

VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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LAB REPORT

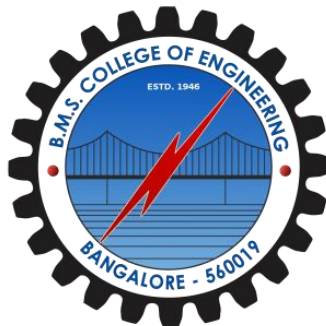
on

Operating Systems (22CS4PCOPS)

Submitted by:

Chinmay N Hegde (1BM21CS044)

in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING



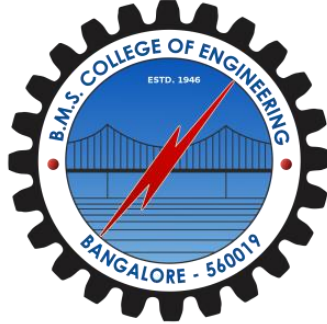
B.M.S. COLLEGE OF ENGINEERING

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CERTIFICATE

This is to certify that the Lab work entitled “**Operating Systems**” carried out by **Chinmay N Hegde(1BM21CS044)**, who is bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2022-23. The Lab report has been approved as it satisfies the academic requirements in respect of **Operating Systems - (22CS4PCOPS)** work prescribed for the said degree.

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Table Of Contents

S.No.	Experiment Title		Page No.
1	Course Outcomes		5
2	Experiments		5-67
	2.1	Experiment - 1	5-11
	2.1.1	Question: Write a C program to simulate the following non-pre-emptive CPU scheduling algorithm to find turnaround time and waiting time. (a) FCFS (b) SJF (pre-emptive & Non-pre-emptive)	5
	2.1.2	Code	5-10
	2.1.3	Output	11
		Experiment - 2	12-16
	2.2.1	Question: Write a C program to simulate the following CPU scheduling algorithm to find turnaround time and waiting time. (a) Priority (pre-emptive & Non-pre-emptive) (b) Round Robin (Experiment with different quantum sizes for RR algorithm)	12
	2.2.2	Code	12-16
	2.2.3	Output	16
	2.3	Experiment - 3	17-19
	2.3.1	Question: Write a C program to simulate multi-level queue scheduling algorithm considering the following scenario. All the processes in the system are divided into two categories – system processes and user processes. System processes are to be given higher priority than user processes. Use FCFS scheduling for the processes in each queue.	17
	2.3.2	Code	17-19
	2.3.3	Output	19
	2.4.	Experiment - 4	20-27

		2.4.1	Question: Write a C program to simulate Real-Time CPU Scheduling algorithms: (a) Rate- Monotonic (b) Earliest-deadline First (c) Proportional scheduling	20
		2.4.2	Code	20-25
		2.4.3	Output	26-27
	2.5.	Experiment - 5		28-30
		2.5.1	Question: Write a C program to simulate producer-consumer problem using semaphores.	28
		2.5.2	Code	28-30
		2.5.3	Output	30
	2.6	Experiment - 6		31-32
		2.6.1	Question: Write a C program to simulate the concept of Dining-Philosophers problem.	31
		2.6.2	Code	31
		2.6.3	Output	32
	2.7	Experiment - 7		33-35
		2.7.1	Question: Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.	33
		2.7.2	Code	33-35
		2.7.3	Output	35
	2.8	Experiment - 8		36-39
		2.8.1	Question: Write a C program to simulate deadlock detection.	36
		2.8.2	Code	36-38
		2.8.3	Output	39
	2.9	Experiment - 9		40-44
		2.9.1	Question:	40

		Write a C program to simulate the following contiguous memory allocation techniques: (a) Worst-fit (b) Best-fit (c) First-fit	
	2.9.2	Code	40-43
	2.9.3	Output	44
2.10	Experiment - 10		45-46
	2.10.1	Question: Write a C program to simulate paging technique of memory management.	45
	2.10.2	Code	45
	2.10.3	Output	46
2.11	Experiment - 11		47-56
	2.11.1	Question: Write a C program to simulate page replacement algorithms: (a) FIFO (b) LRU (c) Optimal	47
	2.11.2	Code	47-54
	2.11.3	Output	54-56
2.12	Experiment - 12		57-62
	2.12.1	Question: Write a C program to simulate disk scheduling algorithms: (a) FCFS (b) SCAN (c) C-SCAN	57
	2.12.2	Code	57-61
	2.12.3	Output	62
2.13	Experiment - 13		63-67
	2.13.1	Question:	63

	Write a C program to simulate disk scheduling algorithms: (a) SSTF (b) LOOK (c) c-LOOK	
2.13.2	Code	62-66
2.13.3	Output	67

1. Course Outcomes

CO1: Apply the different concepts and functionalities of Operating System.

CO2: Analyse various Operating system strategies and techniques.

CO3: Demonstrate the different functionalities of Operating System.

CO4: Conduct practical experiments to implement the functionalities of Operating system.

2. Experiments

2.1 Experiment - 1

2.1.1 Question:

Write a C program to simulate the following non-pre-emptive CPU scheduling algorithm to find turnaround time and waiting time.

(a) FCFS

(b) SJF

2.1.2 Code:

(a) FCFS

```
#include <stdio.h>
```

```
int main() {
```

```
    int n;
```

```
    printf("Enter the number of processes: ");
```

```
    scanf("%d", &n);
```

```
    int pid[n], arrival[n], burst[n], waiting[n], turnaround[n];
```

```
    printf("Enter the process ids:\n");
```

```
    for (int i = 0; i < n; i++) {
```

```
        scanf("%d", &pid[i]);
```

```
// Input process details
```

```
    for (int i = 0; i < n; i++) {
```

```
        printf("Enter arrival time and burst time for process %d: ", i + 1);
```

```
        scanf("%d %d", &arrival[i], &burst[i]);
```

```
    }
```

```
// Sort processes based on arrival time and then burst time
```

```

for (int i = 0; i < n - 1; i++) {
    for (int j = 0; j < n - i - 1; j++) {
        if (arrival[j] == arrival[j + 1] && burst[j] > burst[j + 1]) {
            int temp = burst[j];
            burst[j] = burst[j + 1];
            burst[j + 1] = temp;

            temp = arrival[j];
            arrival[j] = arrival[j + 1];
            arrival[j + 1] = temp;

            temp = pid[j];
            pid[j] = pid[j + 1];
            pid[j + 1] = temp;
        }

        else if (arrival[j] > arrival[j + 1]) {
            int temp = arrival[j];
            arrival[j] = arrival[j + 1];
            arrival[j + 1] = temp;

            temp = burst[j];
            burst[j] = burst[j + 1];
            burst[j + 1] = temp;

            temp = pid[j];
            pid[j] = pid[j + 1];
            pid[j + 1] = temp;
        }
    }
}

waiting[0] = 0;
turnaround[0] = burst[0];

```



```

// Calculate waiting and turnaround times
for (int i = 1; i < n; i++) {
    waiting[i] = turnaround[i - 1] + arrival[i - 1] - arrival[i];
    if (waiting[i] < 0)
        waiting[i] = 0;
    turnaround[i] = waiting[i] + burst[i];
}

float totalWaiting = 0, totalTurnaround = 0;
// Calculate total waiting and turnaround times
for (int i = 0; i < n; i++) {
    totalWaiting += waiting[i];
    totalTurnaround += turnaround[i];
}

float avgWaiting = totalWaiting / n;
float avgTurnaround = totalTurnaround / n;
printf("\nProcess\tArrival Time\tBurst Time\tWaiting Time\tTurnaround Time\n");
for (int i = 0; i < n; i++) {
    printf("%d\t%d\t%d\t%d\t%d\n", pid[i], arrival[i], burst[i], waiting[i], turnaround[i]);
}

printf("\nAverage Waiting Time: %.2f\n", avgWaiting);
printf("Average Turnaround Time: %.2f\n", avgTurnaround);
return 0;
}

```

(b) SJF

```

#include <stdio.h>

void main()
{
    int n,pid[10],bt[10],at[10],swap,tat[10],wt[10],comp=0,min,j,count=0,k;
    float t_tat=0,t_wt=0;
    printf("Enter the number of processes:\n");
    scanf("%d",&n);
    printf("Enter the process id:\n");
}

```

```

for (int i = 0; i < n; i++)
{
    scanf("%d", &pid[i]);
}

printf("Enter the arrival time of the processes:\n");

for (int i = 0; i < n; i++)
{
    scanf("%d", &at[i]);
}

printf("Enter the burst time of the processes:\n");

for (int i = 0; i < n; i++)
{
    scanf("%d", &bt[i]);
}

//sort based on burst time
for(int i=0;i<n-1;i++)
{
    for(int j=0;j<n-i-1;j++)
    {
        if(bt[j]>bt[j+1])
        {
            swap = pid[j];
            pid[j] = pid[j+1];
            pid[j+1] = swap;

            swap= bt[j];
            bt[j] = bt[j+1];
            bt[j+1] = swap;

            swap = at[j];
            at[j] = at[j+1];
            at[j+1] = swap;
        }
    }
}

```

```

    }
}
}
for(int i=0;i<n;i++)
{
    tat[i]=-1;
}
//find the process which has minimum arrival time because the arrays are sorted
min=at[0];
for(int i=1;i<n;i++)
{
    if(at[i]<min)
    {
        min=at[i];
        j=i;
    }
}
comp+=at[j]+bt[j];
tat[j]=comp-at[j];
wt[j]=tat[j]-bt[j];
count++;
k=0;
while(count!=n)
{
    if(tat[k]==-1 && at[k]<=comp)
    {
        comp+=bt[k];
        tat[k]=comp-at[k];
        wt[k]=tat[k]-bt[k];
        count++;
        k=(k+1)%n;
    }
}

```

```

else if(tat[k]!=-1 || at[k]>comp)
{
    k=(k+1)%n;
}
}
for(int i=0;i<n;i++)
{
    t_tat+=tat[i];
    t_wt+=wt[i];
}
printf("Pid\tArrivalTime\tBurstTime\tTAT\tWaitingTime\n");
for(int m=0;m<n;m++)
{
    printf("%d\t%d\t%d\t%d\t%d\n", pid[m],at[m], bt[m],tat[m], wt[m]);
}
printf("Average turn around time:%0.2f\n", (t_tat) / n);
printf("Average waiting time:%0.2f\n", (t_wt) / n);
}

```

2.1.3 Output:

(a) FCFS

```
Enter the number of processes: 4
Enter the process ids:
1 2 3 4
Enter arrival time and burst time for process 1: 0 3
Enter arrival time and burst time for process 2: 1 6
Enter arrival time and burst time for process 3: 4 4
Enter arrival time and burst time for process 4: 6 2
```

Process	Arrival Time	Burst Time	Waiting Time	Turnaround Time
1	0	3	0	3
2	1	6	2	8
3	4	4	5	9
4	6	2	7	9

```
Average Waiting Time: 3.50
Average Turnaround Time: 7.25
```

(b) SJF

```
Enter the number of processes:
4
Enter the process id:
1 2 3 4
Enter the arrival time of the processes:
0 1 4 6
Enter the burst time of the processes:
3 6 4 2
```

Pid	ArrivalTime	BurstTime	TAT	WaitingTime
4	6	2	5	3
1	0	3	3	0
3	4	4	11	7
2	1	6	8	2

```
Average turn around time:6.75
Average waiting time:3.00
```

2.2 Experiment - 2

2.2.1 Question:

Write a C program to simulate the following CPU scheduling algorithm to find turnaround time and waiting time.

(a) Priority (Non-pre-emptive)

(b) Round Robin (Experiment with different quantum sizes for RR algorithm)

2.2.2 Code:

(a) Priority (Non-pre-emptive)

```
#include <stdio.h>
void main()
{
    int n,pid[10],bt[10],at[10],pr[10],swap,tat[10],wt[10],comp=0,min,j,count=0,k;
    float t_tat=0,t_wt=0;
    printf("Enter the number of processes:\n");
    scanf("%d",&n);
    printf("Enter the process id:\n");
    for (int i = 0; i < n; i++)
    {
        scanf("%d", &pid[i]);
    }
    printf("Enter the arrival time of the processes:\n");
    for (int i = 0; i < n; i++)
    {
        scanf("%d", &at[i]);
    }
    printf("Enter the burst time of the processes:\n");
    for (int i = 0; i < n; i++)
    {
        scanf("%d", &bt[i]);
    }
    printf("Enter the priority of processes:\n");
    for (int i = 0; i < n; i++)
    {
        scanf("%d", &pr[i]);
    }

    // sorting based on priority, higher number means higher priority, so sorting in descending order
    for(int i=0;i<n-1;i++)
    {
        for(int j=0;j<n-i-1;j++)
        {
            if(pr[j]<=pr[j+1])
            {
                swap = pr[j];
                pr[j] = pr[j+1];
                pr[j+1] = swap;
            }
        }
    }
}
```

```

        swap = pid[j];
        pid[j] = pid[j+1];
        pid[j+1] = swap;

        swap= bt[j];
        bt[j] = bt[j+1];
        bt[j+1] = swap;

        swap = at[j];
        at[j] = at[j+1];
        at[j+1] = swap;
    }
}
}
for(int i=0;i<n;i++)
{
    tat[i]=-1;
}
//to find which process has arrived first because we have sorted the array based on priority
min=at[0];
j=0;
for(int i=1;i<n;i++)
{
    if(at[i]<min)
    {
        min=at[i];
        j=i;
    }
    else if(at[i]==min) //if arrival time is the same, check which has higher priority
    {
        if(pr[i]>pr[j])
        {
            j=i;
        }
        else if(pr[i]==pr[j]) //if priorities are also same, check whcih one has lesser burst time.
        {
            if(bt[i]<bt[j])
            {
                j=i;
            }
        }
    }
}

//j is the index/process which has arrived first, so compute tat for that first
comp+=at[j]+bt[j];
tat[j]=comp-at[j];
wt[j]=tat[j]-bt[j];

count++; //keeps track of number of processes computed for tat
k=0;
while(count!=n)

```

```

{
    if(tat[k]==-1 && at[k]<=comp) //if tat is not yet computed and arrival time is less than completion time,
    then only we can compute tat
    {
        comp+=bt[k]; //update completion time
        tat[k]=comp-at[k];
        wt[k]=tat[k]-bt[k];
        k=(k+1)%n; // if the process has not arrived, we are not computing for this process rn, so we need to
        come back to check for those not computed
        count++;
    }
    else if(tat[k]!=-1 || at[k]>comp)
    {
        k=(k+1)%n; // if tat already computed or the process has not yet arrived, just circularly increment
    }
}
for(int i=0;i<n;i++)
{
    t_tat+=tat[i];
    t_wt+=wt[i];
}
printf("Pid\tArrivalTime\tBurstTime\tPriority\tTAT\tWaitingTime\n");
for(int m=0;m<n;m++)
{
    printf("%d\t%d\t%d\t%d\t%d\t%d\t%d\n", pid[m],at[m], bt[m],pr[m],tat[m], wt[m]);
}
printf("Average turn around time:%0.1f\n", (t_tat) / n);
printf("Average waiting time:%0.1f\n", (t_wt) / n);
}

```

(b) Round Robin (Non-pre-emptive)

```

#include <stdio.h>
#include <stdbool.h>

int turnarroundtime(int processes[], int n, int bt[], int wt[], int tat[]) {
    for (int i = 0; i < n ; i++)
        tat[i] = bt[i] + wt[i];
    return 1;
}

int waitingtime(int processes[], int n, int bt[], int wt[], int quantum)
{
    int rem_bt[n];
    for (int i = 0 ; i < n ; i++)
        rem_bt[i] = bt[i];
    int t = 0;

    while (1)
    {
        bool done = true;

        for (int i = 0 ; i < n; i++)

```



```

    {
        if (rem_bt[i] > 0)
        {
            done = false;
            if (rem_bt[i] > quantum)
            {
                t += quantum;
                rem_bt[i] -= quantum;
            }

            else
            {
                t = t + rem_bt[i];
                wt[i] = t - bt[i];
                rem_bt[i] = 0;
            }
        }
    }
    if (done == true)
        break;
}
return 1;
}

int findavgTime(int processes[], int n, int bt[], int quantum) {
    int wt[n], tat[n], total_wt = 0, total_tat = 0;

    waitingtime(processes, n, bt, wt, quantum);
    turnarroundtime(processes, n, bt, wt, tat);

    printf("\n\nProcesses\t\t Burst Time\t\t Waiting Time\t\t turnaround time\n");
    for (int i=0; i<n; i++)
    {
        total_wt = total_wt + wt[i];
        total_tat = total_tat + tat[i];
        printf("\n\t%d\t\t\t%d\t\t\t%d\t\t\t%d\n",i+1, bt[i], wt[i], tat[i]);
    }

    printf("\nAverage waiting time = %f", (float)total_wt / (float)n);
    printf("\nAverage turnaround time = %f", (float)total_tat / (float)n);
    return 1;
}

int main()
{
    int n, processes[n], burst_time[n], quantum;
    printf("Enter the Number of Processes: ");
    scanf("%d",&n);

    printf("\nEnter the quantum time: ");
    scanf("%d",&quantum);

```

```

int i=0;
for(i=0;i<n;i++)
{
    printf("\nEnter the process: ");
    scanf("%d",&processes[i]);
    printf("Enter the Burst Time:");
    scanf("%d",&burst_time[i]);
}

findavgTime(processes, n, burst_time, quantum);
return 0;
}

```

2.2.3 Output:

(a) Priority (Non-pre-emptive)

```

Enter the number of processes:
4
Enter the process id:
1 2 3 4
Enter the arrival time of the processes:
0 1 2 3
Enter the burst time of the processes:
4 3 3 5
Enter the priority of processes:
3 4 6 5
Min:0
j:3

```

Pid	ArrivalTime	BurstTime	Priority	TAT	WaitingTime
3	2	3	6	5	2
4	3	5	5	9	4
2	1	3	4	14	11
1	0	4	3	4	0

```

Average turn around time:8.0
Average waiting time:4.3

```

(b) Round Robin (Non-pre-emptive)

```

Enter the Number of Processes: 3
Enter the quantum time: 2
Enter the process: 1
Enter the Burst Time:4
Enter the process: 2
Enter the Burst Time:3
Enter the process: 3
Enter the Burst Time:5

```

Processes	Burst Time	Waiting Time	turnaround time
1	4	4	8
2	3	6	9
3	5	7	12

```

Average waiting time = 5.666667
Average turnaround time = 9.666667

```

2.3 Experiment - 3

2.3.1 Question:

Write a C program to simulate multi-level queue scheduling algorithm considering the following scenario. All the processes in the system are divided into two categories – system processes and user processes. System processes are to be given higher priority than user processes. Use FCFS scheduling for the processes in each queue.

2.3.2 Code:

```
#include <stdio.h>
#include <stdlib.h>

struct process {
    int pid;
    int arrival_time;
    int burst_time;
    int priority;
    int waiting_time;
    int turnaround_time;
};

void FCFS(struct process *queue, int n) {
    int i, j;
    struct process temp;
    for (i = 0; i < n; i++) {
        for (j = i + 1; j < n; j++) {
            if (queue[i].arrival_time > queue[j].arrival_time) {
                temp = queue[i];
                queue[i] = queue[j];
                queue[j] = temp;
            }
        }
    }
}

int main() {
    int n, i;
    struct process *system_queue, *user_queue;
    int system_n = 0, user_n = 0;
    float avg_waiting_time = 0, avg_turnaround_time = 0;

    printf("Enter the number of processes: ");
    scanf("%d", &n);

    system_queue = (struct process *) malloc(n * sizeof(struct process));
    user_queue = (struct process *) malloc(n * sizeof(struct process));

    for (i = 0; i < n; i++) {
        struct process p;
        printf("Enter arrival time, burst time, and priority (0-System/1-User) for process %d: ", i + 1);
```

```

scanf("%d %d %d", &p.arrival_time, &p.burst_time, &p.priority);
p.pid = i + 1;
p.waiting_time = 0;
p.turnaround_time = 0;
if (p.priority == 0) {
    system_queue[system_n++] = p;
} else {
    user_queue[user_n++] = p;
}
}

FCFS(system_queue, system_n);
FCFS(user_queue, user_n);

int time = 0;
int s=0,u=0;
while(s<system_n || u<user_n){
    if(system_queue[s].arrival_time <= time){
        if(user_queue[u].arrival_time <= time && user_queue[u].arrival_time <
system_queue[s].arrival_time){
            user_queue[u].waiting_time = time - user_queue[u].arrival_time;
            time += user_queue[u].burst_time;
            user_queue[u].turnaround_time = user_queue[u].waiting_time + user_queue[u].burst_time;
            avg_waiting_time += user_queue[u].waiting_time;
            avg_turnaround_time += user_queue[u].turnaround_time;
            u++;
        }
        else{
            system_queue[s].waiting_time = time - system_queue[s].arrival_time;
            time += system_queue[s].burst_time;
            system_queue[s].turnaround_time = system_queue[s].waiting_time + system_queue[s].burst_time;
            avg_waiting_time += system_queue[s].waiting_time;
            avg_turnaround_time += system_queue[s].turnaround_time;
            s++;
        }
    }
    else if(user_queue[u].arrival_time <= time){
        user_queue[u].waiting_time = time - user_queue[u].arrival_time;
        time += user_queue[u].burst_time;
        user_queue[u].turnaround_time = user_queue[u].waiting_time + user_queue[u].burst_time;
        avg_waiting_time += user_queue[u].waiting_time;
        avg_turnaround_time += user_queue[u].turnaround_time;
        u++;
    }
    else{
        if(system_queue[s].arrival_time <= user_queue[u].arrival_time){
            time = system_queue[s].arrival_time;
        }
        else{
            time = user_queue[u].arrival_time;
        }
    }
}

```

```

}

avg_waiting_time /= n;
avg_turnaround_time /= n;

printf("PID\tBurst Time\tPriority\tQueue Type\tWaiting Time\tTurnaround Time\n");
for (i = 0; i < system_n; i++) {
    printf("%d\t%d\t%d\t\tSystem\t\t%d\t\t%d\n", system_queue[i].pid, system_queue[i].burst_time,
system_queue[i].priority, system_queue[i].waiting_time, system_queue[i].turnaround_time);
}
for (i = 0; i < user_n; i++) {
    printf("%d\t%d\t%d\t\tUser\t\t\t%d\t\t%d\n", user_queue[i].pid, user_queue[i].burst_time,
user_queue[i].priority, user_queue[i].waiting_time, user_queue[i].turnaround_time);
}

printf("Average Waiting Time: %.2f\n", avg_waiting_time);
printf("Average Turnaround Time: %.2f\n", avg_turnaround_time);

free(system_queue);
free(user_queue);

return 0;
}

```

2.3.3 Output:

```

Enter the number of processes: 4
Enter arrival time, burst time, and priority (0-System/1-User) for process 1: 0 3 0
Enter arrival time, burst time, and priority (0-System/1-User) for process 2: 1 3 1
Enter arrival time, burst time, and priority (0-System/1-User) for process 3: 8 3 0
Enter arrival time, burst time, and priority (0-System/1-User) for process 4: 8 3 1
PID      Burst Time      Priority      Queue Type      Waiting Time      Turnaround Time
1         3                 0            System          0                 3
3         3                 0            System          0                 3
2         3                 1            User            2                 5
4         3                 1            User            3                 6
Average Waiting Time: 1.25
Average Turnaround Time: 4.25

```

2.4 Experiment – 4

2.4.1 Question:

Write a C program to simulate Real-Time CPU Scheduling algorithms:

- (a) Rate- Monotonic
- (b) Earliest-deadline First
- (c) Proportional scheduling

2.4.2 Code:

```
#include <stdio.h>
#include <stdlib.h>
#include <math.h>
#include <stdbool.h>

#define MAX_PROCESS 10

typedef struct {
    int id;
    int burst_time;
    float priority;
} Task;

int num_of_process;
int execution_time[MAX_PROCESS], period[MAX_PROCESS], remain_time[MAX_PROCESS],
deadline[MAX_PROCESS], remain_deadline[MAX_PROCESS];

void get_process_info(int selected_algo)
{
    printf("Enter total number of processes (maximum %d): ", MAX_PROCESS);
    scanf("%d", &num_of_process);
    if (num_of_process < 1)
    {
        exit(0);
    }

    for (int i = 0; i < num_of_process; i++)
    {
        printf("\nProcess %d:\n", i + 1);
        printf("➔ Execution time: ");
        scanf("%d", &execution_time[i]);
        remain_time[i] = execution_time[i];
        if (selected_algo == 2)
        {
            printf("➔ Deadline: ");
            scanf("%d", &deadline[i]);
        }
        else
        {
            printf("➔ Period: ");
            scanf("%d", &period[i]);
        }
    }
}
```

```

}

int max(int a, int b, int c)
{
    int max;
    if (a >= b && a >= c)
        max = a;
    else if (b >= a && b >= c)
        max = b;
    else if (c >= a && c >= b)
        max = c;
    return max;
}

int get_observation_time(int selected_algo)
{
    if (selected_algo == 1)
    {
        return max(period[0], period[1], period[2]);
    }
    else if (selected_algo == 2)
    {
        return max(deadline[0], deadline[1], deadline[2]);
    }
}

void print_schedule(int process_list[], int cycles)
{
    printf("\nScheduling:\n\n");
    printf("Time: ");
    for (int i = 0; i < cycles; i++)
    {
        if (i < 10)
            printf("| 0%d ", i);
        else
            printf("| %d ", i);
    }
    printf("\n");
    for (int i = 0; i < num_of_process; i++)
    {
        printf("P[%d]: ", i + 1);
        for (int j = 0; j < cycles; j++)
        {
            if (process_list[j] == i + 1)
                printf("|####");
            else
                printf("|   ");
        }
        printf("\n");
    }
}

```

```

void rate_monotonic(int time)
{
    int process_list[100] = {0}, min = 999, next_process = 0;
    float utilization = 0;
    for (int i = 0; i < num_of_process; i++)
    {
        utilization += (1.0 * execution_time[i]) / period[i];
    }
    int n = num_of_process;
    int m = (float) (n * (pow(2, 1.0 / n) - 1));
    if (utilization > m)
    {
        printf("\nGiven problem is not schedulable under the said scheduling algorithm.\n");
    }
    for (int i = 0; i < time; i++)
    {
        min = 1000;
        for (int j = 0; j < num_of_process; j++)
        {
            if (remain_time[j] > 0)
            {
                if (min > period[j])
                {
                    min = period[j];
                    next_process = j;
                }
            }
        }
        if (remain_time[next_process] > 0)
        {
            process_list[i] = next_process + 1;
            remain_time[next_process] -= 1;
        }
        for (int k = 0; k < num_of_process; k++)
        {
            if ((i + 1) % period[k] == 0)
            {
                remain_time[k] = execution_time[k];
                next_process = k;
            }
        }
    }
    print_schedule(process_list, time);
}

```

```

void earliest_deadline_first(int time){
    float utilization = 0;
    for (int i = 0; i < num_of_process; i++){
        utilization += (1.0*execution_time[i])/deadline[i];
    }
    int n = num_of_process;

```



```

int process[num_of_process];
int max_deadline, current_process=0, min_deadline, process_list[time];
bool is_ready[num_of_process];

for(int i=0; i<num_of_process; i++){
    is_ready[i] = true;
    process[i] = i+1;
}

max_deadline=deadline[0];
for(int i=1; i<num_of_process; i++){
    if(deadline[i] > max_deadline)
        max_deadline = deadline[i];
}

for(int i=0; i<num_of_process; i++){
    for(int j=i+1; j<num_of_process; j++){
        if(deadline[j] < deadline[i]){
            int temp = execution_time[j];
            execution_time[j] = execution_time[i];
            execution_time[i] = temp;
            temp = deadline[j];
            deadline[j] = deadline[i];
            deadline[i] = temp;
            temp = process[j];
            process[j] = process[i];
            process[i] = temp;
        }
    }
}

for(int i=0; i<num_of_process; i++){
    remain_time[i] = execution_time[i];
    remain_deadline[i] = deadline[i];
}

for (int t = 0; t < time; t++){
    if(current_process != -1){
        --execution_time[current_process];
        process_list[t] = process[current_process];
    }
    else
        process_list[t] = 0;

    for(int i=0;i<num_of_process;i++){
        --deadline[i];
        if((execution_time[i] == 0) && is_ready[i]){
            deadline[i] += remain_deadline[i];
            is_ready[i] = false;
        }
        if((deadline[i] <= remain_deadline[i]) && (is_ready[i] == false)){
            execution_time[i] = remain_time[i];

```

```

        is_ready[i] = true;
    }
}

min_deadline = max_deadline;
current_process = -1;
for(int i=0;i<num_of_process;i++){
    if((deadline[i] <= min_deadline) && (execution_time[i] > 0)){
        current_process = i;
        min_deadline = deadline[i];
    }
}
}
print_schedule(process_list, time);
}

```

```

void proportionalScheduling() {
    int n;
    printf("Enter the number of tasks: ");
    scanf("%d", &n);

    Task tasks[n];
    printf("Enter burst time and priority for each task:\n");
    for (int i = 0; i < n; i++) {
        tasks[i].id = i + 1;
        printf("Task %d – Burst Time: ", tasks[i].id);
        scanf("%d", &tasks[i].burst_time);
        printf("Task %d – Priority: ", tasks[i].id);
        scanf("%f", &tasks[i].priority);
    }

    // Sort tasks based on priority (ascending order)
    for (int i = 0; i < n - 1; i++) {
        for (int j = 0; j < n - i - 1; j++) {
            if (tasks[j].priority > tasks[j + 1].priority) {
                // Swap tasks
                Task temp = tasks[j];
                tasks[j] = tasks[j + 1];
                tasks[j + 1] = temp;
            }
        }
    }

    printf("\nProportional Scheduling:\n");

    int total_burst_time = 0;
    float total_priority = 0.0;

    for (int i = 0; i < n; i++) {
        total_burst_time += tasks[i].burst_time;
        total_priority += tasks[i].priority;
    }
}

```

```

for (int i = 0; i < n; i++) {
    float time_slice = (tasks[i].priority / total_priority) * total_burst_time;
    printf("Task %d executes for %.2f units of time\n", tasks[i].id, time_slice);
}

int main()
{
    int option;
    int observation_time;

    while (1)
    {
        printf("\n1. Rate Monotonic\n2. Earliest Deadline first\n3. Proportional Scheduling\n\nEnter your choice:");
        scanf("%d", &option);
        switch(option)
        {
            case 1: get_process_info(option);
                    observation_time = get_observation_time(option);
                    rate_monotonic(observation_time);
                    break;
            case 2: get_process_info(option);
                    observation_time = get_observation_time(option);
                    earliest_deadline_first(observation_time);
                    break;
            case 3: proportionalScheduling();
                    break;
            case 4: exit (0);
            default: printf("\nInvalid Statement");
        }
    }
    return 0;
}

```

2.4.3 Output:

(a) Rate Monotonic:

```
1. Rate Monotonic
2. Earliest Deadline first
3. Proportional Scheduling

Enter your choice: 1
Enter total number of processes (maximum 10): 3

Process 1:
==> Execution time: 3
==> Period: 20

Process 2:
==> Execution time: 2
==> Period: 5

Process 3:
==> Execution time: 2
==> Period: 10

Scheduling:

Time: | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 | 08 | 09 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 | 18 | 19 |
P[1]: |   |   |   |   |####|   |####|####|   |   |   |   |   |   |   |   |   |   |   |
P[2]: |####|####|   |   |####|####|   |   |####|####|   |   |####|####|   |   |   |   |
P[3]: |   |   |####|####|   |   |   |   |   |   |   |   |####|####|   |   |   |   |
```

(b) Earliest Deadline First:

```
1. Rate Monotonic
2. Earliest Deadline first
3. Proportional Scheduling

Enter your choice: 2
Enter total number of processes (maximum 10): 3

Process 1:
==> Execution time: 3
==> Deadline: 7

Process 2:
==> Execution time: 2
==> Deadline: 4

Process 3:
==> Execution time: 2
==> Deadline: 8

Scheduling:

Time: | 00 | 01 | 02 | 03 | 04 | 05 | 06 | 07 |
P[1]: |   |   |####|####|####|   |   |
P[2]: |####|####|   |   |   |   |####|
P[3]: |   |   |   |   |   |####|####|   |
```

© Proportional Scheduling:

1. Rate Monotonic
2. Earliest Deadline first
3. Proportional Scheduling

Enter your choice: 3

Enter the number of tasks: 3

Enter burst time and priority for each task:

Task 1 - Burst Time: 4

Task 1 - Priority: 2

Task 2 - Burst Time: 6

Task 2 - Priority: 3

Task 3 - Burst Time: 5

Task 3 - Priority: 1

Proportional Scheduling:

Task 3 executes for 2.50 units of time

Task 1 executes for 5.00 units of time

Task 2 executes for 7.50 units of time

2.5 Experiment – 5

2.5.1 Question:

Write a C program to simulate producer-consumer problem using semaphores.

2.5.2 Code:

```
#include <stdio.h>

#include <pthread.h>

#include <semaphore.h>

#define BUFFER_SIZE 10

#define NUM_ITEMS 20

int buffer[BUFFER_SIZE];

int fill = 0; // Index to add data by producer

int use = 0; // Index to consume data by consumer

int count = 0; // Number of items in the buffer

sem_t empty; // Semaphore to track empty slots in the buffer

sem_t full; // Semaphore to track the number of items available for consumption

void put(int value) {
    buffer[fill] = value;
    fill = (fill + 1) % BUFFER_SIZE;
    count++;
}

int get() {
    int tmp = buffer[use];
    use = (use + 1) % BUFFER_SIZE;
    count--;
    return tmp;
}
```

```

void *producer(void *arg) {
    int i;
    for (i = 0; i < NUM_ITEMS; i++) {
        sem_wait(&empty); // Wait for an empty slot
        put(i);
        printf("Produced: %d\n", i);
        sem_post(&full); // Signal that an item is produced
    }
    pthread_exit(NULL);
}

void *consumer(void *arg) {
    int i;
    for (i = 0; i < NUM_ITEMS; i++) {
        sem_wait(&full); // Wait for an item to be produced
        int value = get();
        printf("Consumed: %d\n", value);
        sem_post(&empty); // Signal that an empty slot is available
    }
    pthread_exit(NULL);
}

int main() {
    // Initialize semaphores
    sem_init(&empty, 0, BUFFER_SIZE); // Set empty slots to BUFFER_SIZE
    sem_init(&full, 0, 0); // No items available initially

    pthread_t producer_thread, consumer_thread;

    // Create threads
    pthread_create(&producer_thread, NULL, producer, NULL);
    pthread_create(&consumer_thread, NULL, consumer, NULL);

```

```
// Wait for threads to finish

pthread_join(producer_thread, NULL);

pthread_join(consumer_thread, NULL);


// Destroy semaphores

sem_destroy(&empty);

sem_destroy(&full);


return 0;

}
```

2.5.3 Output:

```
Produced:0
Produced:1
Produced:2
Produced:3
Produced:4
Consumed:0
Consumed:1
Consumed:2
Consumed:3
Consumed:4
Produced:5
Produced:6
Produced:7
Produced:8
Produced:9
Consumed:5
Consumed:6
Consumed:7
Consumed:8
Consumed:9
```


2.6 Experiment – 6

2.6.1 Question:

Write a C program to simulate the concept of Dining-Philosophers problem.

2.6.2 Code:

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

sem_t room;
sem_t chopstick[5];

void * philosopher(void *);
void eat(int);
int main()
{
    int i,a[5];
    pthread_t tid[5];

    sem_init(&room,0,4);

    for(i=0;i<5;i++)
        sem_init(&chopstick[i],0,1);

    for(i=0;i<5;i++){
        a[i]=i;
        pthread_create(&tid[i],NULL,philosopher,(void *)&a[i]);
    }
    for(i=0;i<5;i++)
        pthread_join(tid[i],NULL);
}

void * philosopher(void * num)
{
    int phil=*(int *)num;

    sem_wait(&room);
    printf("\nPhilosopher %d has entered room",phil);
    sem_wait(&chopstick[phil]);
    sem_wait(&chopstick[(phil+1)%5]);

    eat(phil);
    sleep(2);
    printf("\nPhilosopher %d has finished eating",phil);

    sem_post(&chopstick[(phil+1)%5]);
    sem_post(&chopstick[phil]);
    sem_post(&room);
}
```

```
void eat(int phil)
{
printf("\nPhilosopher %d is eating",phil);
}
```

2.6.3 Output:

```
Philo 4 has entered the room.
Philo 4 has started eating.
Philo 3 has entered the room.
Philo 2 has entered the room.
Philo 1 has entered the room.
Philo 4 has finished eating.
Philo 0 has entered the room.
Philo 3 has started eating.
Philo 3 has finished eating.
Philo 2 has started eating.
Philo 2 has finished eating.
Philo 1 has started eating.
Philo 1 has finished eating.
Philo 0 has started eating.
Philo 0 has finished eating.
```

2.7 Experiment – 7

2.7.1 Question:

Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.

2.7.2 Code:

```
#include <stdio.h>

int main()
{
    int n, m, i, j, k;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    printf("Enter the number of resources: ");
    scanf("%d", &m);

    int allocation[n][m];
    printf("Enter the Allocation Matrix:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < m; j++)
        {
            scanf("%d", &allocation[i][j]);
        }
    }

    int max[n][m];
    printf("Enter the MAX Matrix:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < m; j++)
        {
            scanf("%d", &max[i][j]);
        }
    }

    int available[m];
    printf("Enter the Available Resources:\n");
    for (i = 0; i < m; i++)
    {
        scanf("%d", &available[i]);
    }

    int f[n], ans[n], ind = 0;
    for (k = 0; k < n; k++)
    {
        f[k] = 0;
    }

    int need[n][m];
    for (i = 0; i < n; i++)
    {
```

```

    for (j = 0; j < m; j++)
    {
        need[i][j] = max[i][j] - allocation[i][j];
    }
}

int y = 0;
for (k = 0; k < n; k++)
{
    for (i = 0; i < n; i++)
    {
        if (f[i] == 0)
        {
            int flag = 0;
            for (j = 0; j < m; j++)
            {
                if (need[i][j] > available[j])
                {
                    flag = 1;
                    break;
                }
            }

            if (flag == 0)
            {
                ans[ind++] = i;
                for (y = 0; y < m; y++)
                {
                    available[y] += allocation[i][y];
                }
                f[i] = 1;
            }
        }
    }
}

int flag = 1;
for (i = 0; i < n; i++)
{
    if (f[i] == 0)
    {
        flag = 0;
        printf("The following system is not safe\n");
        break;
    }
}

if (flag == 1)
{
    printf("Following is the SAFE Sequence\n");
    for (i = 0; i < n - 1; i++)
    {

```

```

        printf(" P%d ->", ans[i]);
    }
    printf(" P%d\n", ans[n - 1]);
}
return 0;
}

```

2.7.3 Output:

```

Enter the number of processes: 5
Enter the number of resources: 3
Enter the Allocation Matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter the MAX Matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Enter the Available Resources:
3 3 2
Following is the SAFE Sequence
P1 -> P3 -> P4 -> P0 -> P2

```

```

Enter the number of processes: 5
Enter the number of resources: 3
Enter the Allocation Matrix:
0 2 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter the MAX Matrix:
8 4 6
3 5 7
3 6 7
9 5 3
2 5 7
Enter the Available Resources:
3 2 2
The following system is not safe

```

2.8 Experiment – 8

2.8.1 Question:

Write a C program to simulate deadlock detection.

2.8.2 Code:

```
#include<stdio.h>

int max[100][100];
int allocation[100][100];
int need[100][100];
int available[100];
int n,r;

int main()
{
    int i,j;
    printf("Deadlock Detection\n");
    input();
    show();
    cal();
    return 0;
}

void input()
{
    int i,j;
    printf("Enter the no of Processes: ");
    scanf("%d",&n);
    printf("Enter the no of resource instances: ");
    scanf("%d",&r);
    printf("Enter the Max Matrix:\n");
    for(i=0;i<n;i++)
    {
        for(j=0;j<r;j++)
        {
            scanf("%d",&max[i][j]);
        }
    }
    printf("Enter the Allocation Matrix:\n");
    for(i=0;i<n;i++)
    {
        for(j=0;j<r;j++)
        {
            scanf("%d",&allocation[i][j]);
        }
    }
    printf("Enter the available Resources:\n");
    for(j=0;j<r;j++)
    {
        scanf("%d",&available[j]);
    }
}
```

```

}

void show()
{
    int i,j;
    printf("Process\t Allocation\t Max\t Available\t");
    for(i=0;i<n;i++)
    {
        printf("\nP%d\t ",i+1);
        for(j=0;j<r;j++)
        {
            printf("%d ",allocation[i][j]);
        }
        printf("\t");
        for(j=0;j<r;j++)
        {
            printf("%d ",max[i][j]);
        }
        printf("\t");
        if(i==0)
        {
            for(j=0;j<r;j++)
                printf("%d ",available[j]);
        }
    }
}

void cal()
{
    int finish[100],temp,need[100][100],flag=1,k,c1=0;
    int dead[100];
    int safe[100];
    int i,j;
    for(i=0;i<n;i++)
    {
        finish[i]=0;
    }

    for(i=0;i<n;i++)
    {
        for(j=0;j<r;j++)
        {
            need[i][j]=max[i][j]-allocation[i][j];
        }
    }
    while(flag)
    {
        flag=0;
        for(i=0;i<n;i++)
        {
            int c=0;
            for(j=0;j<r;j++)

```

```

    {
        if((finish[i]==0)&&(need[i][j]<=available[j]))
        {
            c++;
            if(c==r)
            {
                for(k=0;k<r;k++)
                {
                    available[k]+=allocation[i][j];
                    finish[i]=1;
                    flag=1;
                }
                if(finish[i]==1)
                {
                    i=n;
                }
            }
        }
    }
}

j=0;
flag=0;
for(i=0;i<n;i++)
{
    if(finish[i]==0)
    {
        dead[j]=i;
        j++;
        flag=1;
    }
}
if(flag==1)
{
    printf("\n\nSystem is in Deadlock and the Deadlock process are\n");
    for(i=0;i<n;i++)
    {
        printf("P%d\t",dead[i]);
    }
}
else
{
    printf("\nNo Deadlock Occur");
}
}

```


2.8.3 Output:

```
Deadlock Detection
Enter the no of Processes: 3
Enter the no of resource instances: 3
Enter the Max Matrix:
3 6 8
4 3 3
3 4 4
Enter the Allocation Matrix:
3 3 3
2 0 4
1 2 4
Enter the available Resources:
1 2 0
Process  Allocation      Max      Available
P0       3 3 3          3 6 8      1 2 0
P1       2 0 4          4 3 3
P2       1 2 4          3 4 4

System is in Deadlock and the Deadlock process are
P0      P1      P2
```

```
Deadlock Detection
Enter the no of Processes: 5
Enter the no of resource instances: 3
Enter the Max Matrix:
0 0 0
2 0 2
0 0 0
1 0 0
0 0 2
Enter the Allocation Matrix:
0 1 0
2 0 0
3 0 3
3 1 1
0 0 2
Enter the available Resources:
0 0 0
Process  Allocation      Max      Available
P0       0 1 0          0 0 0      0 0 0
P1       2 0 0          2 0 2
P2       3 0 3          0 0 0
P3       3 1 1          1 0 0
P4       0 0 2          0 0 2
No Deadlock Occur
```

2.9 Experiment – 9

2.9.1 Question:

Write a C program to simulate the following contiguous memory allocation techniques:

(a) Worst-fit

(b) Best-fit

(c) First-fit

2.9.2 Code:

(a) Worst-fit

```
#include<stdio.h>
void main()
{
    int n,m,i,j;
    printf("Enter the number of processes and number of blocks:\n");
    scanf("%d %d",&n,&m);
    int all[n],blockSize[m],processSize[n];
    printf("Enter %d process sizes:\n",n);
    for(i=0;i<n;i++)
    {
        scanf("%d",&processSize[i]);
        all[i]=-1;
    }
    printf("Enter %d block sizes:\n",m);
    for(j=0;j<m;j++)
    {
        scanf("%d",&blockSize[j]);
    }

    //Since this is worst fit, the largest available partition should be allocated. So we can sort the block sizes
    in descending order.
    for(i=0;i<m-1;i++)
    {
        for(j=0;j<m-i-1;j++)
        {
            if(blockSize[j]<=blockSize[j+1])
            {
                int temp=blockSize[j];
                blockSize[j]=blockSize[j+1];
                blockSize[j+1]=temp;
            }
        }
    }
    for(i=0;i<n;i++)
    {
        for(j=0;j<m;j++)
        {
            if(blockSize[j]>=processSize[i])
            {
```

```

        all[i]=blockSize[j];
        blockSize[j]=-1;
        break;
    }
}
}
printf("****Worst fit memory allocation****\n");
printf("ProcessID\tProcess_Size\tBlock_size_allocated\n");
for(i=0;i<n;i++)
{
    printf("P%d\t\t", (i+1));
    printf("%d\t\t", processSize[i]);
    if(all[i]==-1)
        printf("Not allocated\n");
    else
        printf("%d\n", all[i]);
}
}

```

(b) Best-fit

```

#include<stdio.h>
void main()
{
    int n,m,i,j;
    printf("Enter the number of processes and number of blocks:\n");
    scanf("%d %d",&n,&m);
    int all[n],blockSize[m],processSize[n];
    printf("Enter %d process sizes:\n",n);
    for(i=0;i<n;i++)
    {
        scanf("%d",&processSize[i]);
        all[i]=-1;
    }
    printf("Enter %d block sizes:\n",m);
    for(j=0;j<m;j++)
    {
        scanf("%d",&blockSize[j]);
    }
}

```

/*Since this is best fit, the smallest partition which is adequate is allocated to the processes. So we can sort the blockSizes

```

in ascending order. */
for(i=0;i<m-1;i++)
{
    for(j=0;j<m-i-1;j++)
    {
        if(blockSize[j]>blockSize[j+1])
        {
            int temp=blockSize[j];
            blockSize[j]=blockSize[j+1];
            blockSize[j+1]=temp;
        }
    }
}

```

```

    }
}
}
for(i=0;i<n;i++)
{
    for(j=0;j<m;j++)
    {
        if(blockSize[j]>=processSize[i])
        {
            all[i]=blockSize[j];
            blockSize[j]=-1;
            break;
        }
    }
}
printf("*****Best fit memory allocation*****\n");
printf("ProcessID\tProcess_Size\tBlock_size_allocated\n");
for(i=0;i<n;i++)
{
    printf("P%d\t\t", (i+1));
    printf("%d\t\t", processSize[i]);
    if(all[i]==-1)
        printf("Not allocated\n");
    else
        printf("%d\n", all[i]);
}
}

```

(c) First-fit

```

#include<stdio.h>
void main()
{
    int n,m,i,j,c=0;
    printf("Enter the number of processes and number of blocks:\n");
    scanf("%d %d",&n,&m);
    int all[n];
    for(int i=0;i<n;i++)
    {
        all[i]=-1;
    }
    int blockSize[m],processSize[n];
    printf("Enter the %d block sizes:\n",m);
    for(j=0;j<m;j++)
    {
        scanf("%d",&blockSize[j]);
    }
    printf("Enter the %d process sizes:\n",n);
    {
        for(i=0;i<n;i++)
        {
            scanf("%d",&processSize[i]);
        }
    }
}

```

```

    }
    for(i=0;i<n;i++)
    {
        for(j=0;j<m;j++)
        {
            if(blockSize[j]>=processSize[i])
            {
                all[i]=blockSize[j];
                blockSize[j]=-1;
                break;
            }
        }
    }
    printf("****First fit memory allocation****\n");
    printf("ProcessId\tProcessSize\tBlock_Size_allocated\n");
    for(i=0;i<n;i++)
    {
        printf("P%d\t\t", (i+1));
        printf("%d\t\t", processSize[i]);
        if(all[i]!=-1)
            printf("%d\n", all[i]);
        else
            printf("Not allocated\n");
    }
}

```

2.9.3 Output:

(a) Worst-fit

```
Enter the number of processes and number of blocks:
4 5
Enter 4 process sizes:
212 417 112 426
Enter 5 block sizes:
100 500 200 300 600
****Worst fit memory allocation****
ProcessID      Process_Size  Block_size_allocated
P1              212             600
P2              417             500
P3              112             300
P4              426             Not allocated
```

(b) Best-fit

```
Enter the number of processes and number of blocks:
4 5
Enter 4 process sizes:
212 417 112 426
Enter 5 block sizes:
100 500 200 300 600
****Best fit memory allocation****
ProcessID      Process_Size  Block_size_allocated
P1              212             300
P2              417             500
P3              112             200
P4              426             600
```

(c) First-fit

```
Enter the number of processes and number of blocks:
4 5
Enter the 5 block sizes:
100 500 200 300 600
Enter the 4 process sizes:
212 417 112 426
****First fit memory allocation****
ProcessId      ProcessSize  Block_Size_allocated
P1              212             500
P2              417             600
P3              112             200
P4              426             Not allocated
```

2.10 Experiment – 10

2.10.1 Question:

Write a C program to simulate paging technique of memory management.

2.10.2 Code:

```
#include<stdio.h>
#define MAX 50
int main()
{
    int page[MAX],i,n,f,ps,off,pno;
    int choice=0;
    printf("Enter the number of pages in memory: ");
    scanf("%d",&n);
    printf("\nEnter Page size: ");
    scanf("%d",&ps);

    printf("\nEnter number of frames: ");
    scanf("%d",&f);
    for(i=0;i<n;i++)
        page[i]=-1;

    printf("\nEnter the Page Table\n");
    printf("(Enter frame no as -1 if that page is not present in any frame)\n\n");

    printf("\nPage No\t\tFrame No\n-----\t\t-----");
    for(i=0;i<n;i++)
    {
        printf("\n\n%d\t\t",i);
        scanf("%d",&page[i]);
    }

    do
    {
        printf("\n\nEnter the logical address(i.e,page no & offset):");
        scanf("%d%d",&pno,&off);

        if(page[pno]==-1)
            printf("\n\nThe required page is not available in any of frames");
        else
            printf("\nPhysical address(i.e,frame no & offset):%d,%d",page[pno],off);

        printf("\n\nDo you want to continue(1/0)?");
        scanf("%d",&choice);
    }while(choice==1);

    return 1;
}
```

2.10.3 Output:

```
Enter the number of pages in memory: 4

Enter Page size: 10

Enter number of frames: 4

Enter the Page Table
(Enter frame no as -1 if that page is not present in any frame)

Page No      Frame No
-----      -
0            -1
1            8
2            5
3            2
```

```
Enter the logical address(i.e,page no & offset):0 100

The required page is not available in any of frames

Do you want to continue(1/0)?:1

Enter the logical address(i.e,page no & offset):1 25

Physical address(i.e,frame no & offset):8,25

Do you want to continue(1/0)?:1

Enter the logical address(i.e,page no & offset):2 352

Physical address(i.e,frame no & offset):5,352

Do you want to continue(1/0)?:1

Enter the logical address(i.e,page no & offset):3 20

Physical address(i.e,frame no & offset):2,20

Do you want to continue(1/0)?:0
```


2.11 Experiment – 11

2.11.1 Question:

Write a C program to simulate page replacement algorithms:

- (a) FIFO
- (b) LRU
- (c) Optimal

2.11.2 Code:

(a) FIFO

```
#include<stdio.h>

int isHit(int fr[], int pg, int m)
{
    int hit=0;
    for(int i=0;i<m;i++)
    {
        if(fr[i]==pg)
        {
            hit=1;
            break;
        }
    }
    return hit;
}

void main()
{
    int n,m,k=0,pagefault=0;
    printf("Enter the length of reference sequence:\n");
    scanf("%d",&n);
    int ref[n];
    printf("Enter the page reference sequence:\n");
    for(int i=0;i<n;i++)
    {
```

```

scanf("%d",&ref[i]);
}
printf("Enter the number of frames:\n");
scanf("%d",&m);
int fr[m];
for(int i=0;i<m;i++)
{
    fr[i]=-1;
}
for(int i=0;i<n;i++)
{
    //if it is not a hit

    if(isHit(fr,ref[i],m)==0)
    {
        fr[k]=ref[i];
        k=(k+1)%m; //since this is first come first serve.
        pagefault++;
        printf("%d:Page Fault\n",ref[i]);
    }
    else
        printf("%d:No page fault\n",ref[i]);
}
printf("Total number of page faults:%d\n",pagefault);
}

```

(b) Optimal

```
#include<stdio.h>

int isHit(int fr[], int pg, int m)
{
    int hit=0;
    for(int i=0;i<m;i++)
    {
        if(fr[i]==pg)
        {
            hit=1;
            break;
        }
    }
    return hit;
}

void main()
{
    int i,n,m,k,j,pagfault=0,max=-1,x,y,flag=0,count=0,u;
    printf("Enter the length of reference sequence:\n");
    scanf("%d",&n);
    int ref[n];
    printf("Enter the page reference sequence:\n");
    for(i=0;i<n;i++)
    {
        scanf("%d",&ref[i]);
    }
    printf("Enter the number of frames:\n");
    scanf("%d",&m);
    int fr[m];
    for(i=0;i<m;i++)
    {
        fr[i]=-1;
```

```

}
u=0;
y=0;
while(count<m)
{
    if(isHit(fr,ref[u],m)==0)
    {
        fr[y]=ref[u];
        printf("%d:Page fault\n",ref[u]);
        u++;
        y++;
        count++;
        pagefault++;
    }
    else
    {
        printf("%d:No page fault\n",ref[u]);
        u++;
    }
}
for(i=u;i<n;i++)
{
    if(isHit(fr,ref[i],m)==0)
    {
        for(j=0;j<m;j++)
        {
            for(k=i+1;k<n;k++)
            {
                if(fr[j]==ref[k])//as soon as match happens, break.
                {
                    flag=1;
                    break;

```

```

    }
    else if(k==n-1 && fr[j]!=ref[k])//if there is no demand of a particular page in future, just
replace that.
    {
        flag=-1;
        fr[j]=ref[i];
        break;
    }
}
if(flag==1)//if there is no demand, directly replaced, no need to check other pages in the frames.
break;
else if(flag==1 && k>max)
{
    max=k;
    x=j;
}
}
max=-1; //reset max for other iterations
if(flag!=1
{
    fr[x]=ref[i];
}
pagefault++;
printf("%d:Page fault\n",ref[i]);
}
else
{
    printf("%d:No page fault\n",ref[i]);
}
}
printf("Total no of page faults:%d\n",pagefault);
}

```

(c) LRU

```
#include<stdio.h>

int isHit(int fr[], int pg, int m)
{
    int hit=0;
    for(int i=0;i<m;i++)
    {
        if(fr[i]==pg)
        {
            hit=1;
            break;
        }
    }
    return hit;
}

void main()
{
    int i,n,m,k,j,pagfault=0,min=999,x,y,count=0,u=0;
    printf("Enter the length of reference sequence:\n");
    scanf("%d",&n);
    int ref[n];
    printf("Enter the page reference sequence:\n");
    for(i=0;i<n;i++)
    {
        scanf("%d",&ref[i]);
    }
    printf("Enter the number of frames:\n");
    scanf("%d",&m);
    int fr[m];
    for(i=0;i<m;i++)
    {
        fr[i]=-1;
    }
}
```

```

}
y=0;
u=0;
while(count<m)
{
    if(isHit(fr,ref[u],m)==0)
    {
        fr[y]=ref[u];
        printf("%d:Page Fault\n",ref[u]);
        y++;
        u++;
        pagefault++;
        count++;

    }
    else
    {
        printf("%d:No page fault\n",ref[u]);
        u++;
    }
}
for(i=u;i<n;i++)
{
    if(isHit(fr,ref[i],m)==0)
    {
        for(j=0;j<m;j++)//for every element in the frames, check which index is the least.
        {
            for(k=i-1;k>=0;k--)//to check which index is the least, for each number in the frame, we need to
            start checking from i-1 only.
            {
                if(fr[j]==ref[k])
                {

```

```

        break;
    }
}
if(k<min) /*agar pg no ki index min se kam ho, iska matlab ye hai ki uski demand sabse pehele
hua tha,
sirf tabhi min ko update karna*/
{
    x=j;
    min=k;
}
}
min=999; //reset min for other iterations
fr[x]=ref[i];
pagefault++;
printf("%d:Page fault\n",ref[i]);
}
else
{
    printf("%d:No page fault\n",ref[i]);
}
}
printf("Total number page faults:%d\n",pagefault);
}

```


2.11.3 Output:

(a) FIFO:

```
Enter the length of reference sequence:
20
Enter the page reference sequence:
7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
Enter the number of frames:
4
7:Page Fault
0:Page Fault
1:Page Fault
2:Page Fault
0:No page fault
3:Page Fault
0:No page fault
4:Page Fault
2:No page fault
3:No page fault
0:Page Fault
3:No page fault
2:No page fault
1:Page Fault
2:Page Fault
0:No page fault
1:No page fault
7:Page Fault
0:No page fault
1:No page fault
Total number of page faults:10
```

(b) OPTIMAL:

```
Enter the length of reference sequence:
20
Enter the page reference sequence:
7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
Enter the number of frames:
4
7:Page fault
0:Page fault
1:Page fault
2:Page fault
0:No page fault
3:Page fault
0:No page fault
4:Page fault
2:No page fault
3:No page fault
0:No page fault
3:No page fault
2:No page fault
1:Page fault
2:No page fault
0:No page fault
1:No page fault
7:Page fault
0:No page fault
1:No page fault
Total no of page faults:8
```

(c) LRU:

```
Enter the length of reference sequence:
20
Enter the page reference sequence:
7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
Enter the number of frames:
4
7:Page Fault
0:Page Fault
1:Page Fault
2:Page Fault
0:No page fault
3:Page fault
0:No page fault
4:Page fault
2:No page fault
3:No page fault
0:No page fault
3:No page fault
2:No page fault
1:Page fault
2:No page fault
0:No page fault
1:No page fault
7:Page fault
0:No page fault
1:No page fault
Total number page faults:8
```

2.12 Experiment - 12

2.12.1 Question:

Write a C program to simulate disk scheduling algorithms:

- (a) FCFS
- (b) SCAN
- (c) c-SCAN

2.12.2 Code:

(a) FCFS:

```
#include<stdio.h>
#include<stdlib.h>
void main()
{
    int tr,n,total=0,curr;
    printf("Enter the total no of tracks in the disk:\n");
    scanf("%d",&tr);
    printf("Enter the number of requests in the request queue:\n");
    scanf("%d",&n);
    int arr[n];
    printf("Enter the request sequence:\n");
    for(int i=0;i<n;i++)
    {
        scanf("%d",&arr[i]);
    }
    printf("Enter the current head positon of the disk arm:\n");
    scanf("%d",&curr);
    for(int i=0;i<n;i++)
    {
        printf("The head moves from track %d to %d with seek time %d units\n",curr,arr[i], abs(arr[i]-curr));
        total+=abs(arr[i]-curr);
        curr=arr[i];
    }
    printf("The total head movements using FCFS scheduling are:%d\n",total);
}
```

(b) SCAN:

```
#include<stdio.h>
#include<stdlib.h>
void sortAsc(int arr[], int s,int e)
{
    int temp;
    for(int i=s;i<e-1;i++)
    {
        for(int j=s;j<e-i-1;j++)
        {
            if(arr[j]>arr[j+1])
            {
                temp=arr[j];
                arr[j]=arr[j+1];
                arr[j+1]=temp;
            }
        }
    }
}
```

```

    }
    }
}
void sortDesc(int arr[], int s,int e)
{
    int temp;
    for(int i=s;i<e-1;i++)
    {
        for(int j=s;j<e-i-1;j++)
        {
            if(arr[j]<arr[j+1])
            {
                temp=arr[j];
                arr[j]=arr[j+1];
                arr[j+1]=temp;
            }
        }
    }
}
void main()
{
    int tr,n,total=0,curr,dir,min,max,i,j,k;
    printf("Enter the total no of tracks in the disk:\n");
    scanf("%d",&tr);
    printf("Enter the number of requests in the request queue:\n");
    scanf("%d",&n);
    int arr[n],seek[n+1];
    printf("Enter the request sequence:\n");
    for(int i=0;i<n;i++)
    {
        scanf("%d",&arr[i]);
    }
    printf("Enter the current head positon of the disk arm:\n");
    scanf("%d",&curr);

    printf("Enter head movement direction(1 for High and 0 for Low):\n");
    scanf("%d",&dir);
    switch(dir)
    {
        case 1:
            //disk fulfills all the higher requests first, so the head reaches the higher end of disk and then changes
            direction.
            //That is why, we need to find the lower most request track.
            min=arr[0];
            for(i=1;i<n;i++)
            {
                if(arr[i]<min)
                min=arr[i];
            }
            for(i=0;i<=n;i++)
            {

```

```

        seek[i]=arr[i];
    }
    seek[n]=curr;
    printf("Seek sequence:\n");
    sortDesc(seek,0,n+1); //sort in descending order
    for(i=0;i<=n;i++)
    {
        if(seek[i]==curr)
            k=i;
    }
    sortAsc(seek,0,k);

    for(i=0;i<=n;i++)
    {
        printf("%d ",seek[i]);
    }
    printf("\n");
    total=(tr-1-curr)+(tr-1-min);
    printf("Total head movements using SCAN scheduling are:%d\n",total);
    break;

    case 0:
        //disk fulfills all the lower requests first, so the head reaches the lower end of disk and then changes
        direction.
        //That is why, we need to find the max request track.
        max=arr[0];
        for(i=1;i<n;i++)
        {
            if(arr[i]>max)
                max=arr[i];
        }
        total=(curr-0)+(max-0); //0 is the lower most track
        printf("Total head movements using SCAN scheduling are:%d\n",total);
        break;

    default:
        printf("Invalid choice:\n");
    }
}

```

(c) c-SCAN:

```

#include<stdio.h>
#include<stdlib.h>
#include<limits.h>

void main()
{
    int tr,n,total=0,curr,dir,min,max;

    printf("Enter the total no of tracks in the disk:\n");

```

```

scanf("%d",&tr);
printf("Enter the number of requests in the request queue:\n");
scanf("%d",&n);
int arr[n];
printf("Enter the request sequence:\n");
for(int i=0;i<n;i++)
{
    scanf("%d",&arr[i]);
}
printf("Enter the current head positon of the disk arm:\n");
scanf("%d",&curr);
printf("Enter head movement direction(1 for High and 0 for Low):\n");
scanf("%d",&dir);
switch(dir)
{
    case 1:
        //head first moves to the higher end of disk while the disk fulfills all the higher requests, changes
direction to
        //reach the lower end when th disk does not fulill any lower request. After reaching the lower end, the
head again
        //changes direction when the disk starts fulfilling lower requests.
        //So we need to find max request less than curr head position

        max=INT_MIN;
        for(int i=0;i<n;i++)
        {
            if(arr[i]<curr && arr[i]>max)
            {
                max=arr[i];
            }
        }
        total=(tr-1-curr)+(tr-1-0)+(max-0);
        printf("The total head movements using C-SCAN scheduling are:%d\n",total);

```

```

break;

case 0:
//reverse of case 1

min=INT_MAX;
for(int i=0;i<n;i++)
{
    if(arr[i]>50 && arr[i]<min)
    {
        min=arr[i];
    }
}
printf("Min:%d\n",min);
total=(curr-0)+(tr-1-0)+(tr-1-min);
printf("The total head movements using C-SCAN scheduling are:%d\n",total);
break;

default:
printf("Invalid choice!\n");
}
}

```

2.12.3 Output:

(a) FCFS:

```
Enter the total no of tracks in the disk:
200
Enter the number of requests in the request queue:
7
Enter the request sequence:
82 170 43 140 24 16 190
Enter the current head positon of the disk arm:
50
The total head movements are using FCFS scheduling:642
```

(b) SCAN:

```
Enter the total no of tracks in the disk:
200
Enter the number of requests in the request queue:
7
Enter the request sequence:
82 170 43 140 24 16 190
Enter the current head positon of the disk arm:
50
Enter head movement direction(1 for High and 0 for Low):
1
Seek sequence:
82 140 170 190 50 43 24 16
Total head movements using SCAN scheduling are:332
```

(c) C-SCAN:

```
Enter the total no of tracks in the disk:
200
Enter the number of requests in the request queue:
7
Enter the request sequence:
82 170 43 140 24 16 190
Enter the current head positon of the disk arm:
50
Enter head movement direction(1 for High and 0 for Low):
1
The total head movements using C-SCAN scheduling are:391
```


2.13 Experiment - 13

2.13.1 Question:

Write a C program to simulate disk scheduling algorithms:

- (a) SSTF
- (b) LOOK
- (c) C-LOOK

2.13.2 Code:

(a) SSTF:

```
#include<stdio.h>
#include<stdlib.h>
#include<limits.h>
void main()
{
    int tr,n,total=0,curr,min,count=0,d,ind,i,j=0;
    printf("Enter the total no of tracks in the disk:\n");
    scanf("%d",&tr);
    printf("Enter the number of requests in the request queue:\n");
    scanf("%d",&n);
    int arr[n],seek[n];
    printf("Enter the request sequence:\n");
    for(int i=0;i<n;i++)
    {
        scanf("%d",&arr[i]);
    }
    printf("Enter the current head positon of the disk arm:\n");
    scanf("%d",&curr);
    while(count!=n)
    {
        min=1000;
        for(i=0;i<n;i++)
        {
            if(abs(arr[i]-curr)<min)
            {
                min=abs(arr[i]-curr);
                ind=i;
            }
        }
        seek[j]=arr[ind];
        total+=min;
        curr=arr[ind];
        arr[ind]=1000;
        count++;
        j++;
    }
    printf("Safe sequence is:\n");
    for(i=0;i<n;i++)
    {
        printf("%d ",seek[i]);
    }
}
```

```

    }
    printf("\n");
    printf("Total number of movements using SSTF are:%d\n",total);
}

```

(b) LOOK:

```

#include<stdio.h>

#include<stdlib.h>

void main()
{
    int tr,n,total=0,curr,min,max,i,j=0,index;

    printf("Enter the total no of tracks in the disk:\n");

    scanf("%d",&tr);

    printf("Enter the number of requests in the request queue:\n");

    scanf("%d",&n);

    int arr[n],seek[n];

    printf("Enter the request sequence:\n");

    for(int i=0;i<n;i++)
    {
        scanf("%d",&arr[i]);
    }

    printf("Enter the current head positon of the disk arm:\n");

    scanf("%d",&curr);

    //direction considered- towards larger values first

    max=arr[0];

    min=arr[0];

    for(i=1;i<n;i++)
    {
        if(arr[i]>max)
        {
            max=arr[i];
        }

        if(arr[i]<min)
        {
            min=arr[i];
        }
    }
}

```

```

    }

}

total=(max-curr)+(max-min);

printf("Total number of movements using LOOK scheduling:%d\n",total);

}

```

(c) c-LOOK:

```

#include<stdio.h>

#include<stdlib.h>

#include<limits.h>

void main()

{

    int tr,n,total=0,curr,min,sec_max,i,j=0,index,max;

    printf("Enter the total no of tracks in the disk:\n");

    scanf("%d",&tr);

    printf("Enter the number of requests in the request queue:\n");

    scanf("%d",&n);

    int arr[n],seek[n];

    printf("Enter the request sequence:\n");

    for(int i=0;i<n;i++)

    {

        scanf("%d",&arr[i]);

    }

    printf("Enter the current head positon of the disk arm:\n");

    scanf("%d",&curr);

    //direction considered- towards larger values first

    max=arr[0];

    min=arr[0];

    for(i=1;i<n;i++)

    {

        if(arr[i]>max)

        {

            max=arr[i];

```

```

    }
    if(arr[i]<min)
    {
        min=arr[i];
    }
}
sec_max=INT_MIN;
for(i=0;i<n;i++)
{
    if(arr[i]<curr && arr[i]>sec_max)
    {
        sec_max=arr[i];
    }
}
printf("sec_max:%d\n",sec_max);
total=(max-curr)+(max-min)+(sec_max-min);

printf("Total number of movements using C-LOOK scheduling are:%d\n",total);
}

```

2.13.3 Output:

(a) SSTF:

```
Enter the total no of tracks in the disk:
200
Enter the number of requests in the request queue:
7
Enter the request sequence:
82 170 43 140 24 16 190
Enter the current head positon of the disk arm:
50
Safe sequence is:
43 24 16 82 140 170 190
Total number of movements using SSTF scheduling are:208
```

(b) LOOK:

```
Enter the total no of tracks in the disk:
200
Enter the number of requests in the request queue:
7
Enter the request sequence:
82 170 43 140 24 16 190
Enter the current head positon of the disk arm:
50
Total number of movements using LOOK scheduling are:314
```

(c) c-LOOK:

```
Enter the total no of tracks in the disk:
200
Enter the number of requests in the request queue:
7
Enter the request sequence:
82 170 43 140 24 16 190
Enter the current head positon of the disk arm:
50
sec_max:43
Total number of movements using C-LOOK scheduling are:341
```