VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT

on

Operating Systems

(22CS4PCOPS)

Submitted by:

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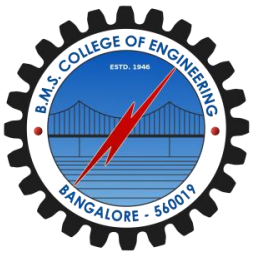
in partial fulfillment for the award of the degree of

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 **Unnati Bansal (1WA23CS025),** 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 2024-25. 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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Course Outcomes

CO1: Apply the different concepts and functionalities of OS

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.

Lab 1:

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

→FCFS

→ SJF (Non-preemptive)

→ SJF (Preemptive)

```
#include <stdio.h>


void calculateTimes(int processes[], int n, int at[], int bt[], int ct[], int tat[], int wt[]) {
    int completion = 0;

    for (int i = 0; i < n; i++) {
        if (completion < at[i]) {
            completion = at[i];
        }
        completion += bt[i];
        ct[i] = completion;
        tat[i] = ct[i] - at[i];
        wt[i]=tat[i]-bt[i];
    }
}


void displayResults(int processes[], int n, int at[], int bt[], int ct[], int tat[], int wt[]) {
    float total_tat = 0, total_wt = 0;

    printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\n");
    for (int i = 0; i < n; i++) {
        total_tat += tat[i];
        total_wt += wt[i];
        printf("%d\t%d\t%d\t%d\t%d\t%d\n", processes[i], at[i], bt[i], ct[i], tat[i], wt[i]);
    }

    printf("\nAverage Turnaround Time = %.2f", total_tat / n);
    printf("\nAverage Waiting Time = %.2f\n", total_wt / n);
}

int main() {
    int n ;
```

```
    printf("Enter no. of processes : ");
    scanf("%d",&n);
    int processes[n];
    for(int i=0;i<n;i++){
        processes[i]=i+1;
          }

    int at[n];
    for(int i=0;i<n;i++){
        printf("Enter arrival time of process %d : ",processes[i]);
        scanf("%d",&at[i]);
          }
    int bt[n];
    for(int i=0;i<n;i++){
        printf("Enter burst time of process %d : ",processes[i]);
        scanf("%d",&bt[i]);
          }
    int ct[n], tat[n], wt[n], rt[n];

    calculateTimes(processes, n, at, bt, ct, tat, wt);
    displayResults(processes, n, at, bt, ct, tat, wt);

    return 0;
}
```

Output:

```
Enter no. of processes : 4
Enter arrival time of process 1 : 0
Enter arrival time of process 2 : 0
Enter arrival time of process 3 : 0
Enter arrival time of process 4 : 0
Enter burst time of process 1 : 7
Enter burst time of process 2 : 3
Enter burst time of process 3 : 4
Enter burst time of process 4 : 6

Process AT      BT      CT      TAT     WT
1       0       7       7       7       0
2       0       3       10      10      7
3       0       4       14      14      10
4       0       6       20      20      14

Average Turnaround Time = 12.75
Average Waiting Time = 7.75
```

1) write a C program to stimulate the following CPU scheduling algorithm to find turnaround time and waiting time

a) FCFS

b) SJF (both preemptive and non-preemptive)

a)
```
#include <stdio.h>
void calculateTimes(int processes[], int n,
int at[], int bt[], int ct[], int tat[],
int wt[]) {
    for (int i=0; i<n; i++) {
        if (completion < at[i]){
            completion = at[i];
        }
        completion += bt[i];
        ct[i] = completion;
        tat[i] = ct[i] - at[i];
        wt[i] = tat[i] - bt[i];
    }
}
void displayResults(int processes[], int n,
int at[], int bt[], int ct[], int tat[],
int wt[]) {
    float total_tat = 0, total_wt = 0;
    printf("\n Process\tAT\tBT\tCT\tTAT\tWT\n");
    for (int i=0; i<n; i++) {
        total_tat += tat[i];
        total_wt += wt[i];
        printf("%d\t%d\t%d\t%d\t%d\t%d\n"
processes[i], at[i], bt[i], ct[i], tat[i], wt[i]);
```

```
    printf("\n Average Turnaround Time = %.2f", total_tat/n);
    printf("\n Average Waiting Time = %.2f\n", total_wt/n);
}
int main() {
    int n;
    printf("Enter no. of processes : ");
    scanf("%d", &n);
    int processes[n];
    for(int i=0; i<n; i++) {
        processes[i] = i+1;
    }
    int at[n];
    for(int i=0; i<n; i++) {
        printf("Enter arrival time of process %d",
                processes[i]);
        scanf("%d", &at[i]);
    }
    int bt[n];
    for(int i=0; i<n; i++) {
        printf("Enter burst time of process %d",
                processes[i]);
        scanf("%d", &bt[i]);
    }
    int ct[n], tat[n], wt[n], rt[n];
    calculateTimes(processes, n, at, bt, ct, tat, wt);
    displayResults(processes, n, at, bt, ct, tat, wt);
    return 0;
}
```

Output

```
Enter no. of processes : 4
Enter arrival time of process 1 : 0
Enter arrival time of process 2 : 0
Enter arrival time of process 3 : 0
Enter arrival time of process 4 : 0
Enter burst time of process 1 : 7
Enter burst time of process 2 : 3
Enter burst time of process 3 : 4
Enter burst time of process 4 : 6
```

Process	AT	BT	CT	TAT	WT
1	0	7	7	7	0
2	0	3	10	10	7
3	0	4	14	14	10
4	0	6	20	20	14

Average Turnaround Time = 12.75
Average Waiting Time = 7.75

6) i) Non preemptive SJF

```
#include<stdio.h>
typedef struct{
   int id, AT, BT, TAT, RT, CT, WT;
}Process;

void sorted(Process p[], int n)
{
   int i, j;
   for(i = 0; i < n-1; i++)
   {
      for(j = 0; j < n-i-1; j++)
      {
         if(p[j].AT > p[j+1].AT)
         {
            Process temp = p[j];
            p[j] = p[j+1];
            p[j+1] = temp;
         }
      }
   }
}

void SJFNonPreemptive(Process p[], int n)
{
   int TotalTAT = 0, TotalWT = 0, time = 0, completed = 0, i;
   int remainingBT[n];
   for(i = 0; i < n; i++)
   {
      remainingBT[i] = p[i].BT;
   }

   while(completed < n)
   {
      int minBTIndex = -1;
      int minBT = 9999;
      for(i = 0; i < n; i++)
      {
         if(p[i].AT <= time && remainingBT[i] > 0 && remainingBT[i] < minBT)
         {
            minBT = remainingBT[i];
```

```
            minBTIndex = i;
        }
    }

    if(minBTIndex != -1)
    {
        time += p[minBTIndex].BT;
        p[minBTIndex].CT = time;
        p[minBTIndex].TAT = p[minBTIndex].CT - p[minBTIndex].AT;
        p[minBTIndex].WT = p[minBTIndex].TAT - p[minBTIndex].BT;
        TotalTAT += p[minBTIndex].TAT;
        TotalWT += p[minBTIndex].WT;
        remainingBT[minBTIndex] = 0;
        completed++;
    }
    else
    {
        time++;
    }
}

float avgTAT = (float)TotalTAT / n;
float avgWT = (float)TotalWT / n;
printf("Average TurnAround Time: %f\n", avgTAT);
printf("Average Waiting Time: %f\n", avgWT);
}

int main()
{
int n, i;
printf("Enter the number of processes: ");
scanf("%d", &n);
Process p[n];

for(i = 0; i < n; i++)
{
    p[i].id = i+1;
    printf("Enter arrival time and burst time for process %d: ", i+1);
    scanf("%d %d", &p[i].AT, &p[i].BT);
}
```

```
    sorted(p, n);
    SJFNonPreemptive(p, n);

    return 0;
}
```

Output:

```
Enter the number of processes: 4
Enter arrival time and burst time for process 1: 0 7
Enter arrival time and burst time for process 2: 8 3
Enter arrival time and burst time for process 3: 3 4
Enter arrival time and burst time for process 4: 5 6
Average TurnAround Time: 9.000000
Average Waiting Time: 4.000000

Process returned 0 (0x0)   execution time : 41.377 s
Press any key to continue.
```

b) i) Non preemptive SJF

```
#include <stdio.h>
typedef struct {
    int id, AT, BT, TAT, RT, CT, WT;
} Process;
void sorted (Process p[], int n)
    {
        int i, j;
        for (i=0; i<n-1; i++)
            {
                for (j=0; j<n-i-1; j++)
                    {
                        if (p[j].AT > p[j+1].AT)
```

```
            {
                Process temp = p[j];
                p[j] = p[j+1];
                p[j+1] = temp;
            }
        }
    }
}
void SJFNonPreemptive (Process p[], int n)
    {
    int totalTAT = 0, totalWT = 0, time = 0,
        completed = 0, i;
    int remainingBT[n];
    for (i=0; i<n; i++)
        {
            remainingBT[i] = p[i].BT;
        }
    while (completed < n)
        {
            int minBTIndex = -1;
            int minBT = 9999;
            for (i=0; i<n; i++)
                {
                if (p[i].AT <= time && remainingBT[i]>0
                        && remainingBT[i] < minBT)
                    {
                        minBT = remainingBT[i];
                        minBTIndex = i;
                    }
                }
```

```
if (minBTIndex != -1)
  {
    time += p[minBTIndex].BT;
    p[minBTIndex].CT = time;
    p[minBTIndex].TAT = p[minBTIndex].CT -
                        p[minBTIndex].AT;

    p[minBTIndex].WT = p[minBTIndex].TAT -
                       p[minBTIndex].BT;

    totalTAT += p[minBTIndex].TAT;
    totalWT += p[minBTIndex].WT;
    remainingBT[minBTIndex] = 0;
    completed ++;
  }
  else
    {
      time++;
    }
  }
float avgTAT = (float) totalTAT/n;
float avgWT = (float) totalWT/n;
printf ("Average TurnAround Time : %f\n", avgTAT);
printf ("Average Waiting Time : %f\n", avgWT);
}
int main () {
    int n, i;
    printf ("Enter the number of processes : ");
    scanf ("%d", &n);
    Process p[n];
```

```
for (i=0; i<n; i++)
   {
    p[i].id = i+1;
    printf ("Enter arrival time and burst
      time for process %d: ", i+1);
    scanf ("%d %d", &p[i].AT, &p[i].BT);
   }
  sorted (p,n);
  SJF NonPreemptive (p,n);

  return 0;
}
```

Output

```
Enter the number of processes : 4
Enter arrival time and burst time for
  process 1 : 0 7
Enter arrival time and burst time for
  process 2 : 8 3
Enter arrival time and burst time for
  process 3 : 3 4
Enter arrival time and burst time for
  process 4 : 5 6
Average TurnAround Time : 9.00
Average Waiting Time : 4.00
```

```
#include<stdio.h>
typedef struct{
   int id, AT, BT, TAT, RT, CT, WT, tempBT;
}Process;

void sorted(Process p[], int n)
{
   int i, j;
   for(i = 0; i < n-1; i++)
   {
      for(j = 0; j < n-i-1; j++)
      {
         if(p[j].AT > p[j+1].AT)
         {
            Process temp = p[j];
            p[j] = p[j+1];
            p[j+1] = temp;
         }
      }
   }
}

void SJFPreemptive(Process p[], int n)
{
   int TotalTAT = 0, TotalWT = 0, time = 0, completed = 0, i, minBTIndex;
   int remainingBT[n];
   for(i = 0; i < n; i++)
   {
      remainingBT[i] = p[i].BT;
   }

   while(completed < n)
   {
      minBTIndex = -1;
      int minBT = 9999;
      for(i = 0; i < n; i++)
      {
         if(p[i].AT <= time && remainingBT[i] > 0 && remainingBT[i] < minBT)
         {
            minBT = remainingBT[i];
            minBTIndex = i;
         }
      }

      if(minBTIndex != -1)
      {
         remainingBT[minBTIndex]--;
         time++;
         if(remainingBT[minBTIndex] == 0)
```

```
            {
                completed++;
                p[minBTIndex].CT = time;
                p[minBTIndex].TAT = p[minBTIndex].CT - p[minBTIndex].AT;
                p[minBTIndex].WT = p[minBTIndex].TAT - p[minBTIndex].BT;
                TotalTAT += p[minBTIndex].TAT;
                TotalWT += p[minBTIndex].WT;
            }
        }
        else
        {
            time++;
        }
    }

    float avgTAT = (float)TotalTAT / n;
    float avgWT = (float)TotalWT / n;
    printf("Average TurnAround Time: %f\n", avgTAT);
    printf("Average Waiting Time: %f\n", avgWT);
}

int main()
{
    int n, i;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    Process p[n];

    for(i = 0; i < n; i++)
    {
        p[i].id = i+1;
        printf("Enter arrival time and burst time for process %d: ", i+1);
        scanf("%d %d", &p[i].AT, &p[i].BT);
    }

    sorted(p, n);
    SJFPreemptive(p, n);

    return 0;
}
```

Output:

```
Enter the number of processes: 4
Enter arrival time and burst time for process 1: 0 8
Enter arrival time and burst time for process 2: 1 4
Enter arrival time and burst time for process 3: 2 9
Enter arrival time and burst time for process 4: 3 5
Average TurnAround Time: 13.000000
Average Waiting Time: 6.500000
```

ii) SJF Preemptive (SRTF)

```
#include <stdio.h>
typedef struct {
    int id, AT, BT, CT, TAT, RT, WT, tempBT;
} Process;
void sorted (Process p[], int n)
{
    int i, j;
    for (i=0; i<n-1; i++)
    {
        for (j=0; j<n-i-1; j++)
        {
            if (p[j].AT > p[j+1].AT)
            {
                Process temp = p[j];
                p[j] = p[j+1];
                p[j+1] = temp;
            }
        }
    }
}
void SJFPreemptive (Process p[], int n)
{
    int TotalTAT = 0, TotalWT = 0, time = 0,
        completed = 0, i, minBTIndex;
    int remainingBT[n];
    for (i=0; i<n; i++)
    {
        remainingBT[i] = p[i].BT;
    }
```

```
while (completed < n)
  {
    minBTIndex = -1;
    int minBT = 9999;
    for (i=0; i<n; i++)
      {
      if (p[i].AT <= time && remainingBT[i]>0
          && remainingBT[i] < minBT)
      {
        minBT = remainingBT[i];
        minBTIndex = i;
      }
    }
  if (minBTIndex != -1)
    {
      remainingBT[minBTIndex]--;
      time++;
      if (remainingBT[minBTIndex] == 0)
      {
        completed++;
        p[minBTIndex].CT = time;
        p[minBTIndex].TAT = p[minBTIndex].CT -
                            p[minBTIndex].AT
        p[minBTIndex].WT = p[minBTIndex].TAT -
                           p[minBTIndex].BT
      TotalTAT += p[minBTIndex].TAT;
      TotalWT += p[minBTIndex].WT;
    }
  }
```

```
    else {
        time++;
    }
}
float avgTAT = (float) TotalTAT / n;
float avgWT = (float) TotalWT / n;
printf("Average TurnAround Time : %f\n", avgTAT);
printf("Average Waiting Time : %f\n", avgWT);
}
int main()
{
    int n, i;
    printf("Enter the number of processes : ");
    scanf("%d", &n);
    Process p[n];
    for(i=0; i<n; i++)
    {
        p[i].id = i+1;
        printf("Enter arrival time and burst
time for process %d :", i+1);
        scanf("%d %d", &p[i].AT, &p[i].BT);
    }
sorted(p, n);
SJFPreemptive(p, n);
return 0;
}
```

Output

```
Enter the number of processes : 4
Enter arrival time and burst time for
process 1 :  0  8
Enter arrival time and burst time for
process 2 :  1  4
Enter arrival time and burst time for
process 3 :  2  9
Enter arrival time and burst time for
process 4 :  3  5

Average TurnAround Time : 13.00
Average Waiting Time : 6.50
```

Lab 2 :

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

(a) Priority Scheduling (Non Preemptive)

(b) Priority Scheduling (Preemptive)

```
#include <stdio.h>

struct Process {
   int id, arrival_time, burst_time, priority;
   int completion_time, turnaround_time, waiting_time;
   int is_completed;
};

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

   struct Process p[n];
   for (int i = 0; i < n; i++) {
      p[i].id = i + 1;
      printf("\nEnter Arrival Time, Burst Time and Priority for Process %d: ", p[i].id);
      scanf("%d %d %d", &p[i].arrival_time, &p[i].burst_time, &p[i].priority);
      p[i].is_completed = 0;
   }

   int current_time = 0, completed = 0;
   float total_tat = 0, total_wt = 0;

   while (completed < n) {
      int selected = -1;
      int min_priority = 9999;

      for (int i = 0; i < n; i++) {
         if (p[i].arrival_time <= current_time && !p[i].is_completed) {
            if (p[i].priority < min_priority ||
              (p[i].priority == min_priority && p[i].arrival_time < p[selected].arrival_time)) {
               min_priority = p[i].priority;
               selected = i;
```

```
            }
        }
    }

    if (selected == -1) {
        current_time++; // No process is available now, so CPU is idle
    } else {
        p[selected].completion_time = current_time + p[selected].burst_time;
        p[selected].turnaround_time = p[selected].completion_time - p[selected].arrival_time;
        p[selected].waiting_time = p[selected].turnaround_time - p[selected].burst_time;
        p[selected].is_completed = 1;
        current_time = p[selected].completion_time;
        completed++;

        total_tat += p[selected].turnaround_time;
        total_wt += p[selected].waiting_time;
    }
}

// Display Results
printf("\nProcess\tAT\tBT\tPriority\tCT\tTAT\tWT\n");
for (int i = 0; i < n; i++) {
    printf("P%d\t%d\t%d\t%d\t\t%d\t%d\t%d\n",
           p[i].id, p[i].arrival_time, p[i].burst_time,
           p[i].priority, p[i].completion_time,
           p[i].turnaround_time, p[i].waiting_time);
}

printf("\nAverage Turnaround Time: %.2f", total_tat / n);
printf("\nAverage Waiting Time: %.2f\n", total_wt / n);

return 0;
}
```

Output:

```
Enter the number of processes: 4

Enter Arrival Time, Burst Time and Priority for Process 1: 0 5 4

Enter Arrival Time, Burst Time and Priority for Process 2: 2 4 2

Enter Arrival Time, Burst Time and Priority for Process 3: 2 2 6

Enter Arrival Time, Burst Time and Priority for Process 4: 4 4 3

Process AT      BT      Priority        CT      TAT     WT
P1      0       5       4               5       5       0
P2      2       4       2               9       7       3
P3      2       2       6               15      13      11
P4      4       4       3               13      9       5

Average Turnaround Time: 8.50
Average Waiting Time: 4.75
```

Write C programs to demonstrate
a) Non Preemptive Priority Scheduling
b) Preemptive Priority Scheduling.

a)
```
#include <stdio.h>
struct Process {
    int id, arrival_time, burst_time, priority;
    int completion_time, turnaround_time, waiting_time;
    int is_completed;
};
int main() {
    int n;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    struct Process p[n];
    for (int i=0; i<n; i++) {
        p[i].id = i+1;
        printf("\n Enter Arrival Time, Burst Time
          and Priority for Process %d: ", p[i].id);
        scanf("%d %d %d", &p[i].arrival_time,
          &p[i].burst_time, &p[i].priority);
        p[i].is_completed = 0;
    }
    int current_time = 0, completed = 0;
    float total_tat = 0, total_wt = 0;
    while (completed < n) {
        int selected = -1;
        int min_priority = 9999;
```

```
for (int i=0; i<n; i++) {
  if (p[i].arrival_time <= current_time && !p[i].is_completed) {
    if (p[i].priority < min_priority ||
      (p[i].priority == min_priority &&
      p[i].arrival_time < p[selected].arrival_time))
    {
      min_priority = p[i].priority;
      selected = i;
    }
  }
}
if (selected == -1) {
  current_time++;
} else {
p[selected].completion_time = current_time +
                    p[selected].burst_time;
p[selected].turnaround_time = p[selected].
                    completion_time - p[selected].
                    arrival_time;
p[selected].waiting_time = p[selected].turnaround_ti
                    - p[selected].burst_time;
p[selected].is_completed = 1;
current_time = p[selected].completion_time;
completed++;
```

```
        total_tat += p[selected].turnaround_time;
        total_wt += p[selected].waiting_time;

    }
}
printf("\n Process\t AT\t BT\t Priority\t CT\t TAT
        \t WT\n");

for(int i=0; i<n; i++) {
    printf("%d\t %d\t %d\t %d\t %d\t %d\t %d\t %d
        \n", p[i].id, p[i].arrival_time,
    p[i].burst_time, p[i].priority, p[i].completion
    time, p[i].turnaround_time,
    p[i].waiting_time);

    }
printf("\n Average Turnaround Time : %.2f",
                                total_tat/n);

printf("\n Average Waiting Time : %.2f",
                                total_wt/n);

return 0;
}
```

Output

```
Enter the number of processes : 4
Enter Arrival Time, Burst Time and Priority for
 process 1 : 0  5  4
Enter Arrival Time, Burst Time and Priority for
process 2 : 2  4  2
Enter Arrival Time, Burst Time and Priority for
process 3 : 2  2  6
```

Enter Arrival Time, Burst Time and Priority for Process 4 : 4 4 3

Process	AT	BT	Priority	CT	TAT	WT
P1	0	5	4	5	5	0
P2	2	4	2	9	7	3
P3	2	2	6	15	13	11
P4	4	4	3	13	9	5

Average Turnaround Time : 8.50
Average Waiting Time : 4.75

```
#include <stdio.h>

struct Process {
    int id, arrival_time, burst_time, priority;
    int remaining_bt, completion_time, turnaround_time, waiting_time, response_time;
    int is_completed, is_started;
};

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

    struct Process p[n];
    for (int i = 0; i < n; i++) {
        p[i].id = i + 1;
        printf("\nEnter Arrival Time, Burst Time and Priority for Process %d: ", p[i].id);
        scanf("%d %d %d", &p[i].arrival_time, &p[i].burst_time, &p[i].priority);
        p[i].remaining_bt = p[i].burst_time;
        p[i].is_completed = 0;
        p[i].is_started = 0;
    }

    int current_time = 0, completed = 0;
    float total_tat = 0, total_wt = 0, total_rt = 0;

    while (completed < n) {
        int selected = -1;
        int min_priority = 9999;

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

```
        if (p[i].arrival_time <= current_time && p[i].remaining_bt > 0) {
            if (p[i].priority < min_priority ||
               (p[i].priority == min_priority && p[i].arrival_time < p[selected].arrival_time)) {
                min_priority = p[i].priority;
                selected = i;
            }
        }
    }

    if (selected == -1) {
        current_time++;
    } else {
        if (p[selected].is_started == 0) {
            p[selected].response_time = current_time - p[selected].arrival_time;
            p[selected].is_started = 1;
        }

        p[selected].remaining_bt--;
        current_time++;

        if (p[selected].remaining_bt == 0) {
            p[selected].completion_time = current_time;
            p[selected].turnaround_time = p[selected].completion_time - p[selected].arrival_time;
            p[selected].waiting_time = p[selected].turnaround_time - p[selected].burst_time;
            total_tat += p[selected].turnaround_time;
            total_wt += p[selected].waiting_time;
            total_rt += p[selected].response_time;
            p[selected].is_completed = 1;
            completed++;
        }
    }
}

// Display Results
printf("\nProcess\tAT\tBT\tPri\tCT\tTAT\tWT\tRT\n");
for (int i = 0; i < n; i++) {
    printf("P%d\t%d\t%d\t%d\t%d\t%d\t%d\t%d\n",
           p[i].id, p[i].arrival_time, p[i].burst_time, p[i].priority,
           p[i].completion_time, p[i].turnaround_time,
           p[i].waiting_time, p[i].response_time);
}

printf("\nAverage Turnaround Time: %.2f", total_tat / n);
printf("\nAverage Waiting Time: %.2f", total_wt / n);
printf("\nAverage Response Time: %.2f\n", total_rt / n);

return 0;
}
```

Output :

```
Enter the number of processes: 4

Enter Arrival Time, Burst Time and Priority for Process 1: 0 5 4

Enter Arrival Time, Burst Time and Priority for Process 2: 2 4 2

Enter Arrival Time, Burst Time and Priority for Process 3: 2 2 6

Enter Arrival Time, Burst Time and Priority for Process 4: 4 4 3

Process AT      BT      Pri     CT      TAT     WT      RT
P1      0       5       4       13      13      8       0
P2      2       4       2       6       4       0       0
P3      2       2       6       15      13      11      11
P4      4       4       3       10      6       2       2

Average Turnaround Time: 9.00
Average Waiting Time: 5.25
Average Response Time: 3.25
```

b)

```
#include <stdio.h>
struct Process {
    int id, arrival_time, burst_time, priority;
    int remaining_bt, completion_time,
    turnaround_time, waiting_time, response_time;
    int is_completed, is_started;
};
int main() {
    int n;
    printf("Enter the number of processes : ");
    scanf("%d",&n);

struct Process p[n];
for(int i=0; i<n; i++) {
    p[i].id = i+1;
    printf("\n Enter Arrival time, Burst Time
and Priority for Process %d :", p[i].id);
    scanf("%d %d %d", &p[i].arrival_time,
    &p[i].burst_time, &p[i].priority);
```

```
    p[i].remaining_bt = p[i].burst_time;
    p[i].is_completed = 0;
    p[i].is_started = 0;
}
int current_time = 0, completed = 0;
float total_tat = 0, total_wt = 0, total_rt = 0;

while (completed < n) {
    int selected = -1;
    int min_priority = 9999;
    for (int i=0; i<n; i++){
        if (p[i].arrival_time <= current_time &&
            p[i].remaining_bt > 0) {
            if (p[i].priority < min_priority ||
                (p[i].priority == min_priority &&
                 p[i].arrival_time < p[selected].arrival_time))
            {
                min_priority = p[i].priority;
                selected = i;
            }
        }
    }
}
if (selected == -1){
    current_time ++;
} else {
    if (p[selected].is_started == 0) {
        p[selected].response_time = current_time -
                                    p[selected].arrival_time;
        p[selected].is_started = 1;
```

```
        p[selected].remaining_bt--;
        current_time++;
        if (p[selected].remaining_bt == 0) {
            p[selected].completion_time = current_time;
            p[selected].turnaround_time = p[selected].
                completion_time - p[selected].arrival_time;
            p[selected].waiting_time = p[selected].
                turnaround_time - p[selected].burst_time;

            total_tat += p[selected].turnaround_time;
            total_wt += p[selected].waiting_time;
            total_rt += p[selected].response_time;
            p[selected].is_completed = 1;
            completed++;
        }
    }
}
printf("\n Process\t AT\t BT\t Pri\t CT\t TAT\t WT
    \t RT \n");

for(int i=0; i<n; i++){
    printf("p%d\t%d\t%d\t%d\t %d\t%d
        \t %d\t %d\n",
    p[i].id, p[i].arrival_time, p[i].burst_time,
    p[i].priority, p[i].completion_time,
    p[i].turnaround_time, p[i].waiting_time,
    p[i].response_time); }
```

```
    printf("\n Average Turnaround Time : %.2f",
                                    total_tat/n);
    printf("\n Average Waiting Time : %.2f",
                                    total_wt/n);
    printf("\n Average Waiting Time : %.2f",
                                    total_rt/n);

    return 0;
}
```

Output

Enter the number of processes : 4

Enter Arrival Time, Burst Time and Priority for Process 1 : 0 5 4

Enter Arrival Time, Burst Time and Priority for Process 2 : 2 4 2

Enter Arrival Time, Burst Time and Priority for Process 3 : 2 2 6

Enter Arrival Time, Burst Time and Priority for Process 4 : 4 4 3

Process	AT	BT	Pri	CT	TAT	WT	RT
P1	0	5	4	13	13	8	0
P2	2	4	2	6	4	0	0
P3	2	2	6	15	13	11	11
P4	4	4	3	10	6	2	2

Average Turnaround Time : 9.00
Average Waiting Time : 5.25
Average Response Time : 3.25

Lab 3:

a.) 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.

```
#include <stdio.h>


#define MAX_PROCESSES 10
#define TIME_QUANTUM 2


typedef struct {
    int id;
    int burst_time;
    int arrival_time;
    int queue; // 1 for system process (RR), 2 for user process (FCFS)
    int remaining_time;
    int waiting_time;
    int turnaround_time;
    int response_time;
} Process;


void round_robin(Process processes[], int n, int tq, int *time) {
    int done, i;
    do {
        done = 1;
        for (i = 0; i < n; i++) {
            if (processes[i].queue == 1 && processes[i].remaining_time > 0) {
                done = 0;
                if (processes[i].remaining_time == processes[i].burst_time)
                    processes[i].response_time = *time - processes[i].arrival_time;
                if (processes[i].remaining_time > tq) {
                    *time += tq;
```

```
                processes[i].remaining_time -= tq;
            } else {
                *time += processes[i].remaining_time;
                processes[i].waiting_time = *time - processes[i].burst_time - processes[i].arrival_time;
                processes[i].turnaround_time = *time - processes[i].arrival_time;
                processes[i].remaining_time = 0;
            }
        }
    }
  } while (!done);
}

void fcfs(Process processes[], int n, int *time) {
  for (int i = 0; i < n; i++) {
    if (processes[i].queue == 2) {
      if (*time < processes[i].arrival_time)
        *time = processes[i].arrival_time;
      processes[i].response_time = *time - processes[i].arrival_time;
      processes[i].waiting_time = *time - processes[i].arrival_time;
      *time += processes[i].burst_time;
      processes[i].turnaround_time = *time - processes[i].arrival_time;
    }
  }
}

void calculate_average(Process processes[], int n) {
  float total_waiting = 0, total_turnaround = 0, total_response = 0;
  for (int i = 0; i < n; i++) {
    total_waiting += processes[i].waiting_time;
    total_turnaround += processes[i].turnaround_time;
    total_response += processes[i].response_time;
  }
```

```
    printf("\nAverage Waiting Time: %.2f", total_waiting / n);
    printf("\nAverage Turn Around Time: %.2f", total_turnaround / n);
    printf("\nAverage Response Time: %.2f", total_response / n);
    printf("\nThroughput: %.2f\n", n / (total_turnaround / n));
}

int main() {
    int n, time = 0;
    Process processes[MAX_PROCESSES];

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

    printf("Queue 1 is system process\nQueue 2 is User Process\n");

    for (int i = 0; i < n; i++) {
        printf("Enter Burst Time, Arrival Time and Queue of P%d: ", i + 1);
        scanf("%d %d %d", &processes[i].burst_time, &processes[i].arrival_time, &processes[i].queue);
        processes[i].id = i + 1;
        processes[i].remaining_time = processes[i].burst_time;
        processes[i].waiting_time = 0;
        processes[i].turnaround_time = 0;
        processes[i].response_time = 0;
    }

    round_robin(processes, n, TIME_QUANTUM, &time);
    fcfs(processes, n, &time);

    printf("\nProcess\tWaiting Time\tTurn Around Time\tResponse Time\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t\t%d\t\t\t%d\n", processes[i].id, processes[i].waiting_time,
processes[i].turnaround_time, processes[i].response_time);
```

```
    }

    calculate_average(processes, n);

    return 0;
}
```

Output:

```
Enter number of processes: 4
Queue 1 is system process
Queue 2 is User Process
Enter Burst Time, Arrival Time and Queue of P1: 2 0 1
Enter Burst Time, Arrival Time and Queue of P2: 1 0 2
Enter Burst Time, Arrival Time and Queue of P3: 5 0 1
Enter Burst Time, Arrival Time and Queue of P4: 3 0 2

Process Waiting Time    Turn Around Time        Response Time
1       0               2                       0
2       7               8                       7
3       2               7                       2
4       8               11                      8

Average Waiting Time: 4.25
Average Turn Around Time: 7.00
Average Response Time: 4.25
Throughput: 0.57
```

Q Write a C program to demonstrate multilevel queue scheduling.

```
#include <stdio.h>
#define MAX_PROCESSES 10
#define TIME_QUANTUM 2

typedef struct {
    int id;
    int burst_time;
    int arrival_time;
    int queue;
    int remaining_time;
    int waiting_time;
    int turnaround_time;
    int response_time;
} Process;

void round_robin(Process processes[], int n,
                 int tq, int *time) {
    int done, i;
    do {
        done = 1;
        for (i=0; i<n; i++) {
            if (processes[i].queue == 1 &&
                processes[i].remaining_time > 0) {
                done = 0;
                if (processes[i].remaining_time == processes[i].
                    burst_time)
                    processes[i].response_time = *time -
                        processes[i].burst_time -
                        processes[i].arrival_time;
```

```
if ( processes[i].remaining_time > tq) {
        *time += tq;
        processes[i].remaining_time -= tq;
    } else {
    *time += processes[i].remaining_time;
    processes[i].waiting_time = *time -
                        processes[i].burst_time
                    - processes[i].arrival_time;
    processes[i].turnaround_time = *time -
                        processes[i].arrival_time;

    processes[i].remaining_time = 0;
    }
  }
 }
} while(!done);
}
void fcfs (Process processes[], int n, int *time) {
    for (int i=0; i<n; i++) {
      if (processes[i].queue == 2) {
        if (*time < processes[i].arrival_time)
          *time = processes[i].arrival_time;
    processes[i].response_time = *time -
                        processes[i].arrival_time;
    processes[i].waiting_time = *time -
                        processes[i].arrival_time;
     *time += processes[i].burst_time;
```

```
            processes[i].turnaround_time = * time -
                                processes[i].arival_time ;
        }
    }
}
void calculate_average (Process processes[], int n){
    float total_waiting = 0 ; total_ turnaround = 0,
        total_ response = 0 ;
    for ( int i=0; i<n ; i++) {
        total_waiting += processes[i]. waiting_time;
        total_turnaround += processes[i]. turnaround_time;
        total_response += processes[i]. response_time ;
    }
    printf ("\n Average Waiting Time : %.2f ",
                                total_waiting / n) ;
    printf ("\n Average Turnaround Time : %.2f",
                                total_turnaround / n) ;
    printf ("\n Average Response Time : %.2f ",
                                total_ response / n) ;
    printf ("\n Throughput : %.2f\n",
                                (total_turnaround / n)) ;
}
int main() {
    int n, time = 0;
    process processes [MAX_PROCESSES] ;
    printf (" Enter number of processes : ");
    scanf ("%d", &n);
```

```
printf ("Queue 1 is system process \n Queue 2
        is user process \n");
for (int i=0 ; i<n; i++) {
printf ("Enter Burst Time, Arrival Time and
        Queue of P%d ", i+1);
scanf ("%d %d %d", &processes[i].burst_time,
        &processes[i].arrival_time,
        &processes[i].queue);
processes[i].id = i+1;
processes[i].remaining_time = processes[i].
                              burst_time;
processes[i].waiting_time = 0;
processes[i].turnaround_time = 0;
processes[i].response_time = 0;
}
round_robin (processes, n, TIME_QUANTUM, &time);
fcfs (processes, n, &time);
printf ("\n Process \t Waiting Time \t Turn Around
    Time \t Response Time \n");
for (int i= 0; i<n; i++) {
  printf ("%d \t %d \t %d \t \t \t %d \n",
  processes[i].pid, processes[i].waiting_time,
  processes[i].turnaround_time, process[i].
  response_time);
}
calculate_average (processes,n);
return 0;
}
```

Output

```
Enter number of processes : 4
Queue 1 is system process
Queue 2 is user process
Enter Burst Time, Arrival Time and Queue of
P1 :  2  0  1
Enter Burst Time, Arrival Time and Queue of
P2 :  1  0  2
Enter Burst Time, Arrival Time and Queue of
P3 :  5  0  1
Enter Burst Time, Arrival Time and Queue of
P4 :  3  0  2
```

Process	Waiting Time	TurnAround Time	Response Tim
1	0	2	0
2	7	8	7
3	2	7	2
4	8	11	8

```
Average Waiting Time : 4.25
Average TurnAround Time : 7.00
Average Response Time : 4.25
Throughput : 0.57
```

b.) Rate- Monotonic

```
#include <stdio.h>

#define MAX_PROCESSES 10

typedef struct {
    int id;
    int burst_time;
    int period;
    int remaining_time;
    int next_deadline;
} Process;

void sort_by_period(Process processes[], int n) {
    for (int i = 0; i < n - 1; i++) {
        for (int j = 0; j < n - i - 1; j++) {
            if (processes[j].period > processes[j + 1].period) {
                Process temp = processes[j];
                processes[j] = processes[j + 1];
                processes[j + 1] = temp;
            }
        }
    }
}

int gcd(int a, int b) {
    return b == 0 ? a : gcd(b, a % b);
}

int lcm(int a, int b) {
    return (a * b) / gcd(a, b);
```

```
}

int calculate_lcm(Process processes[], int n) {
    int result = processes[0].period;
    for (int i = 1; i < n; i++) {
        result = lcm(result, processes[i].period);
    }
    return result;
}

double utilization_factor(Process processes[], int n) {
    double sum = 0;
    for (int i = 0; i < n; i++) {
        sum += (double)processes[i].burst_time / processes[i].period;
    }
    return sum;
}

double rms_threshold(int n) {
    return n * (pow(2.0, 1.0 / n) - 1);
}

void rate_monotonic_scheduling(Process processes[], int n) {
    int lcm_period = calculate_lcm(processes, n);
    printf("LCM=%d\n\n", lcm_period);

    printf("Rate Monotone Scheduling:\n");
    printf("PID  Burst  Period\n");
    for (int i = 0; i < n; i++) {
        printf("%d    %d      %d\n", processes[i].id, processes[i].burst_time, processes[i].period);
    }
```

```
    double utilization = utilization_factor(processes, n);
    double threshold = rms_threshold(n);
    printf("\n%.6f <= %.6f => %s\n", utilization, threshold, (utilization <= threshold) ? "true" : "false");

    if (utilization > threshold) {
        printf("\nSystem may not be schedulable!\n");
        return;
    }

    int timeline = 0, executed = 0;
    while (timeline < lcm_period) {
        int selected = -1;
        for (int i = 0; i < n; i++) {
            if (timeline % processes[i].period == 0) {
                processes[i].remaining_time = processes[i].burst_time;
            }
            if (processes[i].remaining_time > 0) {
                selected = i;
                break;
            }
        }
        if (selected != -1) {
            printf("Time %d: Process %d is running\n", timeline, processes[selected].id);
            processes[selected].remaining_time--;
            executed++;
        } else {
            printf("Time %d: CPU is idle\n", timeline);
        }
        timeline++;
    }
}
```

```
int main() {
    int n;
    Process processes[MAX_PROCESSES];

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

    printf("Enter the CPU burst times:\n");
    for (int i = 0; i < n; i++) {
        processes[i].id = i + 1;
        scanf("%d", &processes[i].burst_time);
        processes[i].remaining_time = processes[i].burst_time;
    }
     printf("Enter the time periods:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d", &processes[i].period);
    }
    sort_by_period(processes, n);
    rate_monotonic_scheduling(processes, n);
    return 0;
}
```

Output:

```
Enter the number of processes: 3
Enter the CPU burst times:
3 6 8
Enter the time periods:
3 4 5
LCM=60

Rate Monotone Scheduling:
PID  Burst  Period
1    3      3
2    6      4
3    8      5

4.100000 <= 0.779763 => false

System may not be schedulable!

Process returned 0 (0x0)   execution time : 49.003 s
Press any key to continue.
```

Q write C program to demonstrate rate monotic.

```
#include <stdio.h>
#define MAX_PROCESSES 10
typedef struct {
    int id;
    int burst_time;
    int period;
    int remaining_time;
    int next_deadline;
} Process;
void sort_by_period (Process processes [], int n) {
  for (int i=0; i<n-1; i++) {
    for (int j=0; j<n-i-1; j++) {
      if (processes[j].period > processes[j+1].period)
        {
          Process temp = processes[j];
          processes[j] = processes[j+1];
          processes[j+1] = temp;
        }
    }
  }
}
int gcd (int a, int b) {
    return b==0 ? a : gcd (b, a%b);
}
int lcm (int a, int b) {
    return (a*b) / gcd (a,b);
}
```

```
int calculate_lcm (Process processes[], int n);
    int result = processes[0].period;
    for(int i=1; i<n; i++) {
        result = lcm ( result, processes[i]. period
    }
    return result;
}
double utilization_factor (Process processes [],
                           int n) {
    double sum = 0;
    for (int i=0; i<n; i++) {
        sum += (double) processes[i] . burst_time
                processes[i]. period ;
    }
    return sum;
}
double rms_threshold ( int n) {
    return n* (pow (2.0, 1.0/n) -1) ;
}
void rate_monotonic_scheduling (Process processes[],
                                int n) {
    int lcm_period = calculate_lcm (processes, n);
    printf ("LCM = %d\n\n", lcm_period);
    printf (" Rate Monotone Scheduling :\n");
    printf (" PID Burst Period \n");
    for (int i=0; i<n; i++) {
        printf ("%d   %d   %d \n)", processes[i].id,
        processes[i]. burst_time, processes[i]. period);
    }
```

```
double utilization = utilization_factor(processes, n);
double threshold = rms_threshold(n);
printf("\n%.6f <= %.6f => %s\n",
       utilisation, threshold, (utilisation <= threshold)

if (utilisation > threshold) {
    printf("\n System may not be schedulable !\n");
    return;
}
int timeline = 0, executed = 0;
while (timeline < lcm_period) {
        int selected = -1;
        for(int i=0; i<n; i++){
            if (timeline % processes[i].period==0)
            {
            processes[i].remaining_time =
                    processes[i].burst_time;
            }
        if (processes[i].remaining_time > 0) {
            selected = i;
            break;
        }
    }
if (selected != -1) {
    printf("Time %d: Process %d is running\n",
           timeline, processes[selected].id);
    processes[selected].remaining_time--;
    executed++;
} else {
    printf("Time %d: CPU is idle\n", timeline);
}
```

```
        timeline++;
    }
}

int main() {
    int n;
    Process processes[MAX_PROCESSES];
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    printf("Enter the CPU burst times:\n");
    for (int i=0; i<n; i++) {
        processes[i].id = i+1;
        scanf("%d", &processes[i].burst_time);
        processes[i].remaining_time =
                    processes[i].burst_time;
    }
    printf("Enter the time periods:\n");
    for (int i=0; i<n; i++) {
        scanf("%d", &processes[i].period);
    }
    sort_by_period(processes, n);
    rate_monotonic_scheduling(processes, n);

    return 0;
}
```

Output

Enter the number of processes : 3
Enter the CPU burst times :
3 6 8
Enter the time periods :
3 4 5
LCM = 60
Rate Monotone scheduling :

PID	Burst	period
1	3	3
2	6	4
3	8	5

4.100000 ⇐ 0.779763 ⇒ false
System may not be schedulable !

c.) Earliest-deadline First

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

typedef struct {
    int pid;
    int burst;
    int deadline;
    int period;
} Process;

void sortByDeadline(Process proc[], int n) {
    for (int i = 0; i < n - 1; i++) {
```

```
        for (int j = 0; j < n - i - 1; j++) {
            if (proc[j].deadline > proc[j + 1].deadline) {
                Process temp = proc[j];
                proc[j] = proc[j + 1];
                proc[j + 1] = temp;
            }
        }
    }
}

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

    Process proc[n];

    printf("\nEnter the CPU burst times:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d", &proc[i].burst);
        proc[i].pid = i + 1;
    }

    printf("\nEnter the deadlines:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d", &proc[i].deadline);
    }

    printf("\nEnter the time periods:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d", &proc[i].period);
    }
```

```
    sortByDeadline(proc, n);

    printf("\nEarliest Deadline Scheduling:\n");
    printf("PID    Burst    Deadline    Period\n");
    for (int i = 0; i < n; i++) {
        printf("%d      %d        %d          %d\n", proc[i].pid, proc[i].burst, proc[i].deadline, proc[i].period);
    }
    printf("\nScheduling occurs for 6 ms\n");
    for (int time = 0; time < 6; time++) {
        printf("%dms : Task %d is running.\n", time, proc[0].pid);
    }
}
```

Output:

```
Enter the number of processes:3

Enter the CPU burst times:
2 3 5

Enter the deadlines:
1 2 3

Enter the time periods:
1 2 3

Earliest Deadline Scheduling:
PID     Burst     Deadline     Period
1       2         1            1
2       3         2            2
3       5         3            3

Scheduling occurs for 6 ms
0ms : Task 1 is running.
1ms : Task 1 is running.
2ms : Task 1 is running.
3ms : Task 1 is running.
4ms : Task 1 is running.
5ms : Task 1 is running.
```

1 Write a C program to demonstrate Earliest deadline first (EDF)

```
#include <stdio.h>
#include <stdlib.h>
typedef struct {
    int pid;
    int burst;
    int deadline;
    int period;
} Process;
void sortByDeadline (Process proc[], int n) {
    for (int i=0; i<n-1; i++) {
        for (int j=0; j<n-i-1; j++) {
            if (proc[j].deadline > proc[j+1].
                                    deadline) {
                Process temp = proc[j];
                proc[j] = proc[j+1];
                proc[j+1] = temp;
            }
        }
    }
}
void main () {
    int n;
    printf ("Enter the number of processes : ");
    scanf ("%d", &n);
    Process proc[n];
    printf ("\nEnter the CPU burst times :\n");
    for (int i=0; i<n; i++) {
        scanf ("%d", &proc[i].burst);
        proc[i].pid = i+1;
    }
```

```
printf("Enter the deadlines :\n");
for (int i=0; i<n; i++) {
    scanf("%d", &proc[i].period);
}
sortByDeadline("\nEnter the deadlines :\n");
for (int i=0; i<n; i++) {
    scanf("%d", &proc[i].deadline);
}
printf("\nEnter the time periods :\n");
for (int i=0; i<n; i++) {
    scanf("%d", &proc[i].period);
}
sortByDeadline(proc, n);
printf("\n Earliest Deadline Scheduling :\n");
printf(" PID  Burst  Deadline  Period\n");
for (int i=0; i<n; i++) {
printf("%d  %d  %d  %d\n",
proc[i].pid, proc[i].burst, proc[i].deadline,
proc[i].period);
}
printf("\n scheduling occurs for 6 ms\n");
for (int time = 0; time < 6 ; time++) {
    printf("%dms : Task %d is running.\n",
        time, proc[0].pid);
}
}
```

Output

Enter the number of processes : 3

Enter the CPU burst times :

2 3 5

Enter the deadlines :

1 2 3

Enter the time periods :

1 2 3

Earliest Deadline Scheduling :

PID	Burst	Deadline	Period
1	2	1	1
2	3	2	2
3	5	3	3

Scheduling occurs for 6 ms

0ms : Task 1 is running

1ms : Task 1 is running

2ms : Task 1 is running

3ms : Task 1 is running

4ms : Task 1 is running

5ms : Task 1 is running.

Lab 4:

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

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

int mutex = 1, full = 0, empty = 3, x = 0, buffer = 0;

int wait(int s) {
   return (--s);
}

int signal(int s) {
   return (++s);
}

void producer() {
   mutex = wait(mutex);
   full = signal(full);
   empty = wait(empty);
   x = rand() % 50;
   buffer = x;
   printf("Producer 1 produced %d\n", x);
   printf("Buffer:%d\n", buffer);
   mutex = signal(mutex);
}

void consumer() {
   mutex = wait(mutex);
   full = wait(full);
```

```
    empty = signal(empty);
    printf("Consumer 2 consumed %d\n", buffer);
    printf("Current buffer len: 0\n");
    x--;
    mutex = signal(mutex);
}

void main() {
    int choice, p, c;

    srand(time(0));
    printf("Enter the number of Producers:");
    scanf("%d", &p);
    printf("Enter the number of Consumers:");
    scanf("%d", &c);
    printf("Enter buffer capacity:");
    scanf("%d", &empty);

    for (int i = 1; i <= p; i++)
        printf("Successfully created producer %d\n", i);
    for (int i = 1; i <= c; i++)
        printf("Successfully created consumer %d\n", i);

    while (1) {
        printf("\n1.Producer\n2.Consumer\n3.Exit\n");
        scanf("%d", &choice);
        switch (choice) {
            case 1:
                if ((mutex == 1) && (empty != 0))
                    producer();
                else
                    printf("Buffer is full\n");
```

```
            break;
        case 2:
            if ((mutex == 1) && (full != 0))
                consumer();
            else
                printf("Buffer is empty\n");
            break;
        case 3:
            exit(0);
    }
  }
}
```

Output:

```
Enter the number of Producers:1
Enter the number of Consumers:1
Enter buffer capacity:1
Successfully created producer 1
Successfully created consumer 1

1.Producer
2.Consumer
3.Exit
1
Producer 1 produced 10
Buffer:10

1.Producer
2.Consumer
3.Exit
2
Consumer 2 consumed 10
Current buffer len: 0

1.Producer
2.Consumer
3.Exit
1
Producer 1 produced 12
Buffer:12

1.Producer
2.Consumer
3.Exit
2
Consumer 2 consumed 12
Current buffer len: 0

1.Producer
2.Consumer
3.Exit
```

9 Write a c program to demonstrate producer consumer problem.

```
# include <stdio.h>
# include <stdlib.h>
# include <time.h>
int mutex = 1, full = 0, empty = 3, x = 0,
    buffer = 0;
int wait (int s) {
    return (--s);
}
int signal (int s) {
    return (++s);
}
void producer () {
    mutex = wait (mutex);
    full = signal (full);
    empty = wait (empty);
    x = rand () % 50;
    buffer = x;
    printf ("Producer 1 produced %d\n", x);
    printf ("Buffer %d\n", buffer);
    mutex = signal (mutex);
}
void consumer () {
    int choice, p, c;
    srand (time (0));
    printf ("Enter the number of Producers : ");
    scanf ("%d", &p);
    printf ("Enter the number of consumers : ");
    scanf ("%d", &c);
    printf ("Enter buffer capacity : ");
    scanf ("%d", &empty);
```

```
for (int i=1; i<=p ; i++)
    printf ("Successfully created producer %d\n",i);
for (int i=1; i<=c; i++)
    printf ("successfully created consumer %d\n", i);

while (1) {
  printf ("\n1. Producer \n2. Consumer \n3. Exit\n");
  scanf ("%d", &choice);
  switch (choice) {
      case 1:
          if ((mutex==1) && (empty!=0))
              producer();
          else
              printf ("Buffer is full\n");
          break;
      case 2:
          if ((mutex==1) && (full!=0))
              consumer();
          else
              printf ("Buffer is empty\n");
          break;
      case 3:
          exit(0);
  }
```

Output

```
Enter the number of producers : 1
Enter the number of consumers : 1
Enter buffer capacity : 1
successfully created producer 1
successfully created consumer 1

1. Producer
2. Consumer
3. Exit

1
Producer 1 produced 10
Buffer : 10

1. Producer
2. Consumer
3. Exit
2
Consumer 2 consumed 10
Current buffer len : 10

1. Producer
2. Consumer
3. Exit
1
producer 1 produced 12
Buffer : 12

1. Producer
2. Consumer
3. Exit
2
Consumer 2 consumed 12
Current buffer len : 0

1. Producer
2. Consumer
3. Exit
3.
```

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

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

int n;
sem_t *chopstick;
pthread_t *philosopher;
int *phil_ids;

void* philosopher_fn(void* num) {
    int i = *(int*)num;
    int left = i;
    int right = (i + 1) % n;
    printf("Philosopher %d is hungry\n", i + 1);
    sem_wait(&chopstick[left]);
    sem_wait(&chopstick[right]);
    printf("Philosopher %d took chopstick %d and %d\n", i + 1, left + 1, right + 1);
    printf("Philosopher %d is eating\n", i + 1);
    sleep(1);
    printf("Philosopher %d finished eating and kept the chopstick back on table\n", i + 1);
    sem_post(&chopstick[left]);
    sem_post(&chopstick[right]);
    return NULL;
}

int main() {
    int hungry, i;
    printf("Enter the number of philosophers:");
```

```
    scanf("%d", &n);
    chopstick = malloc(n * sizeof(sem_t));
    philosopher = malloc(n * sizeof(pthread_t));
    phil_ids = malloc(n * sizeof(int));
    for (i = 0; i < n; i++) sem_init(&chopstick[i], 0, 1);
    printf("Enter number of hungry philosophers:");
    scanf("%d", &hungry);
    for (i = 0; i < hungry; i++) {
        phil_ids[i] = i;
        pthread_create(&philosopher[i], NULL, philosopher_fn, &phil_ids[i]);
        sleep(1);
    }
    for (i = 0; i < hungry; i++) {
        pthread_join(philosopher[i], NULL);
    }
    free(chopstick);
    free(philosopher);
    free(phil_ids);
    return 0;
}
```

Output :

```
Enter the number of philosophers:5
Enter number of hungry philosophers:5
Philosopher 1 is hungry
Philosopher 1 took chopstick 1 and 2
Philosopher 1 is eating
Philosopher 1 finished eating and kept the chopstick back on table
Philosopher 2 is hungry
Philosopher 2 took chopstick 2 and 3
Philosopher 2 is eating
Philosopher 2 finished eating and kept the chopstick back on table
Philosopher 3 is hungry
Philosopher 3 took chopstick 3 and 4
Philosopher 3 is eating
Philosopher 3 finished eating and kept the chopstick back on table
Philosopher 4 is hungry
Philosopher 4 took chopstick 4 and 5
Philosopher 4 is eating
Philosopher 5 is hungry
Philosopher 4 finished eating and kept the chopstick back on table
Philosopher 5 took chopstick 5 and 1
Philosopher 5 is eating
Philosopher 5 finished eating and kept the chopstick back on table
```

Q Write a C program to demonstrate dining philosophers problem.

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

int n;
sem_t * chopstick;
pthread_t * philosopher;
int * phil_ids;
void * philosopher_fn (void * num) {
    int i = * (int *) num;
    int left = i;
    int right = (i+1) % n;
    printf ("Philosopher %d is hungry\n", i+1);
    sem_wait (& chopstick [left]);
    sem_wait (& chopstick [right]);
    printf ("Philosopher %d took chopstick %d
        and %d \n", i+1, left+1, right+1);
    printf ("Philosopher %d is eating \n", i+1);
    sleep (1);
    printf ("Philosopher %d finished eating and
    kept the chopsticks back on table \n",
        i+1);
```

```
    sem_post (&chopstick [left]);
    sem_post (&chopstick [right]);
    return NULL;
}
int main () {
    int hungry, i;
    printf ("Enter the number of philosophers:");
    scanf ("%d", &n);
    chopstick = malloc (n * sizeof (sem_t));
    philosopher = malloc (n * sizeof (pthread_t));
    phil_ids = malloc (n * size of (int));
    for (i=0; i<n; i++)
        sem_init (&chopstick [i], 0, 1);
    printf ("Enter number of hungry philosophers:")
    scanf ("%d", & hungry);
    for (i=0; i< hungry; i++) {
        phil_ids[i] = i;
        pthread_create (& philosopher [i],
            NULL, philosopher_fn, &
            phil_ids [i]);

    sleep (1);
}
for (i=0; i < hungry; i++) {
    pthread_join (philosopher [i], NULL);

}
free (chopstick);
free (philosopher);
free (phil_ids);
return 0;

}
```

Output

```
Enter the number of philosophers : 5
Enter the number of hungry philosophers : 5
Philosopher 1 is hungry
Philosopher 1 took chopstick 1 and 2
Philosopher 1 is eating
Philosopher 1 finished eating and kept the
chopstick back on the table.
Philosopher 2 is hungry
Philosopher 2 took chopstick 2 and 3.
Philosopher 2 is eating
Philosopher 2 finished eating and kept the
chopstick back on the table.
Philosopher 3 is hungry
Philosopher 3 took chopstick 3 and 4
Philosopher 3 is eating
Philosopher 3 finished eating and kept the
chopstick back on the table.
Philosopher 4 is hungry
Philosopher 4 took chopstick 4 and 5
Philosopher 4 is eating
Philosopher 4 finished eating and kept the
chopstick back on the table.
Philosopher 5 is hungry
Philosopher 5 took chopstick 5 and 1
Philosopher 5 is eating
Philosopher 5 finished eating and kept the
chopstick back on the table.
```

Lab 5:

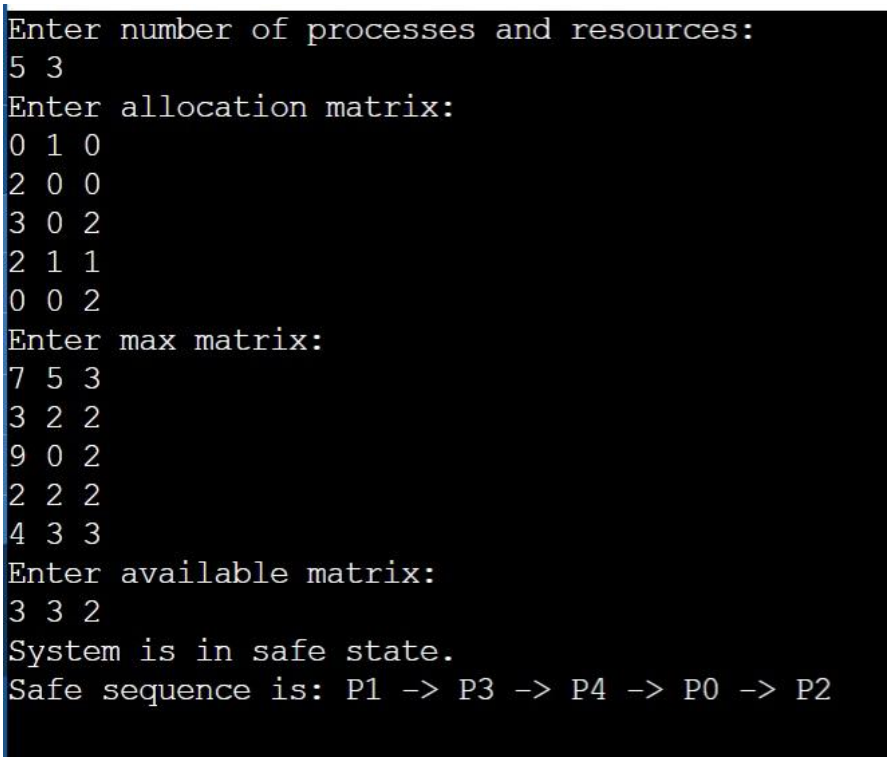
Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.

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

void main() {
   int n, m;
   printf("Enter number of processes and resources:\n");
   scanf("%d %d", &n, &m);

   int alloc[n][m], max[n][m], avail[m];
   printf("Enter allocation matrix:\n");
   for (int i = 0; i < n; i++)
      for (int j = 0; j < m; j++)
         scanf("%d", &alloc[i][j]);

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

   printf("Enter available matrix:\n");
   for (int i = 0; i < m; i++)
      scanf("%d", &avail[i]);

   int finish[n];
   int safeSeq[n];
   for (int i = 0; i < n; i++) finish[i] = 0;
```

```
int need[n][m];
for (int i = 0; i < n; i++)
    for (int j = 0; j < m; j++)
        need[i][j] = max[i][j] - alloc[i][j];

int count = 0;
while (count < n) {
    bool found = false;
    for (int i = 0; i < n; i++) {
        if (!finish[i]) {
            int j;
            for (j = 0; j < m; j++)
                if (need[i][j] > avail[j])
                    break;
            if (j == m) {
                for (int k = 0; k < m; k++)
                    avail[k] += alloc[i][k];
                safeSeq[count++] = i;
                finish[i] = 1;
                found = true;
            }
        }
    }
    if (!found) break;
}

if (count == n) {
    printf("System is in safe state.\n");
    printf("Safe sequence is: ");
    for (int i = 0; i < n; i++) {
        printf("P%d", safeSeq[i]);
        if (i != n - 1) printf(" -> ");
```

```
        }
        printf("\n");
    } else {
        printf("System is not in a safe state.\n");
    }

}
```

Output:



1 Write a C program to demonstrate Banker's Algorithm.

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

void main () {
    int n, m;
    printf ("enter number of processes and
            resources : \n");
    scanf ("%d %d", &n, &m);
    int alloc [n][m], max [n][m], avail [m];
    printf ("enter allocation matrix : \n");
    for (int i = 0 ; i < n ; i++)
        for (int j = 0 ; j < m ; j++)
            scanf ("%d", & alloc [i][j]);

    printf (" enter max matrix : \n");
    for (int i = 0 ; i < m ; i++)
        for (int j = 0 ; j < m ; j++)
            scanf ("%d", & max [i] [j]);

    printf ("enter available matrix : \n");
    for (int i = 0 ; i < m ; i++)
        scanf ("%d", & avail [i]);

    int finish [n];
    int safeseq [n];
    for (int i = 0 ; i < n ; i++)
        finish [i] = 0 ;

    int need [n][m];
    for (int i = 0 ; i < n ; i++)
        for (int j = 0 ; j < m ; j++)
            need [i][j] = max [i][j] - alloc [i][j];
```

```
int count = 0;
while (count < n) {
    bool found = false;
    for (int i=0; i<n; i++) {
        if (!finish[i]) {
            int j;
            for (j=0; j<m; j++)
                if (need[i][j] > avail[j])
                    break;
            if (j==m) {
                for (int k=0; k<m; k++)
                    avail[k] += alloc[i][k];
                safeseq[count++] = i;
                finish[i] = 1;
                found = true;
            }
        }
    }
    if (!found) break;
}
if (count==n) {
    printf("System is in safe state.\n");
    printf("Safe sequence is : ");
    for (int i=0; i<n; i++) {
        printf("P%d", safeseq[i]);
        if (i!=n-1) printf(" -> ");
    }
    printf("\n");
} else {
    printf("System is not in a safe state.\n");
}
}
```

Output

```
Enter number of processes and resources:
5 3
Enter allocation matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter max matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Enter available matrix:
3 3 2
System is in safe state
Safe sequence is: P1 --> P3 --> P4 --> P0 --> P2
```

b.) Write a C program to simulate deadlock detection

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

int main() {
    int n, m;
    printf("Enter number of processes and resources:\n");
```

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

int alloc[n][m], request[n][m], avail[m];
printf("Enter allocation matrix:\n");
for (int i = 0; i < n; i++)
    for (int j = 0; j < m; j++)
        scanf("%d", &alloc[i][j]);

printf("Enter request matrix:\n");
for (int i = 0; i < n; i++)
    for (int j = 0; j < m; j++)
        scanf("%d", &request[i][j]);

printf("Enter available matrix:\n");
for (int i = 0; i < m; i++)
    scanf("%d", &avail[i]);

int finish[n];
for (int i = 0; i < n; i++) finish[i] = 0;

int count = 0;
while (count < n) {
    bool found = false;
    for (int i = 0; i < n; i++) {
        if (!finish[i]) {
            int j;
            for (j = 0; j < m; j++)
                if (request[i][j] > avail[j])
                    break;
            if (j == m) {
                for (int k = 0; k < m; k++)
                    avail[k] += alloc[i][k];
```

```
                finish[i] = 1;
                printf("Process %d can finish.\n", i);
                count++;
                found = true;
            }
        }
    }
    if (!found) break;
}

if (count == n)
    printf("System is not in a deadlock state.\n");
else
    printf("System is in a deadlock state.\n");

return 0;
}
```

Output:

```
Enter number of processes and resources:
5 3
Enter allocation matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter request matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Enter available matrix:
3 3 2
Process 1 can finish.
Process 3 can finish.
Process 4 can finish.
System is in a deadlock state.
```

1 write a C program to demonstrate deadlock in operating system.

```
#include <stdio.h>
#include <stdbool.h>
int main () {
    int n, m;
    printf ("Enter number of processes and
            resources :\n");
    scanf ("%d %d", &n, &m);
    int alloc[n][m], request[n][m], avail[m];
    printf ("Enter allocation matrix :\n");
    for (int i=0; i<n; i++)
        for (int j=0; j<m; j++)
            scanf ("%d", &alloc[i][j]);
    printf ("Enter request matrix :\n");
    for (int i=0; i<n; i++)
        for (int j=0; j<m; j++)
            scanf ("%d", &request[i][j]);
    printf ("Enter available matrix:\n");
    for (int i=0; i<m; i++)
        scanf ("%d", &avail[i]);
    int finish[n];
    for (int i=0; i<n; i++)
        finish[i] = 0;
int count = 0;
while (count < n) {
    bool found = false;
    for (int i=0; i<n; i++) {
```

```
if (!finish[i]) {
    int j;
    for (j=0; j<m; j++)
        if (request[i][j] > avail[j])
            break;
    if (j==m) {
        for(int k=0; k<m; k++)
            avail[k] += alloc[i][k];
        finish[i] = 1;
        printf("Process %d can finish\n", i);
        count++;
        found = true;
    }
  }
  if (!found) break;
}
if (count==n)
    printf("System is not in a deadlock state.\n");
else
    printf("System is in deadlock state.\n");

return 0;
}
```

Output

```
Enter number of processes and resources :
5 3
Enter allocation matrix :
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter request matrix :
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Enter available matrix :
3 3 2
Process 1 can finish
Process 3 can finish
Process 4 can finish
System is in a deadlock state.
```

Lab 6:

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

a) Worst-fit

b) Best-fit

c) First-fit

```
#include <stdio.h>

struct Block {
    int block_no;
    int block_size;
    int is_free;
};

struct File {
    int file_no;
    int file_size;
};

// First Fit allocation function
void firstFit(struct Block blocks[], int n_blocks, struct File files[], int n_files) {
    printf("\nMemory Management Scheme - First Fit\n");
    printf("File_no\tFile_size\tBlock_no\tBlock_size\tFragment\n");

    for (int i = 0; i < n_files; i++) {
        int allocated = 0;

        for (int j = 0; j < n_blocks; j++) {
            if (blocks[j].is_free && blocks[j].block_size >= files[i].file_size) {
                int fragment = blocks[j].block_size - files[i].file_size;
                blocks[j].is_free = 0;
```

```
            printf("%d\t%d\t\t%d\t\t%d\t\t%d\n",
                   files[i].file_no,
                   files[i].file_size,
                   blocks[j].block_no,
                   blocks[j].block_size,
                   fragment);

            allocated = 1;
            break;
        }
    }

    if (!allocated) {
        printf("%d\t%d\t\tNot Allocated\n", files[i].file_no, files[i].file_size);
    }
  }
}

// Best Fit allocation function
void bestFit(struct Block blocks[], int n_blocks, struct File files[], int n_files) {
  printf("\nMemory Management Scheme - Best Fit\n");
  printf("File_no\tFile_size\tBlock_no\tBlock_size\tFragment\n");

  for (int i = 0; i < n_files; i++) {
    int best_fit_block = -1;
    int min_fragment = 10000; // Large initial value

    for (int j = 0; j < n_blocks; j++) {
      if (blocks[j].is_free && blocks[j].block_size >= files[i].file_size) {
        int fragment = blocks[j].block_size - files[i].file_size;
        if (fragment < min_fragment) {
          min_fragment = fragment;
```

```
                best_fit_block = j;
            }
        }
    }

    if (best_fit_block != -1) {
        blocks[best_fit_block].is_free = 0;
        printf("%d\t%d\t\t%d\t\t%d\t\t%d\n",
               files[i].file_no,
               files[i].file_size,
               blocks[best_fit_block].block_no,
               blocks[best_fit_block].block_size,
               min_fragment);
    } else {
        printf("%d\t%d\t\tNot Allocated\n", files[i].file_no, files[i].file_size);
    }
  }
}

// Worst Fit allocation function
void worstFit(struct Block blocks[], int n_blocks, struct File files[], int n_files) {
  printf("\nMemory Management Scheme - Worst Fit\n");
  printf("File_no\tFile_size\tBlock_no\tBlock_size\tFragment\n");

  for (int i = 0; i < n_files; i++) {
    int worst_fit_block = -1;
    int max_fragment = -1;

    for (int j = 0; j < n_blocks; j++) {
      if (blocks[j].is_free && blocks[j].block_size >= files[i].file_size) {
        int fragment = blocks[j].block_size - files[i].file_size;
        if (fragment > max_fragment) {
```

```
                max_fragment = fragment;
                worst_fit_block = j;
            }
        }
    }

    if (worst_fit_block != -1) {
        blocks[worst_fit_block].is_free = 0;
        printf("%d\t%d\t\t%d\t\t%d\t\t%d\n",
               files[i].file_no,
               files[i].file_size,
               blocks[worst_fit_block].block_no,
               blocks[worst_fit_block].block_size,
               max_fragment);
    } else {
        printf("%d\t%d\t\tNot Allocated\n", files[i].file_no, files[i].file_size);
    }
  }
}

void resetBlocks(struct Block blocks[], struct Block original[], int n_blocks) {
  for (int i = 0; i < n_blocks; i++) {
    blocks[i] = original[i]; // reset to original state
  }
}

int main() {
  int n_blocks, n_files;

  // Input number of blocks
  printf("Enter the number of blocks: ");
  scanf("%d", &n_blocks);
```

```
struct Block blocks[n_blocks], original_blocks[n_blocks];

// Input block sizes
for (int i = 0; i < n_blocks; i++) {
    blocks[i].block_no = i + 1;
    printf("Enter the size of block %d: ", i + 1);
    scanf("%d", &blocks[i].block_size);
    blocks[i].is_free = 1;
    original_blocks[i] = blocks[i]; // Save initial state
}

// Input number of files
printf("Enter the number of files: ");
scanf("%d", &n_files);

struct File files[n_files];

// Input file sizes
for (int i = 0; i < n_files; i++) {
    files[i].file_no = i + 1;
    printf("Enter the size of file %d: ", i + 1);
    scanf("%d", &files[i].file_size);
}

int choice;

do {
    printf("\nSelect the memory management scheme:\n");
    printf("1. First Fit\n");
    printf("2. Best Fit\n");
    printf("3. Worst Fit\n");
```

```
        printf("0. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        // Reset block status before each allocation attempt
        resetBlocks(blocks, original_blocks, n_blocks);

        switch (choice) {
            case 1:
                firstFit(blocks, n_blocks, files, n_files);
                break;
            case 2:
                bestFit(blocks, n_blocks, files, n_files);
                break;
            case 3:
                worstFit(blocks, n_blocks, files, n_files);
                break;
            case 0:
                printf("Exiting program.\n");
                break;
            default:
                printf("Invalid choice!\n");
        }
    } while (choice != 0);

    return 0;
}
```

Output :

```
Enter the number of blocks: 4
Enter the size of block 1: 10
Enter the size of block 2: 20
Enter the size of block 3: 30
Enter the size of block 4: 40
Enter the number of files: 5
Enter the size of file 1: 5
Enter the size of file 2: 10
Enter the size of file 3: 15
Enter the size of file 4: 20
Enter the size of file 5: 25

Select the memory management scheme:
1. First Fit
2. Best Fit
3. Worst Fit
0. Exit
Enter your choice: 1

Memory Management Scheme - First Fit
File_no File_size       Block_no        Block_size      Fragment
1       5               1               10              5
2       10              2               20              10
3       15              3               30              15
4       20              4               40              20
5       25              Not Allocated
```

```
Select the memory management scheme:
1. First Fit
2. Best Fit
3. Worst Fit
0. Exit
Enter your choice: 2

Memory Management Scheme - Best Fit
File_no File_size       Block_no        Block_size      Fragment
1       5               1               10              5
2       10              2               20              10
3       15              3               30              15
4       20              4               40              20
5       25              Not Allocated
```

```
Select the memory management scheme:
1. First Fit
2. Best Fit
3. Worst Fit
0. Exit
Enter your choice: 3

Memory Management Scheme - Worst Fit
File_no File_size       Block_no        Block_size      Fragment
1       5               4               40              35
2       10              3               30              20
3       15              2               20              5
4       20              Not Allocated
5       25              Not Allocated

Select the memory management scheme:
1. First Fit
2. Best Fit
3. Worst Fit
0. Exit
Enter your choice: 0
Exiting program.
```

1 Write a C program to simulate the following contigous memory allocation technique.

a) Worst fit b) Best-fit c) First-fit.

```
#include <stdio.h>
struct Block {
    int block_no;
    int block_size;
    int is_free;
};
```

~~void firstfit(struct Block blocks[], int n_blocks, struct File files[], int n_files) {~~

```
struct File {
    int file_no;
    int file_size;
};
void firstfit (struct Block blocks [], int n_blocks,
    struct File files [], int n_files ) {
printf ("\n Memory Management Scheme -
        First Fit \n");

printf ("File_no \tFile_size\t Block_no \t Block_
 size \t Fragment \n");

for (int i=0; i < n_files ; i++) {
    int allocated 0;
for (int j=0 ; j < n_blocks ; j++) {
    if (Blocks [j]. is_free && blocks [j]. block_
     size >= files[i]. file_size)
```

```
{
int fragment = blocks[j].block_size -
                files[i].file_size;
blocks[j].is_free = 0;
printf("%d\t%d\t\t%d\t\t%d\t\t%d\n",
        files[i].file_no,
        files[i].file_size,
        blocks[j].block_no,
        blocks[j].block_size,
        fragment);
allocated = 1;
break;
}
}
if(!allocated) {
printf("%d\t%d\t\tNot allocated\n",
        files[i].file_no, files[i].file_size);
}
}
void bestfit(struct Block blocks[], int n_blocks,
struct File files[], int n_files) {
printf("\nMemory Management Scheme -
                Best fit:\n");
printf("File_no\tFile_size\tBlock_no\t
        Block_size\tFragment\n");
```

```
for (int i=0; i < n_files ; i++) {
    if (blocks[j].is_free && blocks[j].block_size
      >= files[i].file_size ) {

    int fragment = blocks[j].block_size -
                   files[i].file_size ;

    if (fragment < min_fragment) {
        min_fragment = fragment ;
        best_fit_block = j;
    }
    }
  }
if (best_fit_block != -1) {
blocks [best_fit_block].is_free = 0
printf ("%d\t %d\t \t %d\t \t %d\t \t %d
\n", files[i].file_no,
     files[i].file_size
     blocks [best_fit_block].block_no,
     blocks [best_fit_block].block_size ,
     min_fragment );

} else {
printf ("%d\t %d\t \t Not allocated \n",
files[i].file_no , files[i].file_size);

}}
}
```

```
void worstfit (struct Blocks blocks [], int n_blocks,
struct File files [], int n_files) {
  printf ("\n Memory Management scheme - Worst
                                    fit \n");
printf ("File_no \t File_size \t Block_no \t Block_size
  \t Fragment \n");
for (int i=0; i < n_files ; i++) {
    int worst_fit_block = -1;
    int max_fragment = -1;
for (int j=0; j < n_blocks ; j++) {
  if (blocks [j]. is_free && blocks[j] . block_size
>= files [i] . file_size) {
    int fragment = blocks [j]. block_size
- files[i]. file_size ;
if (fragment > max_fragment) {
      max_fragment = fragment;
      worst_fit_block = j;
  }
 }
}
if (worst_fit_block != -1) {
  blocks [worst_fit_block]. is_free = 0;
  printf ("%d\t%d\t\t%d\t\t%d\t\t%d\n",
      files [i]. file_no,
      files [i]. file_size,
      blocks [worst_fit_block]. block_no,
      blocks [worst_fit_block]. block_size,
      max_fragment);
}
```

```
        else {
            printf("%d\t%d\t\tNot allocated\n",
                files[i].file_no, files[i].file_size);
        }
    }
}
int main() {
    int n_blocks, n_files;
    printf("Enter the number of blocks: ");
    scanf("%d", &n_blocks);
    struct Block blocks[n_blocks];
    for(int i=0; i<n_blocks; i++) {
        blocks[i].block_no = i+1;
        printf("Enter the size of block %d: ",
                                    i+1);
        scanf("%d", &blocks[i].block_size);
        blocks[i].is_free = 1;
    }
    printf("Enter the number of files: ");
    scanf("%d", &n_files);
    struct File files[n_files];
    for(int i=0; i<n_files; i++) {
        files[i].file_no = i+1;
        printf("Enter the size of file %d: ",
                                    i+1);
        scanf("%d", &files[i].file_size);
}
```

```
int choice;
printf("\n Select the memory management
        scheme : \n");
printf("1. First fit \n");
printf("2. Best fit \n");
printf("3. Worst fit \n");
printf("Enter your choice : ");
scanf("%d", &choice);
switch(choice) {
    case 1:
        firstfit(blocks, n_blocks, files, n_files);
        break;
    case 2:
        bestfit(blocks, n_blocks, files, n_files);
        break;
    case 3:
        worstfit(blocks, n_blocks, files, n_files);
        break;
    default:
        printf("Invalid choice! \n");
}
return 0;
}
```

Output

```
Enter the number of blocks : 4
Enter the size of block 1 : 10
Enter the size of block 2 : 20
Enter the size of block 3 : 30
Enter the size of block 4 : 40
Enter the number of files : 5
Enter the size of file 1 : 5
Enter the size of file 2 : 10
```

Enter the size of file 3 : 15
Enter the size of file 4 : 20
Enter the size of file 5 : 25

Select the memory management scheme :
1. First Fit
2. Best Fit
3. Worst Fit
0. Exit
Enter your choice : 1

Memory Management Scheme - First Fit

File_No	File_size	Block_no	Block_size	Fragment
1	5	1	10	5
2	10	2	20	10
3	15	3	30	15
4	20	4	40	20
5	25	Not Allocated		

Select the memory management scheme :
1. First Fit
2. Best Fit
3. Worst Fit
0. Exit
Enter your choice : 2

Memory Management scheme - Best Fit

File_No	File_size	Block_no	Block_size	Fragment
1	5	1	10	5
2	10	2	20	10
3	15	3	30	15
4	20	4	40	20
5	25	Not Allocated		

Select the memory management scheme:

1. First fit
2. Best fit
3. Worst fit
0. Exit

Enter your choice: 3

Memory Management Scheme - Worst fit

File_No:	File_size	Block_no	Block_size	fragme
1	5	4	40	35
2	10	3	30	20
3	15	2	20	5
4	20	Not Allocated		
5	25	Not Allocated		

select the memory management scheme:

1. First fit
2. Best fit
3. Worst fit
0. Exit

Enter your choice: 0

Exiting program.

Lab 7

Write a C program to simulate page replacement algorithms

a)FIFO

```
#include <stdio.h>

int main() {
   int frames, pages[50], n, frame[10], i, j, k, avail, count = 0;

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

   printf("Enter the page reference string:\n");
   for(i = 0; i < n; i++)
      scanf("%d", &pages[i]);

   printf("Enter number of frames: ");
   scanf("%d", &frames);

   for(i = 0; i < frames; i++)
      frame[i] = -1;
   printf("\nPage\tFrames\t\tPage Fault\n");
   j = 0;
   for(i = 0; i < n; i++) {
      avail = 0;

      for(k = 0; k < frames; k++) {
         if(frame[k] == pages[i]) {
            avail = 1;
            break;
         }
      }

      if(avail == 0) {
         frame[j] = pages[i];
         j = (j + 1) % frames;
```

```
            count++;
            printf("%d\t", pages[i]);
            for(k = 0; k < frames; k++) {
               if(frame[k] != -1)
                  printf("%d ", frame[k]);
               else
                  printf("- ");
            }
            printf("\tYes\n");
         } else {
            printf("%d\t", pages[i]);
            for(k = 0; k < frames; k++) {
               if(frame[k] != -1)
                  printf("%d ", frame[k]);
               else
                  printf("- ");
            }
            printf("\tNo\n");
         }
      }
      printf("\nTotal Page Faults = %d\n", count);
      return 0;
   }
```

Output:

```
Enter number of pages: 15
Enter the page reference string:
7 0 1 2 0 3 0 4 2 3 0 3 1 2 0
Enter number of frames: 3

Page    Frames          Page Fault
7       7 - -   Yes
0       7 0 -   Yes
1       7 0 1   Yes
2       2 0 1   Yes
0       2 0 1   No
3       2 3 1   Yes
0       2 3 0   Yes
4       4 3 0   Yes
2       4 2 0   Yes
3       4 2 3   Yes
0       0 2 3   Yes
3       0 2 3   No
1       0 1 3   Yes
2       0 1 2   Yes
0       0 1 2   No

Total Page Faults = 12
```

1 Write C programs to demonstrate page replacement by the following techniques.

i) FIFO
ii) LRU
iii) Optimal

i)
```
#include <stdio.h>
int main () {
    int frames, pages [50], n, frame [10], i,
      j, k, avail, count = 0;
printf ("Enter number of pages : ");
scanf ("%d", &n);
printf ("Enter the page reference string\n");
for (i=0; i<n; i++)
        scanf ("%d", & pages [i]);
printf ("Enter number of frames : ");
scanf ("%d", & frames);
for (i=0 ; i< frames ; i++)
    frame [i] = -1;
printf ("\n Page \t Frames \t\t Page fault \n");
j=0;
for (i=0; i<n; i++) {
    avail = 0;
  for (k=0; k<frames ; k++) {
    if ( frame [k] = = pages [i]) {
        avail = 1;
        break;
    }
  }
}
```

```
if (avail == 0) {
    frame[j] = pages[i];
    j = (j+1) % frames;
    count++;
    printf("%d\t", pages[i]);
    for (k=0; k < frames; k++) {
        if (frame[k] != -1)
            printf("%d", frame[k]);
        else
            printf("-");
    }
    printf("\t Yes\n");
} else {
    printf("%d\t", pages[i]);
    for (k=0; k < frames; k++) {
        if (frame[k] != -1)
            printf("%d", frame[k]);
        else
            printf("-");
    }
    printf("\tNo\n");
}
}
printf("\nTotal Page Faults = %d\n", count);
return 0;
}
```

Output

Enter the number of pages : 15
Enter the page reference string :
7 0 1 2 0 3 0 4 2 3 0 3 1 2 0
Enter the number of frames : 3

Page	Frames	Page Fault
7	7 _ _	Yes
0	7 0 _	Yes
1	7 0 1	Yes
2	2 0 1	Yes
0	2 0 1	No
3	2 3 1	Yes
0	2 3 0	Yes
4	4 3 0	Yes
2	4 2 0	Yes
3	4 2 3	Yes
0	0 2 3	Yes
3	0 2 3	No
1	0 1 3	Yes
2	0 1 2	Yes
0	0 1 2	No

Total Page faults = 12.

b.) LRU

```
#include <stdio.h>

int main() {
   int n, frames, i, j, k, faults = 0;
   printf("Enter number of pages: ");
   scanf("%d", &n);
   int pages[n];
   printf("Enter the reference string: ");
   for(i = 0; i < n; i++)
      scanf("%d", &pages[i]);

   printf("Enter number of frames: ");
   scanf("%d", &frames);

   int frame_arr[frames];
   int time[frames]; // To track the usage time
   for(i = 0; i < frames; i++) {
      frame_arr[i] = -1;
      time[i] = 0;
   }

   int counter = 0;
   for(i = 0; i < n; i++) {
      int flag = 0;
      for(j = 0; j < frames; j++) {
         if(frame_arr[j] == pages[i]) {
            flag = 1;
            counter++;
            time[j] = counter; // Update the usage time
            break;
         }
      }

      if(flag == 0) { // Page fault
         faults++;
```

```
            int min_time = time[0], min_pos = 0;
            for(k = 1; k < frames; k++) {
                if(time[k] < min_time) {
                    min_time = time[k];
                    min_pos = k;
                }
            }
            frame_arr[min_pos] = pages[i]; // Replace the least recently used
            counter++;
            time[min_pos] = counter; // Update the usage time for the new page
        }

        printf("Frames after accessing %d: ", pages[i]);
        for(j = 0; j < frames; j++) {
            if(frame_arr[j] == -1)
                printf("- ");
            else
                printf("%d ", frame_arr[j]);
        }
        printf("\n");
    }

    printf("Total page faults: %d\n", faults);
    int Hits = n-faults;
    printf("Total page Hits: %d\n",Hits);
    return 0;
}
```

Output:

```
Enter number of pages: 7
Enter the reference string: 1 3 0 3 5 6 3
Enter number of frames: 3
Frames after accessing 1: 1 - -
Frames after accessing 3: 1 3 -
Frames after accessing 0: 1 3 0
Frames after accessing 3: 1 3 0
Frames after accessing 5: 5 3 0
Frames after accessing 6: 5 3 6
Frames after accessing 3: 5 3 6
Total page faults: 5
Total page Hits: 2
```

ii)
```
#include <stdio.h>
int main () {
    int n, frames, i, j, k, faults = 0;
    printf ("Enter number of pages : ");
    scanf ("%d", &n);
    int pages[n];
    printf ("Enter the reference string : ");
    for (i=0; i<n; i++)
        scanf ("%d", &pages[i]);
    printf ("Enter number of frames: ");
    scanf ("%d", &frames);
    int frame_arr[frames];
    int time[frames];
    for (i=0; i<frames; i++) {
        frame_arr[i] = -1;
        time[i] = 0;
    }
int counter = 0;
for (i=0; i<n; i++) {
    int flag = 0;
    for (j=0; j<frames; j++) {
        if (frame_arr[j] == pages[i]) {
            flag = 1;
            counter++;
            time[j] = counter;
            break;
        }
    }
}
```

```
if (flag == 0) {
    faults++;
    int min_time = time[0], min_pos = 0;
    for (k=1; k < frames; k++) {
        if (time[k] < min_time) {
            min_time = time[k];
            min_pos = k;
        }
    }
    frame_arr[min_pos] = pages[i];
    counter++;
    time[min_pos] = counter;
}
printf("Frames after accessing %d: ", pages[i]);
for(j=0; j<frames; j++) {
    if (frame_arr[j] == -1)
        printf("- ");
    else
        printf("%d", frame_arr[j]);
}
printf("\n");
}
printf("Total page faults: %d\n", faults);
int Hits = n - faults;
printf("Total page Hits: %d\n", Hits);
return 0;
}
```

Output

```
Enter number of pages : 7
Enter the reference string : 1 3 0 3 5 6 3
Enter the number of frames : 3
Frames after accessing 1 : 1 - -
Frames after accessing 3 : 1 3 -
Frames after accessing 0 : 1 3 0
Frames after accessing 3 : 1 3 0
Frames after accessing 5 : 5 3 0
Frames after accessing 6 : 5 3 6
Frames after accessing 3 : 5 3 6
Total page faults : 5
Total page Hits : 2.
```

c) Optimal

```
#include <stdio.h>

int main() {
   int n, frames, i, j, k, faults = 0;
   printf("Enter number of pages: ");
   scanf("%d", &n);
   int pages[n];
   printf("Enter the reference string: ");
   for(i = 0; i < n; i++)
      scanf("%d", &pages[i]);

   printf("Enter number of frames: ");
   scanf("%d", &frames);

   int frame_arr[frames];
   for(i = 0; i < frames; i++)
      frame_arr[i] = -1;

   for(i = 0; i < n; i++) {
      int flag = 0;
      for(j = 0; j < frames; j++) {
         if(frame_arr[j] == pages[i]) {
            flag = 1;
            break;
         }
      }
      if(flag == 0) {
         faults++;
         int pos = -1;
         for(j = 0; j < frames; j++) {
            if(frame_arr[j] == -1) {
               pos = j;
               break;
            }
         }
         if(pos == -1) {
            int farthest = i, replace_index = 0;
            for(j = 0; j < frames; j++) {
               int found = 0;
               for(k = i + 1; k < n; k++) {
                  if(frame_arr[j] == pages[k]) {
                     if(k > farthest) {
                        farthest = k;
                        replace_index = j;
                     }
                     found = 1;
                     break;
                  }
```

```
                }
                if(!found) {
                    replace_index = j;
                    break;
                }
            }
            pos = replace_index;
        }
        frame_arr[pos] = pages[i];
    }
    printf("%d: ", pages[i]);
    for(j = 0; j < frames; j++) {
        if(frame_arr[j] == -1)
            printf("_ ");
        else
            printf("%d ", frame_arr[j]);
    }
    printf("\n");
  }
  printf("Total page faults: %d\n", faults);
  int Hits = n-faults;
  printf("Total page Hits: %d\n",Hits);
  return 0;
}
```

Output:

```
Enter number of pages: 7
Enter the reference string: 1 3 0 3 5 6 3
Enter number of frames: 3
Frames after accessing 1: 1 _ _
Frames after accessing 3: 1 3 _
Frames after accessing 0: 1 3 0
Frames after accessing 3: 1 3 0
Frames after accessing 5: 5 3 0
Frames after accessing 6: 6 3 0
Frames after accessing 3: 6 3 0
Total page faults: 5
Total page Hits: 2
```

iii)
```
#include <stdio.h>
int main() {
    int n, frames, i, j, k, faults = 0;
    printf("Enter number of pages: ");
    scanf("%d", &n);
    int pages[n];
    printf("Enter the reference string: ");
    for(i=0; i<n; i++)
        scanf("%d", &pages[i]);

    printf("Enter number of frames: ");
    scanf("%d", &frames);

    int frame_arr[frames];
    for(i=0; i<frames; i++)
        frame_arr[i] = -1;
```

```
for (i=0; i<n; i++) {
    int flag = 0;
    for (j=0; j< frames ; j++) {
        if ( frame_arr [j] == pages [i]) {
            flag = 1;
            break;
        }
    }
if (pos == -1) {
int farthest = i , replace_index = 0;
for (j=0; j< frames ; j++) {
    int found = 0;
    for ( k = i+1; k <n;  k++) {
        if (frame_arr [j] == pages (k]){
            if (k > farthest) {
                farthest = k;
                replace_index = j;
            }
            found = 1;
            break;
        }
    }
    if (!found) {
        replace_index = j;
        break;
    }
}
pos = replace_index ;
}
frame_arr [pos] = pages [i];
}
```

```
printf ("%d:", pages[i]);
for (j=0; j < frames ; j++) {
    if (frame_arr[j] == -1)
        printf ("_ ");
    else
        printf ("%d", frame_arr[j]);
}
printf ("\n");
}
printf ("Total page faults : %d\n", faults);
int Hits = n - faults ;
printf ("Total page Hits : %d\n", Hits);
return 0;
}
```

Output

```
Enter number of pages : 7
Enter the reference string : 1 3 0 3 5 6 3
Enter the number of frames : 3
Frames after accessing 1 : 1 _ _
Frames after accessing 3 : 1 3 _
Frames after accessing 0 : 1 3 0
Frames after accessing 3 : 1 3 0
Frames after accessing 5 : 5 3 0
Frames after accessing 6 : 6 3 0
Frames after accessing 3 : 6 3 0
Total page faults : 5
Total page Hits : 2.
```