addresses – **11(1011), 4(100) and 21(10101)** [3]

d) If the page size is **7 KB**, how many frames will be needed in Main memory for a process size of **93,600 Bytes**? Is there any internal fragmentation? - If yes, **calculate** the value. [1 KB = 1024 Bytes] [2]

e) In a particular time, the snapshot of Main memory given below for dynamic partitioning where gray portions of the memory are representing occupied spaces. Apply worst fit and first fit algorithms to place processes with the space requirement of **P1=600k, P2=400k, P3=298k, P4=292k, P5=200k, P6=100k, P7=44k and P8=58k** (in order). Explain which algorithm makes the most effective use of memory? [5]

800K	600K	320K	100K	400K	522K
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4. a) Consider a computer with a main memory that has 3 frames and page reference string of 0-7 page **[3, 5, 4, 6, 7, 4, 2, 6, 7, 6]**. The page reference string represents the order in which the pages are accessed by a program. **Apply LRU & OPT** algorithm to **simulate** the page replacement that occurs when the main memory can hold at most 3 pages at a time. **Record** the number of **page faults** and compare the result. **Mention** which algorithm performs better in this scenario. [6]

CO5