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

(Autonomous Institution under VTU)

BENGALURU-560019

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B. M. S. College of Engineering,
Bull Temple Road, Bangalore 560019
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Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "**Operating Systems**" carried out by **Vismitha Raj S Doshi(1WA23CS047),** who is a 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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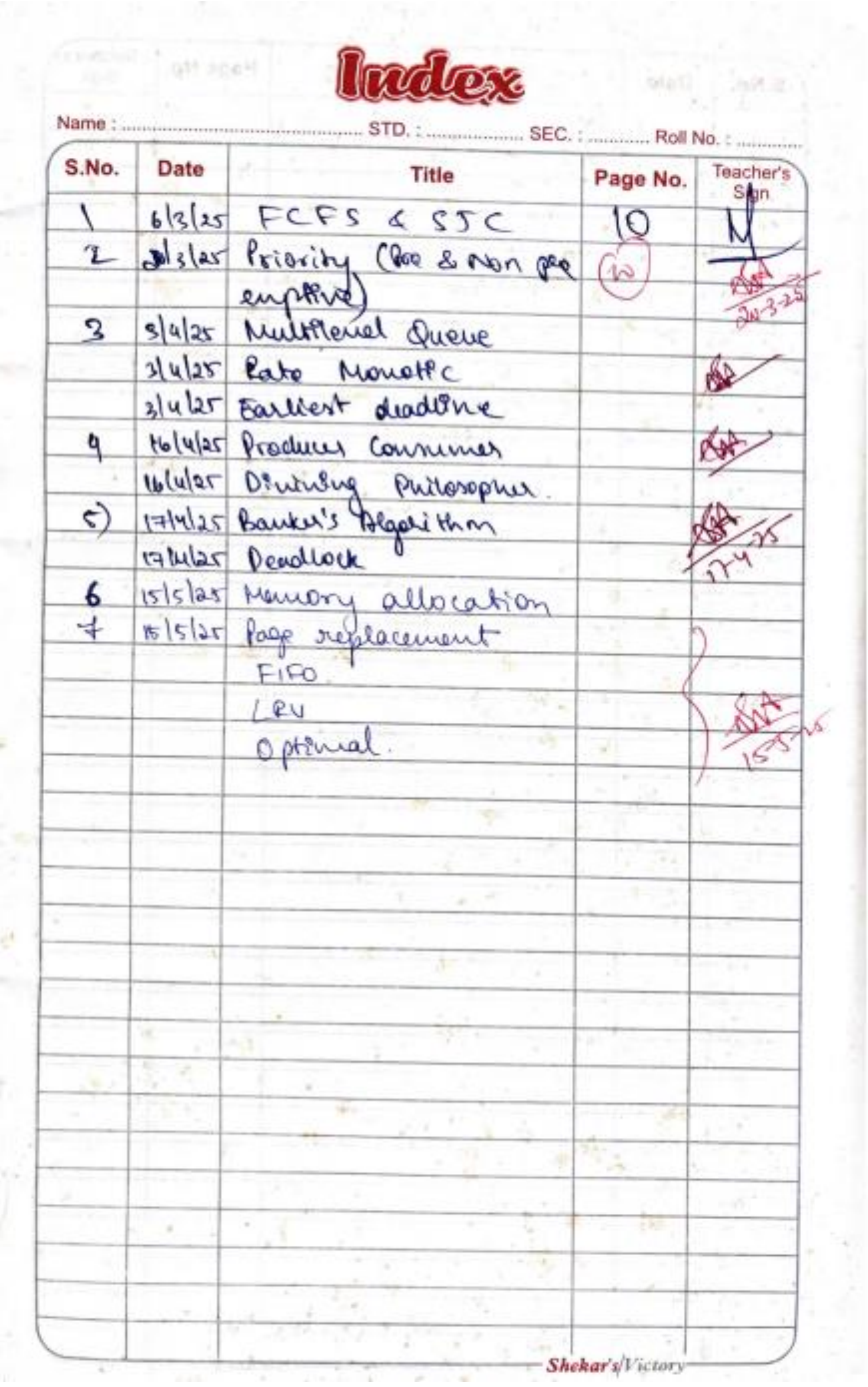

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Name : .... STD. : .... SEC. : .... Roll No. : ....

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.

GITHUB LINK:

https://github.com/vismitharaj/OS-lab

Experiments

1. **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

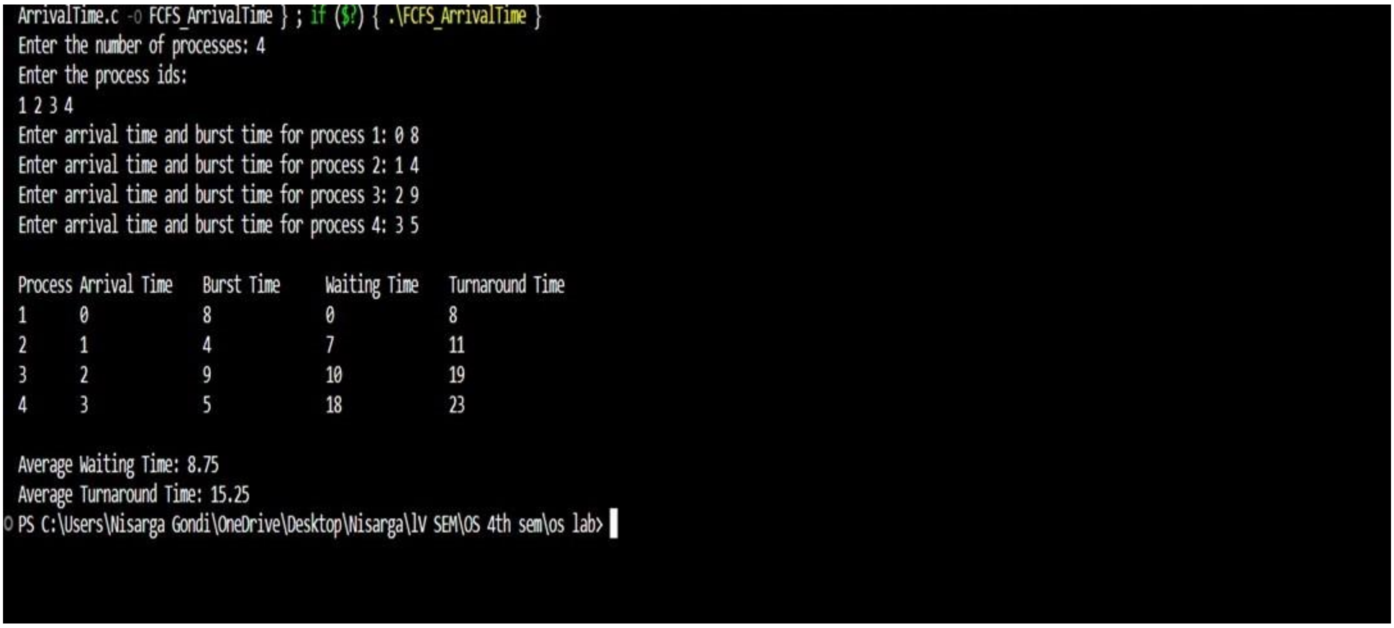
```
#include<stdio.h>
   int n, i, j, pos, temp, choice, Burst_time[20], Waiting_time[20],
   Turn_around_time[20], process[20], total=0;
   float avg_Turn_around_time=0, avg_Waiting_time=0;

int FCFS()
{
   Waiting_time[0]=0;

   for(i=1;i<n;i++)
   {
      Waiting_time[i]=0;
      for(j=0;j<i;j++)
         Waiting_time[i]+=Burst_time[j];
   }

   printf("\nProcess\t\tBurst Time\t\tWaiting Time\t\tTurnaround Time");

   for(i=0;i<n;i++)
   {
      Turn_around_time[i]=Burst_time[i]+Waiting_time[i];
      avg_Waiting_time+=Waiting_time[i];
      avg_Turn_around_time+=Turn_around_time[i];

printf("\nP[%d]\t\t%d\t\t\t%d\t\t\t\t%d",i+1,Burst_time[i],Waiting_time[i],Turn_around_t
ime[i]);
   }

   avg_Waiting_time =(float)(avg_Waiting_time)/(float)i;
   avg_Turn_around_time=(float)(avg_Turn_around_time)/(float)i;
   printf("\nAverage Waiting Time:%.2f",avg_Waiting_time);
   printf("\nAverage Turnaround Time:%.2f\n",avg_Turn_around_time);

   return 0;
}
```

```
int SJF()
{
   //sorting
   for(i=0;i<n;i++)
   {
      pos=i;
      for(j=i+1;j<n;j++)
      {
         if(Burst_time[j]<Burst_time[pos])
            pos=j;
      }

      temp=Burst_time[i];
      Burst_time[i]=Burst_time[pos];
      Burst_time[pos]=temp;

      temp=process[i];
      process[i]=process[pos];
      process[pos]=temp;
   }
      Waiting_time[0]=0;


   for(i=1;i<n;i++)
   {
      Waiting_time[i]=0;

      for(j=0;j<i;j++)
         Waiting_time[i]+=Burst_time[j];

      total+=Waiting_time[i];
   }

   avg_Waiting_time=(float)total/n;
   total=0;

   printf("\nProcess\t\tBurst Time\t\tWaiting Time\t\tTurnaround Time");

   for(i=0;i<n;i++)
   {
      Turn_around_time[i]=Burst_time[i]+Waiting_time[i];
      total+=Turn_around_time[i];

printf("\nP[%d]\t\t%d\t\t\t%d\t\t\t\t%d",process[i],Burst_time[i],Waiting_time[i],Turn_ar
ound_time[i]);
```

```
    }

    avg_Turn_around_time=(float)total/n;
    printf("\n\nAverage Waiting Time=%f",avg_Waiting_time);
    printf("\nAverage Turnaround Time=%f\n",avg_Turn_around_time);
}

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

    printf("\nEnter Burst Time:\n");
    for(i=0;i<n;i++)
    {
        printf("P[%d]:",i+1);
        scanf("%d",&Burst_time[i]);
        process[i]=i+1;
    }

    while(1)
    {   printf("\n-----MAIN MENU -----\n");
        printf("1. FCFS Scheduling\n2. SJF Scheduling\n");
        printf("\nEnter your choice:");
        scanf("%d", &choice);
        switch(choice)
        {
            case 1: FCFS();
            break;

            case 2: SJF();
            break;

            default: printf("Invalid Input!!!");
        }
    }
    return 0;
}
```

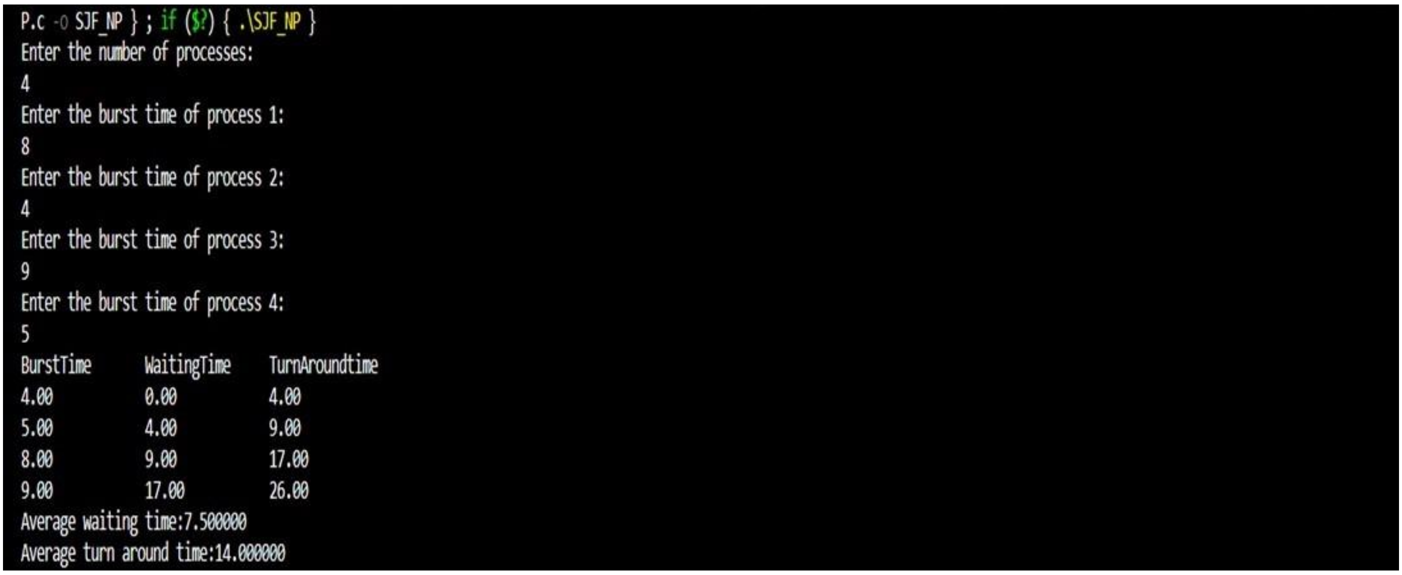
Output:

a.

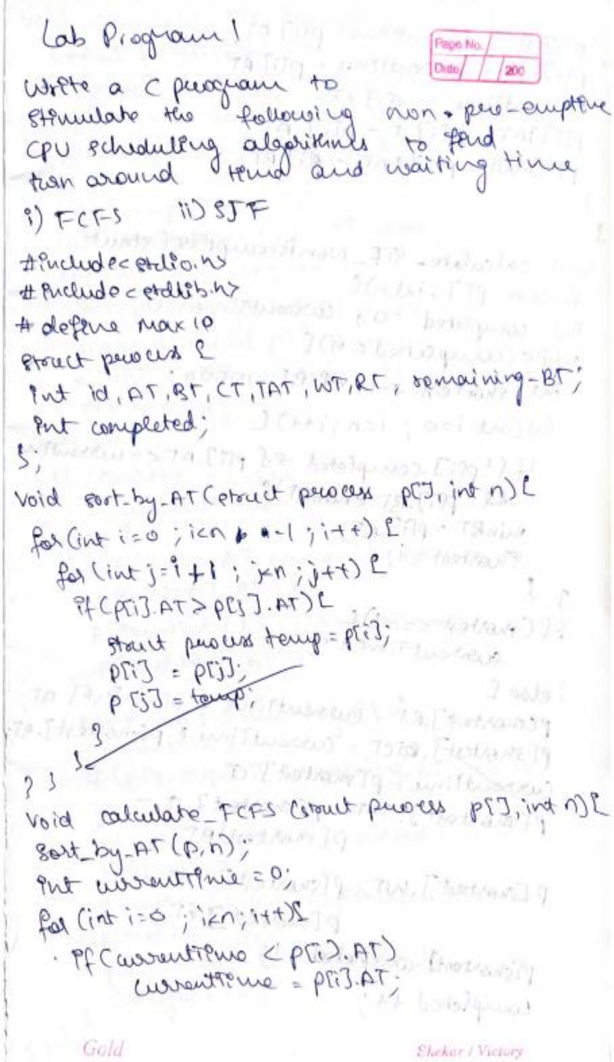


```
ArrivalTime.c -o FCFS_ArrivalTime } ; if ($?) { .\FCFS_ArrivalTime }
Enter the number of processes: 4
Enter the process ids:
1 2 3 4
Enter arrival time and burst time for process 1: 0 8
Enter arrival time and burst time for process 2: 1 4
Enter arrival time and burst time for process 3: 2 9
Enter arrival time and burst time for process 4: 3 5

Process Arrival Time    Burst Time      Waiting Time    Turnaround Time
1       0               8               0               8
2       1               4               7               11
3       2               9               10              19
4       3               5               18              23

Average Waiting Time: 8.75
Average Turnaround Time: 15.25
○ PS C:\Users\Nisarga Gondi\OneDrive\Desktop\Nisarga\lV SEM\OS 4th sem\os lab>
```

b.



```
P.c -o SJF_NP } ; if ($?) { .\SJF_NP }
Enter the number of processes:
4
Enter the burst time of process 1:
8
Enter the burst time of process 2:
4
Enter the burst time of process 3:
9
Enter the burst time of process 4:
5
BurstTime       WaitingTime     TurnAroundtime
4.00            0.00            4.00
5.00            4.00            9.00
8.00            9.00            17.00
9.00            17.00           26.00
Average waiting time:7.500000
Average turn around time:14.000000
```



Lab Program 1

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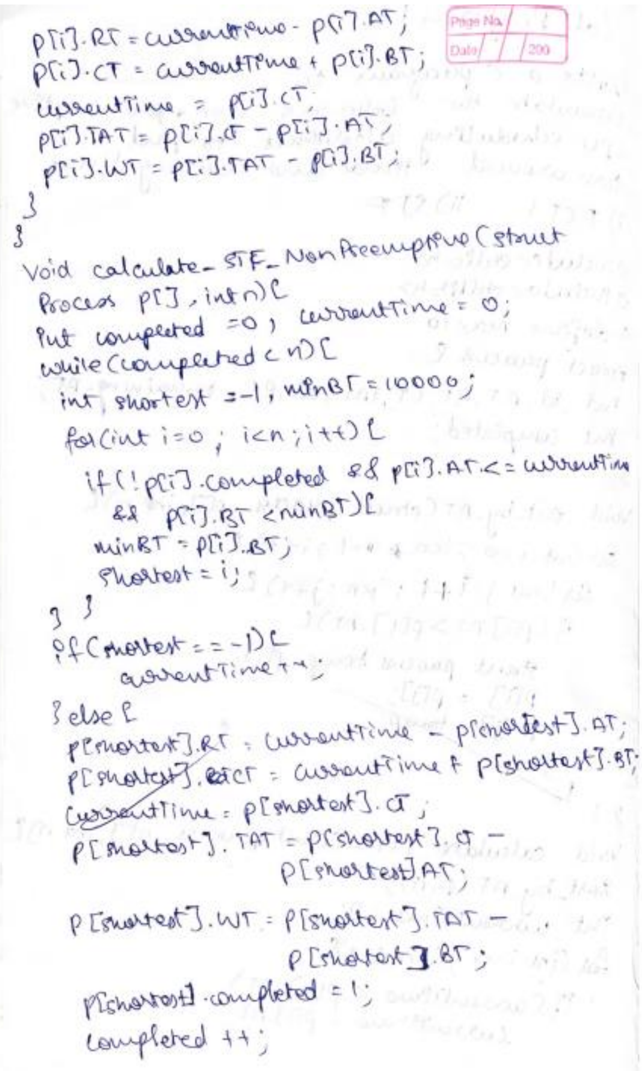
Write a C program to stimulate the following non-pre-emptive CPU scheduling algorithms to find turn around time and waiting time

i) FCFS   ii) SJF

```
#include<stdio.h>
#include<stdlib.h>
#define max 10
struct process {
 int id, AT, BT, CT, TAT, WT, RT, remaining_BT;
 int completed;
};
void sort_by_AT(struct process p[], int n){
 for(int i=0 ; i<n-1 ; i++) {
  for(int j=i+1 ; j<n ; j++) {
   if(p[i].AT > p[j].AT){
     struct process temp = p[i];
     p[i] = p[j];
     p[j] = temp;
   }
  }
 }}
void calculate_FCFS (struct process p[], int n){
 sort_by_AT(p, n);
 int currentTime = 0;
 for (int i=0 ; i<n; i++){
  if(currentTime < p[i].AT)
       currentTime = p[i].AT;
```

Gold   Shekar / Victory



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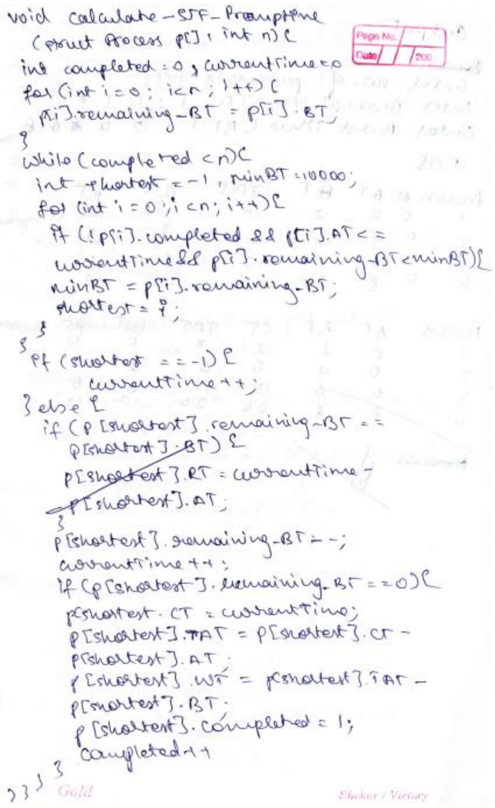
```
p[i].RT = currentTime - p[i].AT;
p[i].CT = currentTime + p[i].BT;
currentTime = p[i].CT;
p[i].TAT = p[i].CT - p[i].AT;
p[i].WT = p[i].TAT - p[i].BT;
}
}
void calculate_SJF_NonPreemptive(struct
 Process p[], int n){
 int completed =0, currentTime = 0;
 while(completed < n){
  int shortest =-1, minBT = 10000;
  for(int i=0 ; i<n; i++){
   if(!p[i].completed && p[i].AT <= currentTime
     && p[i].BT < minBT){
   minBT = p[i].BT;
   shortest = i;
  }}
  if(shortest == -1){
     currentTime++;
  }else{
   p[shortest].RT = currentTime - p[shortest].AT;
   p[shortest].~~BT~~CT = currentTime + p[shortest].BT;
   currentTime = p[shortest].CT;
   p[shortest].TAT = p[shortest].CT -
                 p[shortest].AT;

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

   p[shortest].completed = 1;
   completed ++;
```



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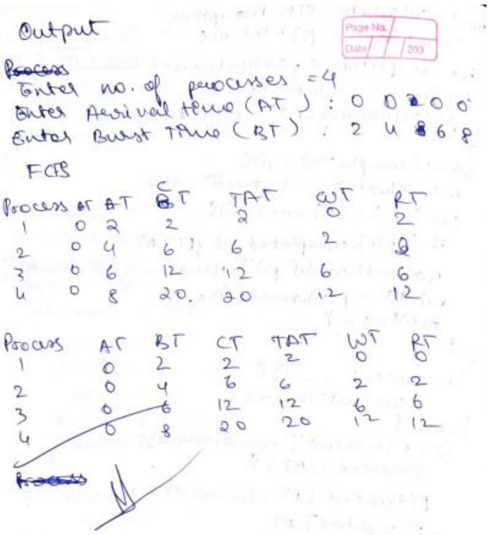
```
void calculate_SJF_Preemptive
 (struct Process p[], int n){
 int completed = 0, currentTime = 0
 for (int i=0; i<n; i++){
  p[i].remaining_BT = p[i].BT;
 }
 while (completed < n){
  int shortest = -1, minBT =10000;
  for (int i = 0; i<n; i++){
   if (!p[i].completed && p[i].AT <=
   currentTime && p[i].remaining_BT<minBT){
   minBT = p[i].remaining_BT;
   shortest = i;
  }
 }
  if (shortest == -1){
      currentTime++;
 }else{
  if (p[shortest].remaining_BT ==
    p[shortest].BT){
   p[shortest].RT = currentTime -
   p[shortest].AT;
  }
  p[shortest].remaining_BT--;
  currentTime++;
  if (p[shortest].remaining_BT == 0){
   p[shortest.CT = currentTime;
   p[shortest].TAT = p[shortest].CT -
   p[shortest].AT;
   p[shortest].WT = p[shortest].TAT -
   p[shortest].BT;
   p[shortest].completed = 1;
   completed++
 }}
}}
```

Gold   Shekar / Victory



Output

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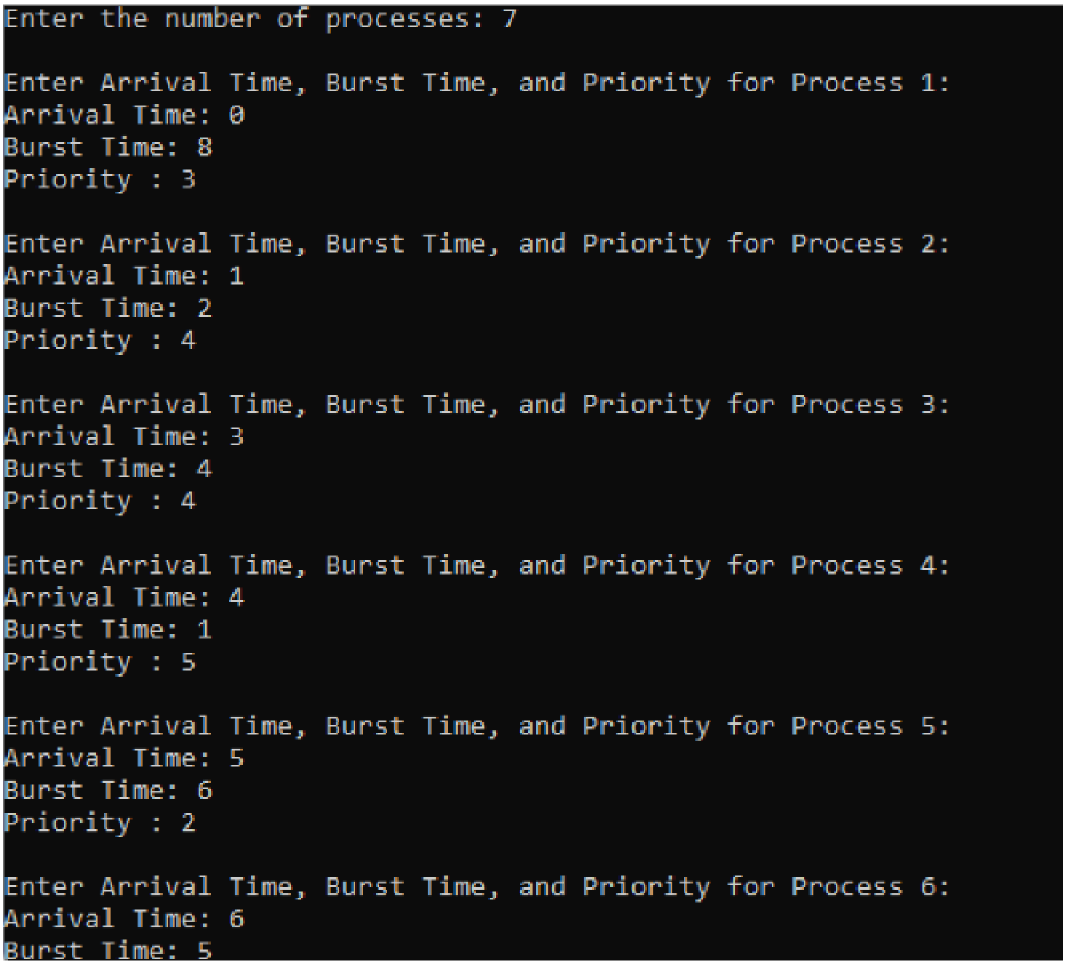
```
~~Process~~
Enter no. of processes =4
Enter Arrival time (AT) : 0 0 0 0
Enter Burst Time (BT) : 2 4 6 8
 FCFS
Process AT AT  CT   TAT   WT   RT
  1     0  2   2     2    0    2
  2     0  4   6     6    2    2
  3     0  6   12    12   6    6
  4     0  8   20.   20   12   12

Process   AT  BT   CT   TAT   WT   RT
  1       0   2    2     2    0    0
  2       0   4    6     6    2    2
  3       0   6    12    12   6    6
  4       0   8    20    20   12   12
~~Process~~
```

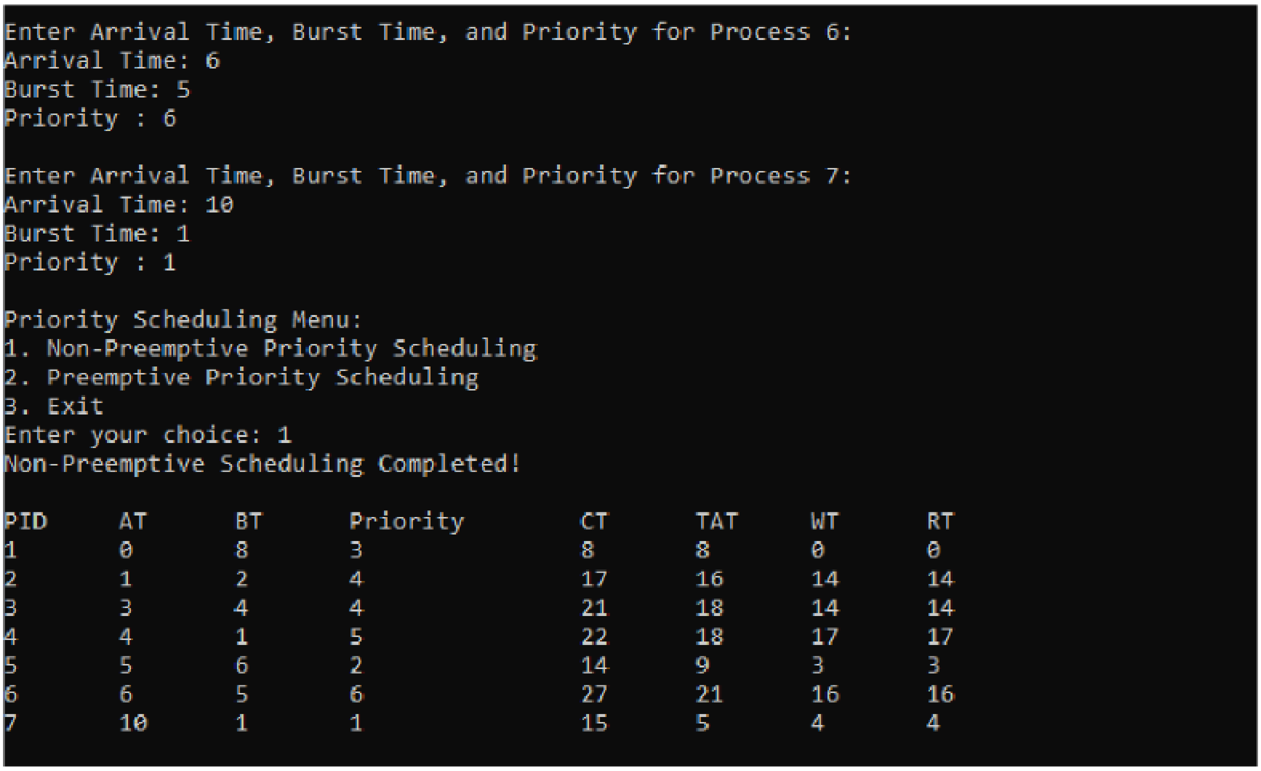
2.Priority

```
#include <stdio.h>
#define MAX 10
typedef struct {
    int pid, at, bt, pt, remaining_bt, ct, tat, wt, rt, is_completed, st;
} Process;
void nonPreemptivePriority(Process p[], int n) {
    int time = 0, completed = 0;
    while (completed < n) {
        int highest_priority = 9999, selected = -1;

        for (int i = 0; i < n; i++) {
            if (p[i].at <= time && !p[i].is_completed && p[i].pt < highest_priority) {
                highest_priority = p[i].pt;
                selected = i;
            }
        }
        if (selected == -1) {
            time++;
            continue;
        }
        if (p[selected].rt == -1) {
            p[selected].st = time;  // Start time
            p[selected].rt = time - p[selected].at;
        }
        time += p[selected].bt;
        p[selected].ct = time;
        p[selected].tat = p[selected].ct - p[selected].at;
        p[selected].wt = p[selected].tat - p[selected].bt;
        p[selected].is_completed = 1;
        completed++;
    }
}
void preemptivePriority(Process p[], int n) {
    int time = 0, completed = 0;

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

        for (int i = 0; i < n; i++) {
            if (p[i].at <= time && p[i].remaining_bt > 0 && p[i].pt < highest_priority) {
                highest_priority = p[i].pt;
                selected = i;
            }
        }
        if (selected == -1) {
            time++;
            continue;
        }
        if (p[selected].rt == -1) {
            p[selected].st = time;  // Start time
            p[selected].rt = time - p[selected].at;
        }
        p[selected].remaining_bt--;
        time++;

        if (p[selected].remaining_bt == 0) {
            p[selected].ct = time;
            p[selected].tat = p[selected].ct - p[selected].at;
            p[selected].wt = p[selected].tat - p[selected].bt;
            completed++;
        }
    }
}
void displayProcesses(Process p[], int n) {
    float avg_tat = 0, avg_wt = 0, avg_rt = 0;

    printf("\nPID\tAT\tBT\tPriority\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t%d\t%d\t\t%d\t%d\t%d\t%d\n",
               p[i].pid, p[i].at, p[i].bt, p[i].pt, p[i].ct, p[i].tat, p[i].wt, p[i].rt);
        avg_tat += p[i].tat;
        avg_wt += p[i].wt;
        avg_rt += p[i].rt;
    }

    printf("\nAverage TAT: %.2f", avg_tat / n);
    printf("\nAverage WT: %.2f", avg_wt / n);
    printf("\nAverage RT: %.2f\n", avg_rt / n);
}
int main() {
    Process p[MAX];
    int n, choice;

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

    for (int i = 0; i < n; i++) {
        p[i].pid = i + 1;
        printf("\nEnter Arrival Time, Burst Time, and Priority for Process %d:\n", p[i].pid);
        printf("Arrival Time: ");
        scanf("%d", &p[i].at);
        printf("Burst Time: ");
        scanf("%d", &p[i].bt);
        printf("Priority : ");
        scanf("%d", &p[i].pt);
        p[i].remaining_bt = p[i].bt;
        p[i].is_completed = 0;
        p[i].rt = -1;
    }

    while (1) {
        printf("\nPriority Scheduling Menu:\n");
        printf("1. Non-Preemptive Priority Scheduling\n");
        printf("2. Preemptive Priority Scheduling\n");
        printf("3. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
            case 1:
                nonPreemptivePriority(p, n);
                printf("Non-Preemptive Scheduling Completed!\n");
                displayProcesses(p, n);
                break;
            case 2:
                preemptivePriority(p, n);
                printf("Preemptive Scheduling Completed!\n");
                displayProcesses(p, n);
                break;
            case 3:
                printf("Exiting...\n");
                return 0;
            default:
                printf("Invalid choice! Try again.\n");
        }
    }


    return 0;
}
```

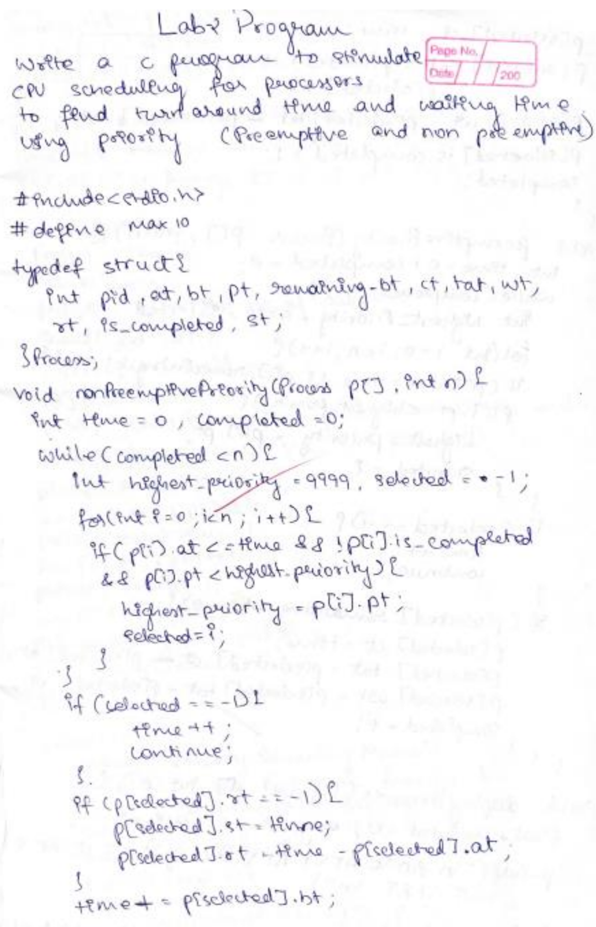
Output:



```
Enter the number of processes: 7

Enter Arrival Time, Burst Time, and Priority for Process 1:
Arrival Time: 0
Burst Time: 8
Priority : 3

Enter Arrival Time, Burst Time, and Priority for Process 2:
Arrival Time: 1
Burst Time: 2
Priority : 4

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

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

Enter Arrival Time, Burst Time, and Priority for Process 5:
Arrival Time: 5
Burst Time: 6
Priority : 2

Enter Arrival Time, Burst Time, and Priority for Process 6:
Arrival Time: 6
Burst Time: 5
```



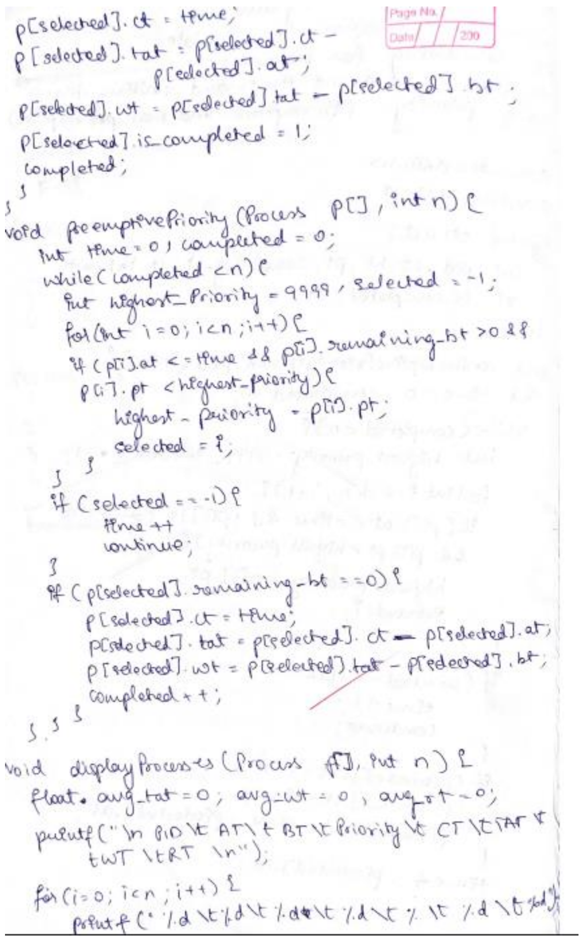
```
Enter Arrival Time, Burst Time, and Priority for Process 6:
Arrival Time: 6
Burst Time: 5
Priority : 6

Enter Arrival Time, Burst Time, and Priority for Process 7:
Arrival Time: 10
Burst Time: 1
Priority : 1

Priority Scheduling Menu:
1. Non-Preemptive Priority Scheduling
2. Preemptive Priority Scheduling
3. Exit
Enter your choice: 1
Non-Preemptive Scheduling Completed!

PID     AT      BT      Priority        CT      TAT     WT      RT
1       0       8       3               8       8       0       0
2       1       2       4               17      16      14      14
3       3       4       4               21      18      14      14
4       4       1       5               22      18      17      17
5       5       6       2               14      9       3       3
6       6       5       6               27      21      16      16
7       10      1       1               15      5       4       4
```



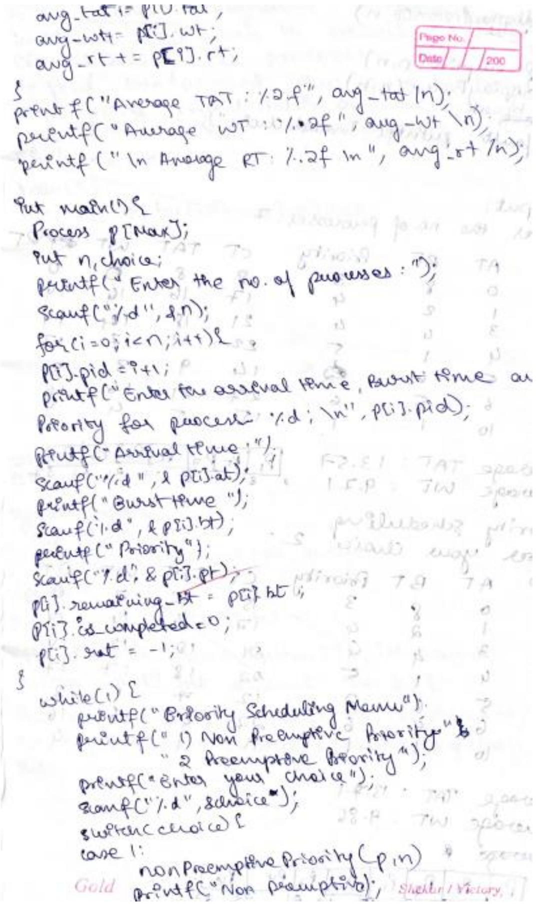
Lab2 Program

Write a c program to stimulate CPU scheduling for processors to find turnaround time and waiting time using priority (Preemptive and non preemptive)

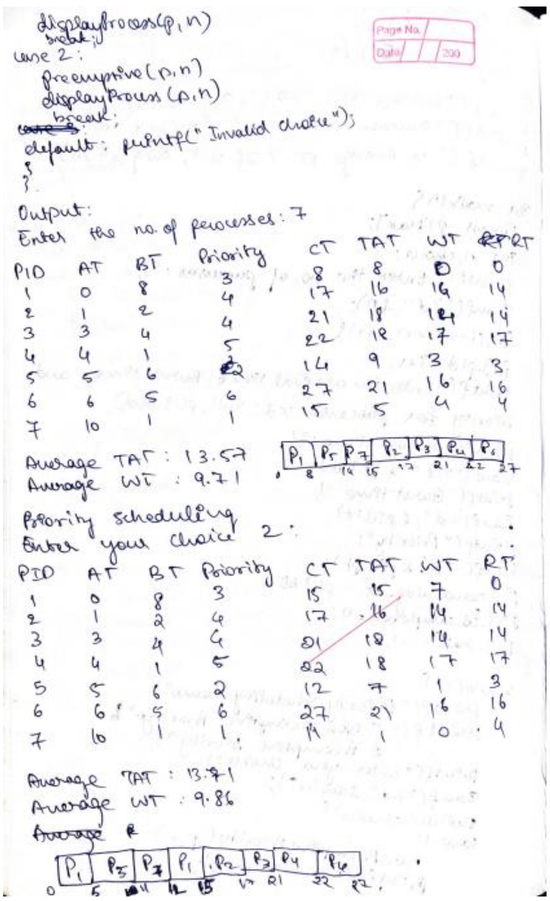
```
#include<stdio.h>
#define max 10

typedef struct{
  int pid, at, bt, pt, remaining-bt, ct, tat, wt,
   rt, is_completed, st;
}Process;
void nonPreemptivePriority(Process p[], int n) {
 int time = 0, completed =0;
 while(completed <n){
   int highest_priority = 9999, selected = -1;
    for(int i=0 ; i<n ; i++){
     if(p[i].at <= time && !p[i].is_completed
      && p[i].pt <highest_priority){
        highest_priority = p[i].pt;
        selected=i;
     }
   }
  if (selected ==-1){
       time++;
       continue;
   }.
  if (p[selected].rt ==-1){
      p[selected].st = time;
      p[selected].rt = time - p[selected].at;
  }
  time+= p[selected].bt;
```



```
p[selected].ct = time;
p[selected].tat = p[selected].ct -
            p[selected].at;
p[selected].wt = p[selected] tat - p[selected] bt;
p[selected].is_completed = 1;
completed;
}
}
void preemptivePriority(Process p[], int n) {
  int time=0, completed = 0;
  while(completed <n){
   int highest_Priority = 9999, selected = -1;
   for(int i=0; i<n ;i++){
   if (p[i].at <= time && p[i].remaining-bt >0 &&
    p[i].pt <highest_priority){
       highest - priority = p[i].pt;
       selected = i;
     }
  }
  if (selected == -1){
      time ++
      continue;
  }
  if (p[selected].remaining-bt ==0){
     p[selected].ct = time;
     p[selected].tat = p[selected].ct - p[selected].at;
     p[selected].wt = p[selected].tat - p[selected].bt;
     completed++;
} } }

void displayProcesses(Process p[], int n) {
 float avg_tat =0; avg_wt = 0, avg_rt =0;
 printf("\n PID \t AT\t BT\t Priority \t CT \t TAT \t
      tWT \tRT \n");
 for(i=0; i<n ; i++) {
   printf(" %d \t %d\t %d\t %d\t % \t %d \t %d");
```



```
 avg_tat += p[i].tat;
 avg-wt+= p[i].wt;
 avg_rt += p[i].rt;
}
printf("Average TAT : %.2f", avg_tat /n);
printf("Average WT : %.2f", avg-wt \n);
printf(" \n Average RT : %.2f \n", avg_rt /n);

int main(){
 Process p[Max];
 int n, choice;
 printf(" Enter the no. of processes : ");
 scanf("%d", &n);
 for(i=0; i<n; i++){
  p[i].pid =i+1;
  printf("Enter the arrival time, Burst time and
 Priority for process %d; \n", p[i].pid);
 printf("Arrival time :");
 scanf("%d", & p[i].at);
 printf("Burst time ");
 scanf("%d", & p[i].bt);
 printf(" Priority");
 scanf("%d", & p[i].pt);
 p[i].remaining_bt = p[i] bt;
 p[i].is_completed=0;
 p[i].rat = -1;
}
 while(1) {
   printf("Priority Scheduling Menu");
   printf(" 1) Non Preemptive Priority"
           " 2 Preemptive Priority");
   printf("Enter your choice");
   scanf("%d", &choice);
   switch(choice) {
   case 1:
         nonPreemptivePriority(p,n)
         printf("Non preemptive");
```



```
 displayProcess(p,n)
 break;
case 2:
 preemptive(p,n)
 displayProcess(p,n)
 break;
default: printf(" Invalid choice");
}
}.
```

Output:

Enter the no. of processes: 7

PID	AT	BT	Priority	CT	TAT	WT	~~RT~~RT
1	0	8	3	8	8	0	0
2	1	2	4	17	16	16	14
3	3	4	4	21	18	14	14
4	4	1	5	22	18	17	17
5	5	6	2	14	9	3	3
6	6	5	6	27	21	16	16
7	10	1	1	15	5	4	4

Average TAT : 13.57
Average WT : 9.71

```
| P1 | P5 | P7 | P2 | P3 | P4 | P6 |
0    8    14   15   17   21   22   27
```

Priority scheduling
Enter your choice 2 :

PID	AT	BT	Priority	CT	TAT	WT	RT
1	0	8	3	15	15	7	0
2	1	2	4	17	16	14	14
3	3	4	4	21	18	14	14
4	4	1	5	22	18	17	17
5	5	6	2	12	7	1	3
6	6	5	6	27	21	16	16
7	10	1	1	11	1	0	4

Average TAT : 13.71
Average WT : 9.86
~~Average~~ R

```
| P1 | P5 | P7 | P1 | P2 | P3 | P4 | P6 |
0    5    11   12   15   17   21   22   27
```

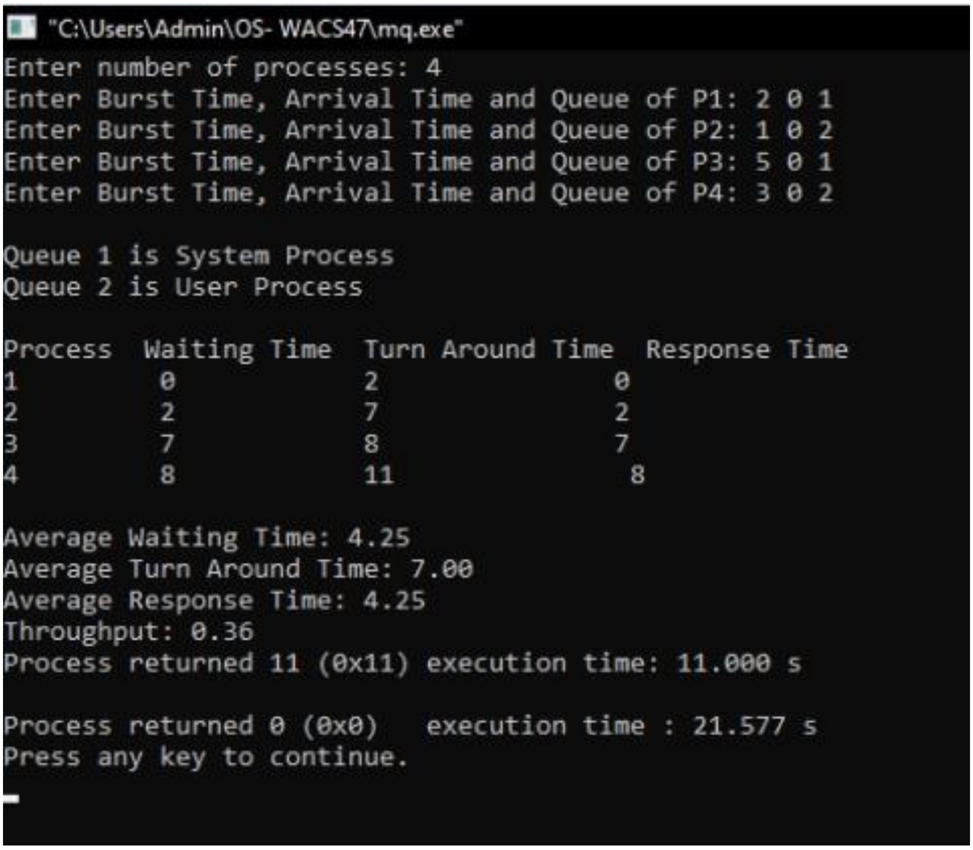
3.Write a C program to simulate multi-level queue scheduling algorithm considering the following scenario. All the processes in the system are divided into two categories – system processes and user processes. System processes are to be given higher priority than user processes. Use FCFS scheduling for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

```
#include <stdio.h>
#define MAX_PROCESSES 10
#define TIME_QUANTUM 2
typedef struct {
    int burst_time, arrival_time, queue_type, waiting_time, turnaround_time,
response_time, remaining_time;
} Process;
void round_robin(Process processes[], int n, int time_quantum, int *time) {
    int done, i;
    do {
        done = 1;
        for (i = 0; i < n; i++) {
            if (processes[i].remaining_time > 0) {
                done = 0;
                if (processes[i].remaining_time > time_quantum) {
                    *time += time_quantum;
                    processes[i].remaining_time -= time_quantum;
                } else {
                    *time += processes[i].remaining_time;
                    processes[i].waiting_time = *time - processes[i].arrival_time -
processes[i].burst_time;
                    processes[i].turnaround_time = *time - processes[i].arrival_time;
                    processes[i].response_time = processes[i].waiting_time;
                    processes[i].remaining_time = 0;
                }
            }
        }
    } while (!done);
}
void fcfs(Process processes[], int n, int *time) {
    for (int i = 0; i < n; i++) {
        if (*time < processes[i].arrival_time) {
            *time = processes[i].arrival_time;
        }
        processes[i].waiting_time = *time - processes[i].arrival_time;
        processes[i].turnaround_time = processes[i].waiting_time +
processes[i].burst_time;
        processes[i].response_time = processes[i].waiting_time;
        *time += processes[i].burst_time;
    }
}
```

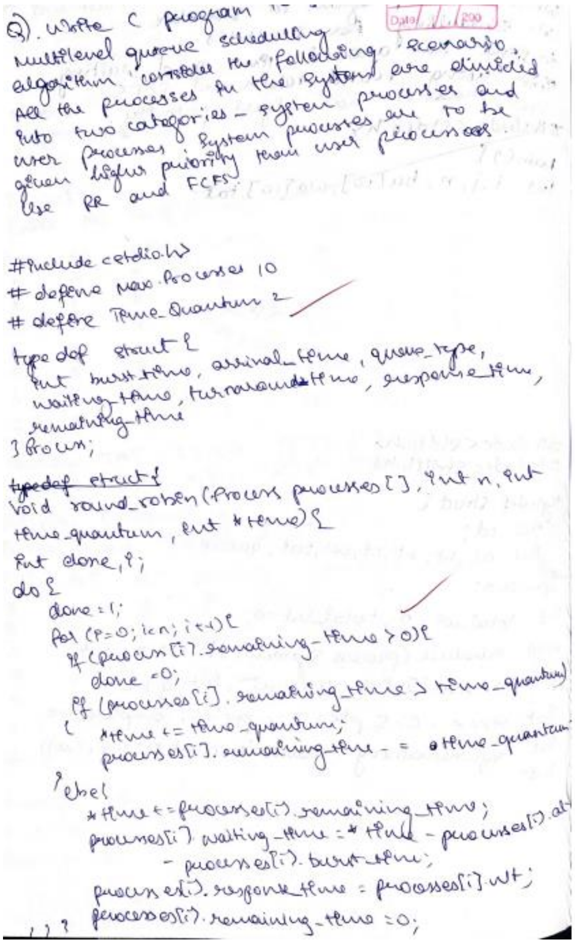
```
int main() {
   Process processes[MAX_PROCESSES], system_queue[MAX_PROCESSES],
user_queue[MAX_PROCESSES];
   int n, sys_count = 0, user_count = 0, time = 0;
   float avg_waiting = 0, avg_turnaround = 0, avg_response = 0, throughput;
   printf("Enter number of processes: ");
   scanf("%d", &n);
   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_type);
      processes[i].remaining_time = processes[i].burst_time;

      if (processes[i].queue_type == 1) {
         system_queue[sys_count++] = processes[i];
      } else {
         user_queue[user_count++] = processes[i];
      }
   }
   for (int i = 0; i < user_count - 1; i++) {
      for (int j = 0; j < user_count - i - 1; j++) {
         if (user_queue[j].arrival_time > user_queue[j + 1].arrival_time) {
            Process temp = user_queue[j];
            user_queue[j] = user_queue[j + 1];
            user_queue[j + 1] = temp;
         }
      }
   }
   printf("\nQueue 1 is System Process\nQueue 2 is User Process\n");
   round_robin(system_queue, sys_count, TIME_QUANTUM, &time);
   fcfs(user_queue, user_count, &time);

   printf("\nProcess  Waiting Time  Turn Around Time  Response Time\n");

   for (int i = 0; i < sys_count; i++) {
      avg_waiting += system_queue[i].waiting_time;
      avg_turnaround += system_queue[i].turnaround_time;
      avg_response += system_queue[i].response_time;
      printf("%d        %d           %d              %d\n", i + 1,
system_queue[i].waiting_time, system_queue[i].turnaround_time,
system_queue[i].response_time);
   }

   for (int i = 0; i < user_count; i++) {
      avg_waiting += user_queue[i].waiting_time;
```

```
            avg_turnaround += user_queue[i].turnaround_time;
            avg_response += user_queue[i].response_time;
            printf("%d        %d          %d              %d\n", i + 1 + sys_count,
    user_queue[i].waiting_time, user_queue[i].turnaround_time,
    user_queue[i].response_time);
        }

        avg_waiting /= n;
        avg_turnaround /= n;
        avg_response /= n;
        throughput = (float)n / time;

        printf("\nAverage Waiting Time: %.2f", avg_waiting);
        printf("\nAverage Turn Around Time: %.2f", avg_turnaround);
        printf("\nAverage Response Time: %.2f", avg_response);
        printf("\nThroughput: %.2f", throughput);
        printf("\nProcess returned %d (0x%d) execution time: %.3f s\n", time, time,
    (float)time);

        return 0;
}
```

Output:



```
Enter number of processes: 4
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

Queue 1 is System Process
Queue 2 is User Process

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

Average Waiting Time: 4.25
Average Turn Around Time: 7.00
Average Response Time: 4.25
Throughput: 0.36
Process returned 11 (0x11) execution time: 11.000 s

Process returned 0 (0x0)   execution time : 21.577 s
Press any key to continue.
```



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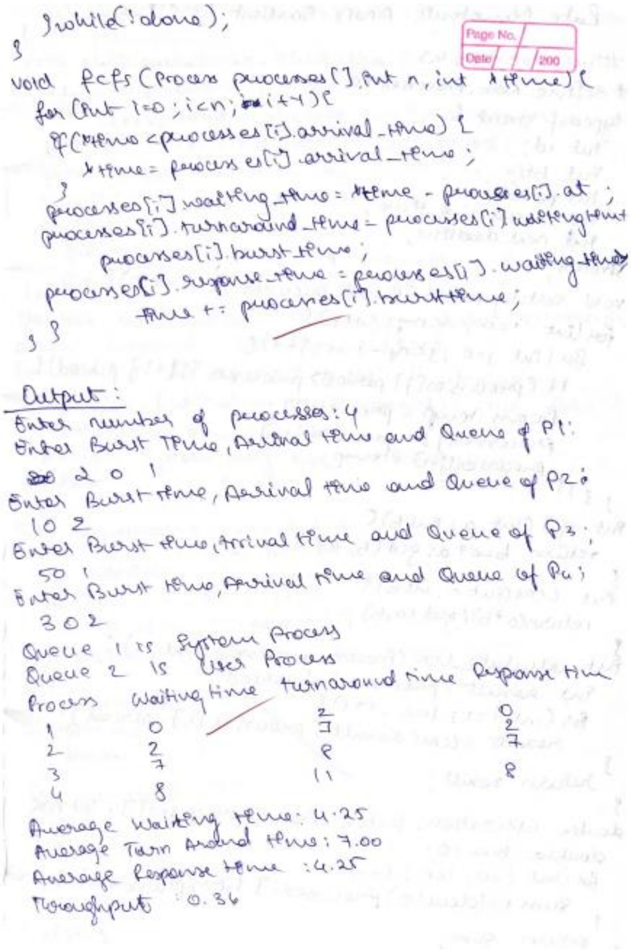
Q). Write C program multilevel queue scheduling algorithm consider the following scenario, All the processes in the system are divided into two categories - system processes and user processes; System processes are to be given higher priority than user processes Use RR and FCFS

```
#include <stdio.h>
# define Max Processes 10
# define Time_Quantum 2

typedef struct {
  int burst time, arrival_time, queue_type,
  waiting_time, turnaround time, response_time,
  remaining_time
} Process;

~~typedef struct {~~
void round_robin(Process processes[], int n, int
time_quantum, int *time) {
int done, i;
do {
    done = 1;
    for (i=0; i<n; i++) {
      if (process[i].remaining_time > 0) {
        done = 0;
      if (processes[i]. remaining_time > time_quantum)
      {   *time += time_quantum;
          processes[i]. remaining_time -= time_quantum
      } else {
        *time += processes[i]. remaining_time;
        processes[i]. waiting_time = *time - processes[i].at
                  - processes[i]. burst_time;
        processes[i]. response_time = processes[i].wt;
  } } }  processes[i]. remaining_time = 0;
```



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

Output:

```
Enter number of processes: 4
Enter Burst Time, Arrival time and Queue of P1:
 ~~20~~ 2 0 1
Enter Burst time, Arrival time and Queue of P2:
 10 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
Queue 1 is System Process
Queue 2 is User Process
Process   Waiting time    turnaround time   Response time
                              2                 0
  1          0                7                 2
  2          2                8                 7
  3          7               11                 8
  4          8
Average Waiting time: 4.25
Average Turn Around time: 7.00
Average Response time  : 4.25
Throughput  : 0.36
```

4.Write a C program to simulate Real-Time CPU Scheduling

algorithms: a) Rate- Monotonic b) Earliest-deadline First

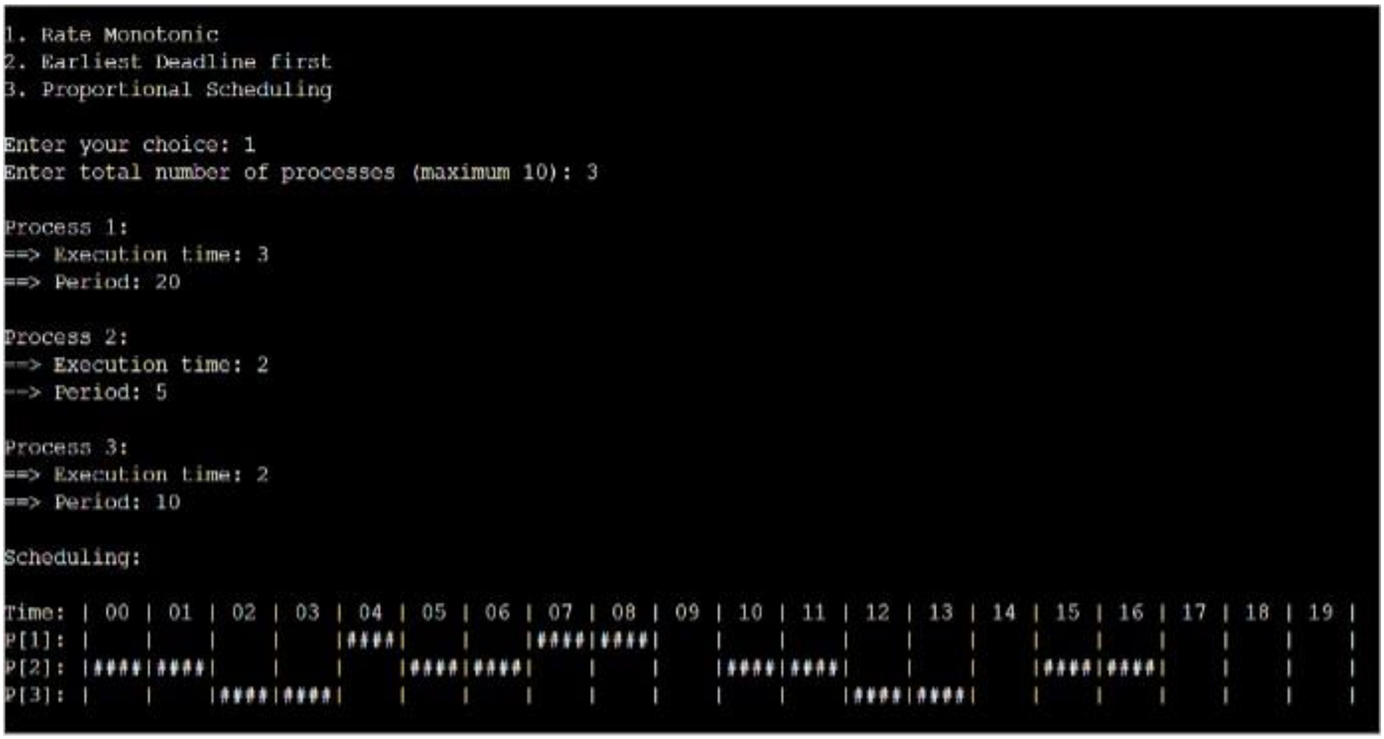
```
#include <stdio.h>

#include <stdlib.h>

#include <math.h>

#include <stdbool.h>

#define MAX_PROCESS 10

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() {
    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];
        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)
```

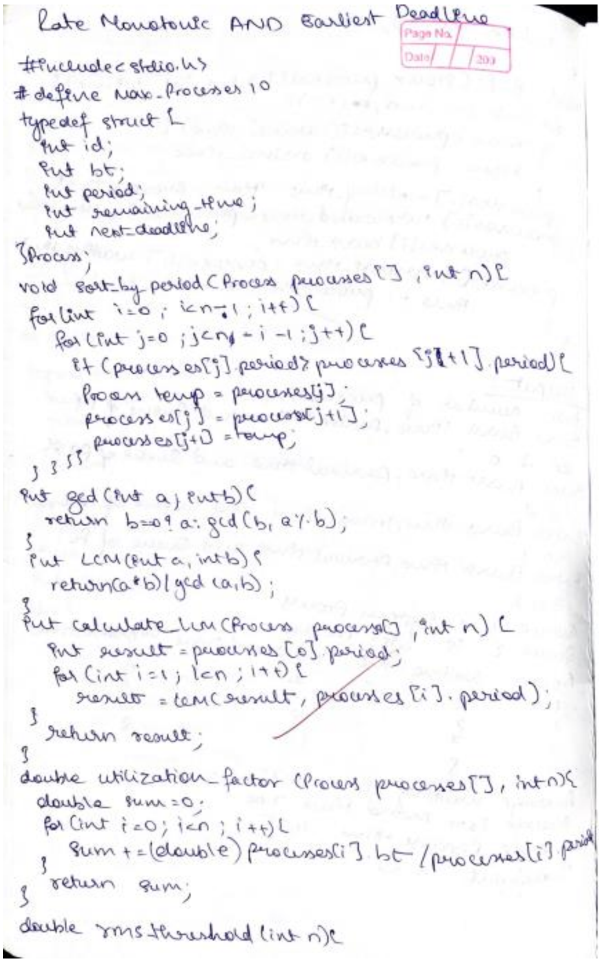
```
        max = c;
    return max;
}
void print_schedule(int process_list[], int cycles) {
    printf("\nScheduling:\n\n");
    printf("Time: ");
    for (int i = 0; i < cycles; i++) {
        if (i < 10)
            printf("| 0%d ", i);
        else
            printf("| %d ", i);
    }
    printf("|\n");
 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;
    float m = 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);
}
int main() {
    int observation_time;
    get_process_info();
    observation_time = max(period[0], period[1], period[2]);
    rate_monotonic(observation_time);
    return 0;
}
```

Output:



```
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]: |    |    |####|####|    |    |    |    |    |    |    |    |####|####|    |    |    |    |    |    |
```



Rate Monotonic AND Earliest Deadline

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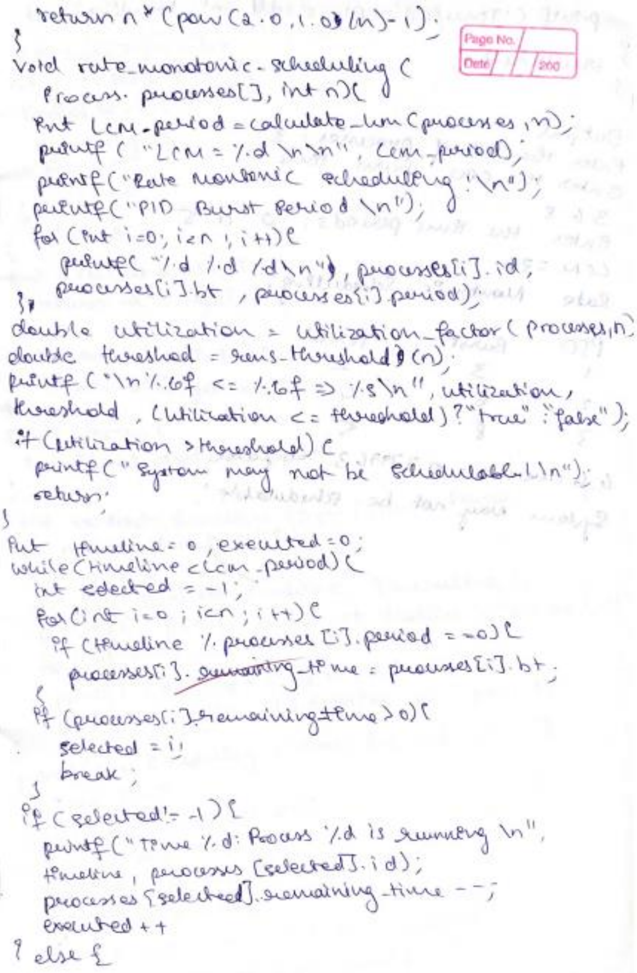
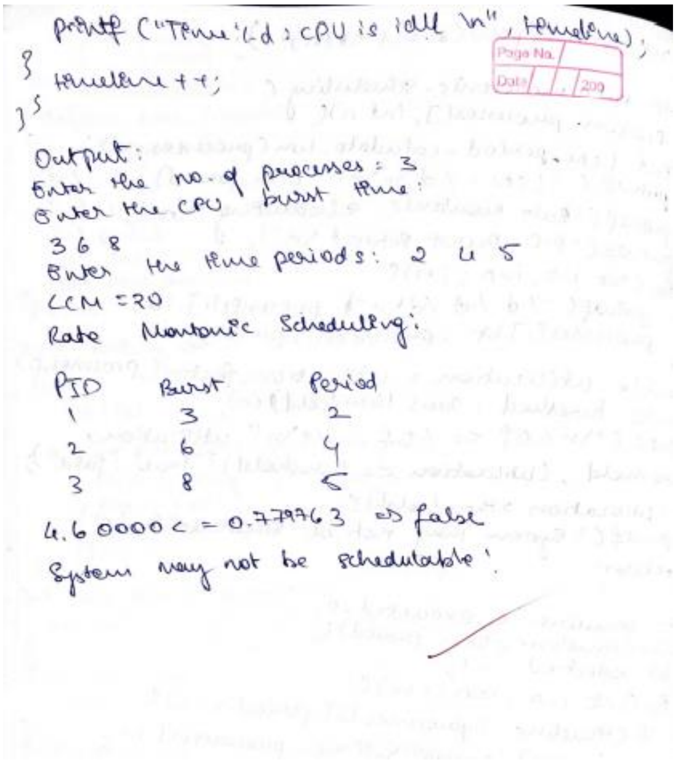
```
#include<stdio.h>
#define Max_Processes 10
typedef struct {
  int id;
  int bt;
  int period;
  int remaining_time;
  int next_deadline;
}Process;
void sort_by_period(Process processes[], int n){
 for(int i=0; i<n-1; i++){
   for(int j=0; j<n-i-1; j++){
     if(processes[j].period> processes[j+1].period){
      Process temp = processes[j];
      processes[j] = process[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 process[], 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].bt / 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 Monotonic Scheduling:\n");
 printf("PID Burst Period \n");
 for(int i=0; i<n; i++){
   printf("%d %d %d\n", processes[i].id,
   processes[i].bt, 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("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].bt;
  }
  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 {
```



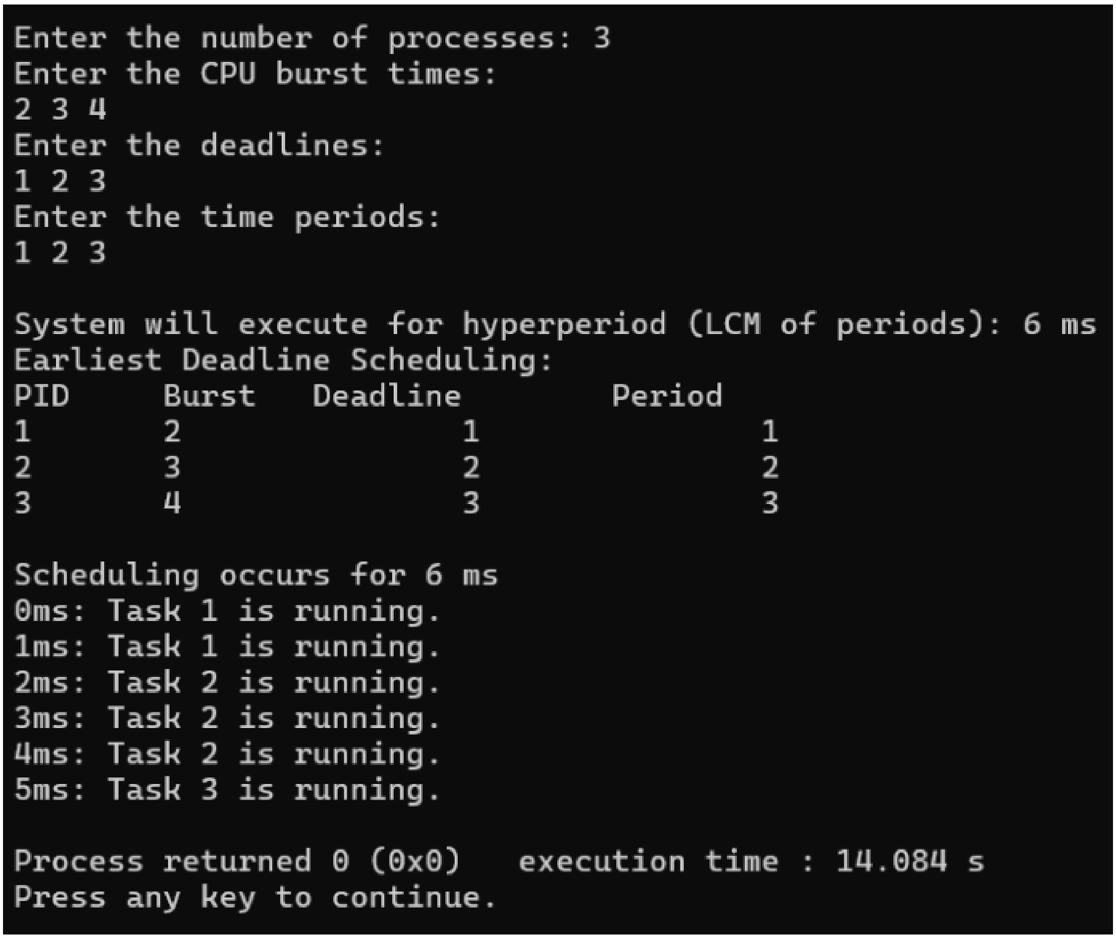
```
printf ("Time %d : CPU is idle \n", timeline);
}
timeline ++;
}}
```

```
Output:
Enter the no. of processes : 3
Enter the CPU burst time:
 3 6 8
Enter the time periods: 2 4 5
LCM =20
Rate Monotonic Scheduling:

 PID    Burst    Period
  1      3        2
  2      6        4
  3      8        5
4.60000 <= 0.779763 => false
System may not be schedulable!
```

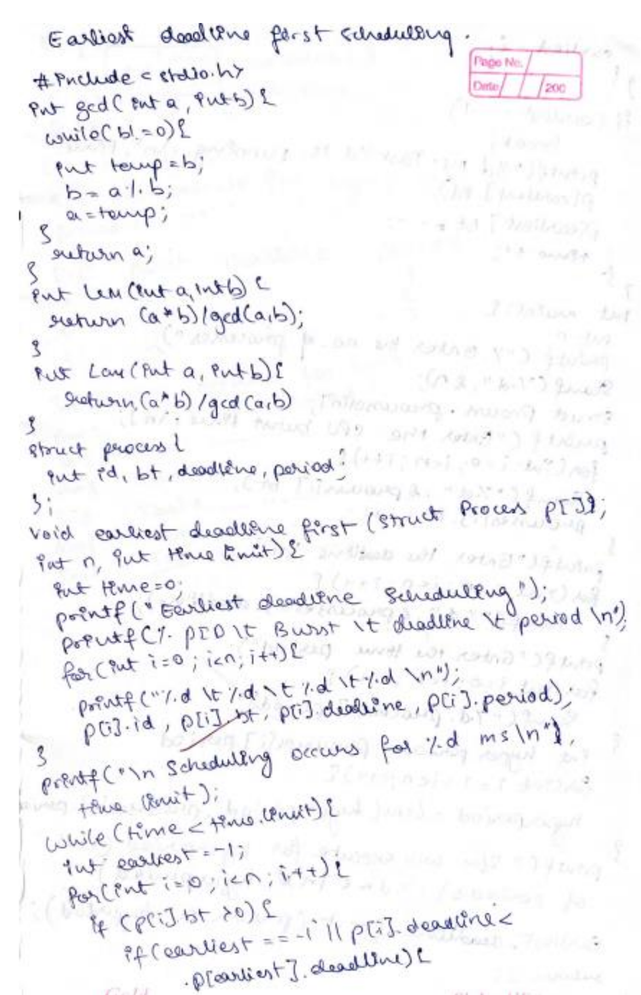
Earliest Deadline

```
#include <stdio.h>

int gcd(int a, int b) {
    while (b != 0) {
        int temp = b;
        b = a % b;
        a = temp;
    }
    return a;
}

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

struct Process {
    int id, burst_time, deadline, period;
};

void earliest_deadline_first(struct Process p[], int n, int time_limit) {
    int time = 0;
    printf("Earliest Deadline Scheduling:\n");
    printf("PID\tBurst\tDeadline\tPeriod\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t\t%d\t\t%d\n", p[i].id, p[i].burst_time, p[i].deadline, p[i].period);
    }

    printf("\nScheduling occurs for %d ms\n", time_limit);
    while (time < time_limit) {
        int earliest = -1;
        for (int i = 0; i < n; i++) {
            if (p[i].burst_time > 0) {
                if (earliest == -1 || p[i].deadline < p[earliest].deadline) {
                    earliest = i;
                }
            }
        }

        if (earliest == -1) break;

        printf("%dms: Task %d is running.\n", time, p[earliest].id);
        p[earliest].burst_time--;
        time++;
    }
}

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

    struct Process processes[n];
    printf("Enter the CPU burst times:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d", &processes[i].burst_time);
        processes[i].id = i + 1;
    }

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

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

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

        printf("\nSystem will execute for hyperperiod (LCM of periods): %d ms\n",
    hyperperiod);

        earliest_deadline_first(processes, n, hyperperiod);

        return 0;
}
```

Output:

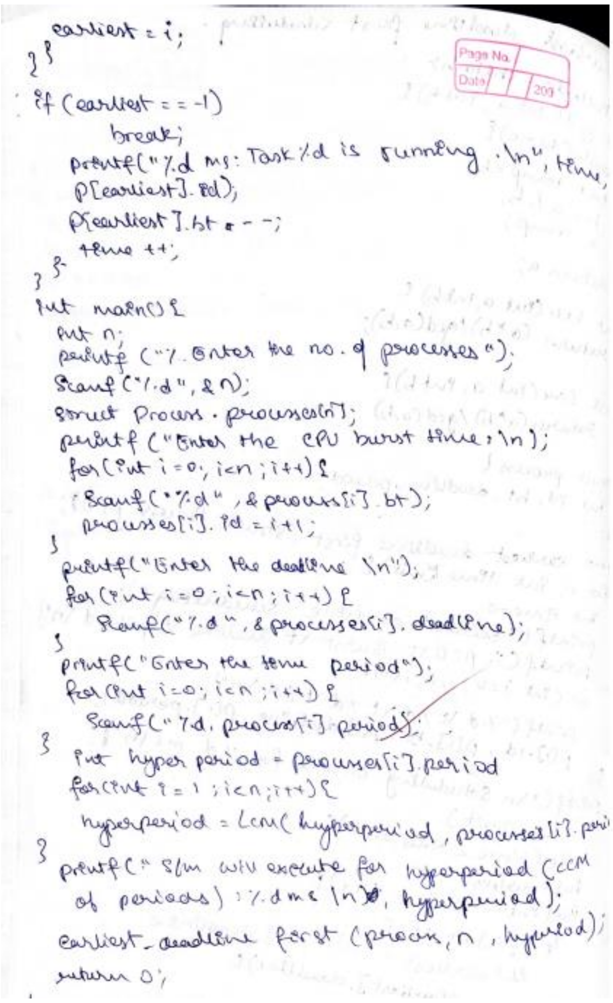


```
Enter the number of processes: 3
Enter the CPU burst times:
2 3 4
Enter the deadlines:
1 2 3
Enter the time periods:
1 2 3

System will execute for hyperperiod (LCM of periods): 6 ms
Earliest Deadline Scheduling:
PID     Burst   Deadline        Period
1       2               1               1
2       3               2               2
3       4               3               3

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

Process returned 0 (0x0)   execution time : 14.084 s
Press any key to continue.
```

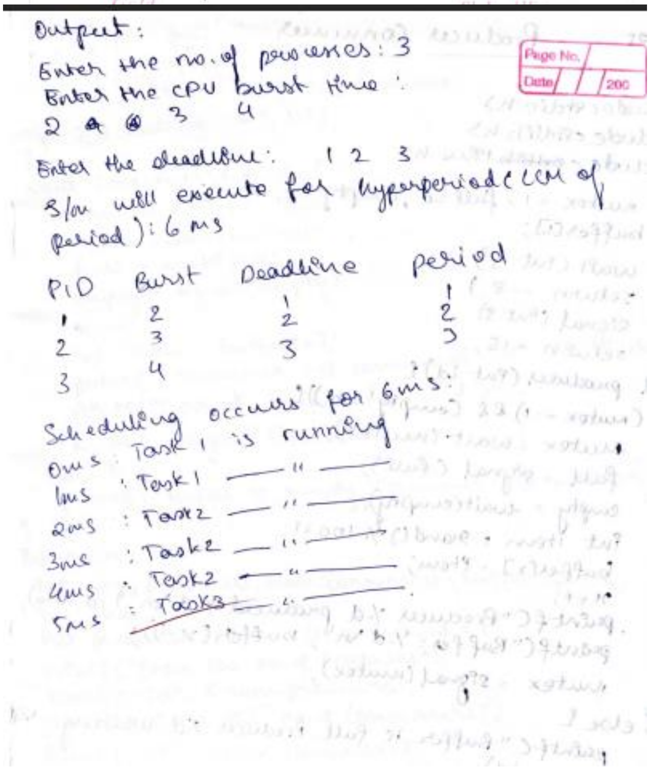


Earliest deadline first Scheduling.

```
#include <stdio.h>
int gcd(int a, int b){
 while(b!=0){
  int temp=b;
   b=a%b;
   a=temp;
 }
  return a;
}
int Lcm(int a,int b) {
  return (a*b)/gcd(a,b);
}
int Lcm(int a, int b){
   return (a*b)/gcd(a,b)
}
struct process {
 int id, bt, deadline, period;
};
void earliest deadline first (struct Proces p[]);
int n, int time limit){
 int time=0;
 printf("Earliest deadline Scheduling");
 printf("% PID \t Burst \t deadline \t period \n");
 for(int i=0; i<n; i++){
   printf("%d \t %d \t %d \t %d \n");
   p[i].id, p[i].bt, p[i].deadline, p[i].period);
 }
 printf("\n Scheduling occurs for %d ms \n"),
   time limit);
 while(time < time.limit){
  int earliest=-1;
  for(int i=0; i<n; i++){
    if (p[i].bt >0) {
      if(earliest == -1 || p[i].deadline<
        .p[earliest].deadline){
```



```
  earliest = i;
 }}
 if (earliest == -1)
      break;
   printf("%d ms: Task %d is running.\n", time,
   p[earliest].id);
   p[earliest].bt --;
   time ++;
 }
}
int main(){
 int n;
 printf("% Enter the no. of processes");
 Scanf("%d", &n);
 struct Process. processes[n];
 printf("Enter the CPU burst time:\n);
  for(int i=0; i<n; i++){
   Scanf("%d", &process[i].bt);
   processes[i]. id = i+1;
 }
 printf("Enter the deadline \n");
 for(int i=0; i<n; i++) {
   Scanf("%d", &processes[i]. deadline);
 }
 printf("Enter the time period");
 for(int i=0; i<n; i++) {
   Scanf(" %d, process[i].period);
 }
 int hyper period = processes[i].period
 for(int i=1; i<n; i++){
  hyperperiod = Lcm( hyperperiod, processes[i].peri
 }
 printf(" S/m will execute for hyperperiod (LCM
  of periods) : %d ms \n", hyperperiod);
earliest_deadline first (process, n, hyperiod);
return 0;
```



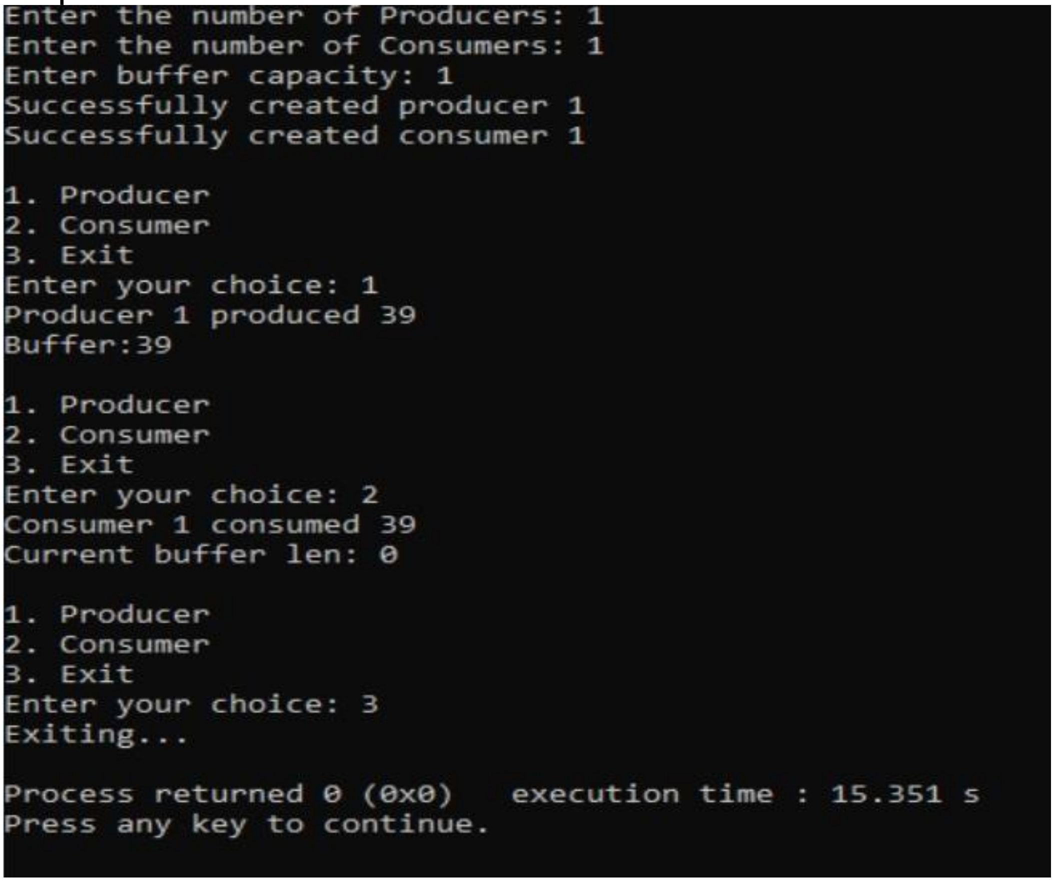
Output:

```
Enter the no. of processes: 3
Enter the CPU burst time :
2  3  4
Enter the deadline:   1  2  3
S/m will execute for hyperperiod (LCM of
period ): 6 ms
PID   Burst   Deadline   period
                            1
 1     2        1           2
 2     3        2           3
 3     4        3
Scheduling occurs for 6ms:
0ms : Task 1 is running
1ms : Task 1 —— " ——
2ms : Task 2 —— " ——
3ms : Task 2 —— " ——
4ms : Task 2 —— " ——
5ms : Task 3 —— " ——
```

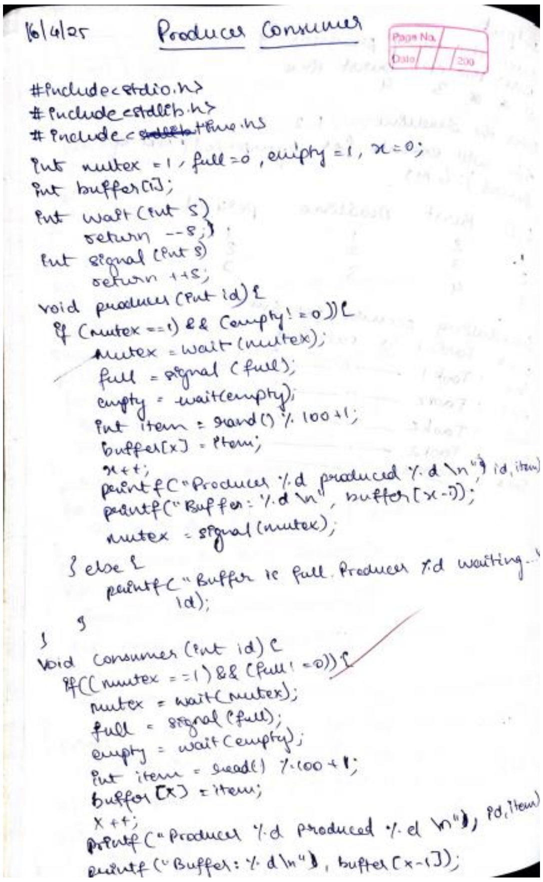
5. Write a C program to simulate producer-consumer problem using semaphores

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

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

void producer();
void consumer();
int wait(int);
int signal(int);

int main() {
    int n;
    printf("\n1. Producer\n2. Consumer\n3. Exit");
    while(1) {
        printf("\nEnter your choice: ");
        scanf("%d", &n);
        switch(n) {
            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);
                break;
        }
    }
    return 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++;
    printf("\nProducer produces the item %d\n", x);
    mutex = signal(mutex);
}

void consumer() {
    mutex = wait(mutex);
    full = wait(full);
    empty = signal(empty);
    printf("\nConsumer consumes item %d\n", x);
    x--;
    mutex = signal(mutex);
}
```

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
Enter your choice: 1
Producer 1 produced 39
Buffer:39

1. Producer
2. Consumer
3. Exit
Enter your choice: 2
Consumer 1 consumed 39
Current buffer len: 0

1. Producer
2. Consumer
3. Exit
Enter your choice: 3
Exiting...

Process returned 0 (0x0)   execution time : 15.351 s
Press any key to continue.
```



16/4/25 Producer Consumer

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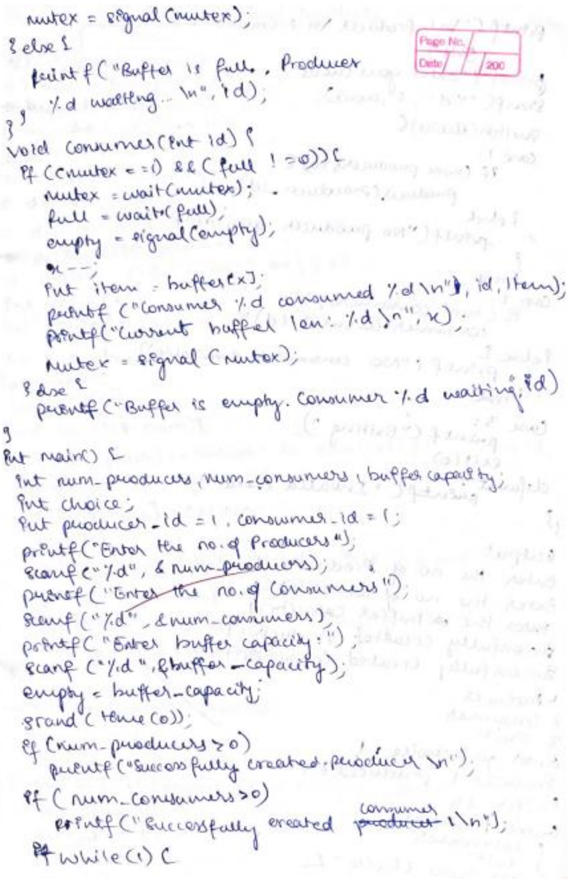
```
#include<stdio.h>
#include<stdlib.h>
#include<~~stdlib~~time.h>
int mutex =1, full=0 ,empty =1, x=0;
int buffer[1];
int wait (int s)
     return --s;}
int signal (int s)
     return ++s;
void producer (int id) {
  if (mutex ==1) && (empty! =0)){
     mutex =wait (mutex);
     full = signal (full);
     empty = wait(empty);
     int item = rand () % 100+1;
     buffer[x] = item;
     x++;
     printf("Producer %d produced %d \n", id, item)
     printf(" Buffer: %d \n", buffer[x-1]);
     mutex = signal (mutex);

  } else {
     printf(" Buffer is full. Producer %d waiting..."
              id);
    }
}
void consumer (int id) {
  if((mutex ==1)&& (full! =0)){
    mutex = wait(mutex);
    full = signal (full);
    empty = wait (empty);
    int item = read() %100 + 1;
    buffer [x] = item;
    x ++;
   printf ("Producer %d produced %d \n"), id, item)
   printf ("Buffer: % d\n"), buffer [x-1]);
```



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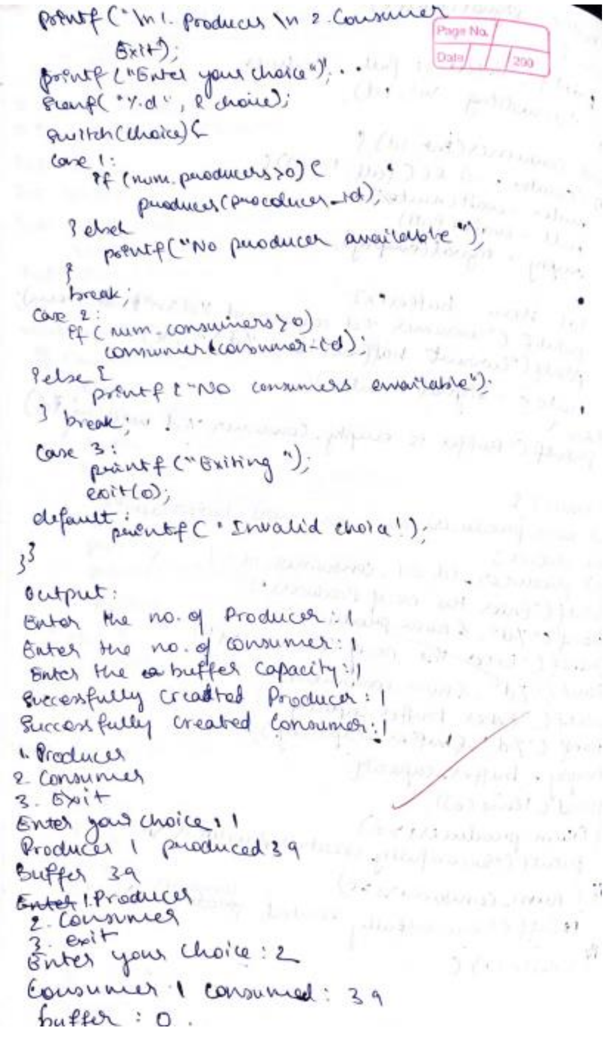
```
 mutex = signal (mutex);
} else {
  printf ("Buffer is full. Producer
   %d waiting.. \n", id);
}}
void consumer(int id) {
 if (mutex ==1) && (full !=0)){
   mutex =wait(mutex);
   full = wait(full);
   empty = signal(empty);
   x--;
   int item = buffer[x];
   printf ("Consumer %d consumed %d \n"), id, item);
   printf("Current buffer len: %d \n", x);
   mutex = signal (mutex);
 } else {
  printf ("Buffer is empty. Consumer %d waiting, id)
}
int main() {
 int num_producers, num_consumers, buffer capacity;
 int choice;
 int producer_id =1, consumer_id = 1;
 printf("Enter the no. of Producers");
 scanf("%d", & num_producers);
 printf("Enter the no. of Consumers");
 scanf("%d", &num_consumers)
 printf("Enter buffer capacity:")
 scanf ("%d", &buffer_capacity);
 empty = buffer_capacity;
 srand ( time (0));
 if (num_producers>0)
   printf ("Successfully created producer \n");
 if (num_consumers>0)
    printf("Successfully created ~~producer~~ consumer 1\n");
  while(1) {
```



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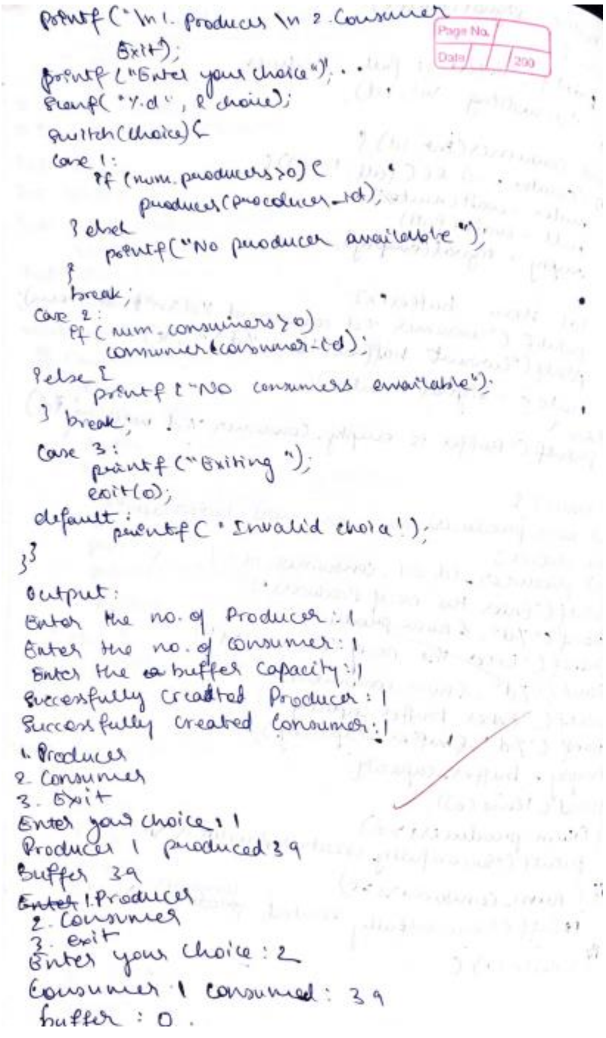
```
printf("\n1. Producer \n 2 Consumer
        Exit");
printf ("Enter your choice");
scanf( "%d", & choice);
switch(choice){
 case 1:
     if (num.producers>0) {
          producer(producer_id);
   } else
      printf("No producer available");
   }
   break;
 case 2:
    if (num_consumers>0)
      consumer(consumer_id);
 } else {
     printf ("No consumers available");
  } break;
 case 3:
     printf ("Exiting ");
     exit(0);
 default:
     printf (' Invalid choice!);
}}
```

Output:

```
Enter the no. of Producer: 1
Enter the no. of Consumer: 1
Enter the ~~a~~ buffer capacity: 1
Successfully created Producer: 1
Successfully created Consumer: 1
1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Producer 1 produced 39
Buffer 39
~~Enter~~ 1.Producer
 2. Consumer
 3. exit
Enter your choice: 2
Consumer 1 consumed: 39
 buffer : 0 .
```



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```
printf("\n1. Producer \n 2 Consumer
        Exit");
printf ("Enter your choice");
scanf( "%d", & choice);
switch(choice){
 case 1:
     if (num.producers>0) {
          producer(producer_id);
   } else
      printf("No producer available");
   }
   break;
 case 2:
    if (num_consumers>0)
      consumer(consumer_id);
 } else {
     printf ("No consumers available");
  } break;
 case 3:
     printf ("Exiting ");
     exit(0);
 default:
     printf (' Invalid choice!);
}}
```

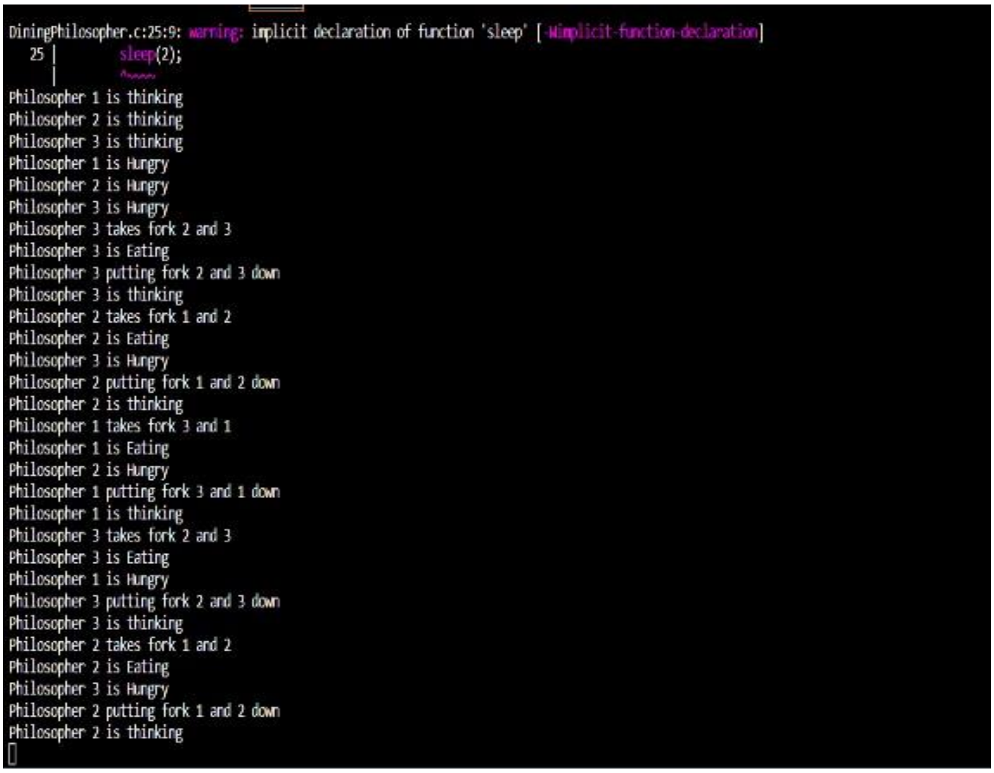
Output:

```
Enter the no. of Producer: 1
Enter the no. of Consumer: 1
Enter the ~~a~~ buffer capacity: 1
Successfully created Producer: 1
Successfully created Consumer: 1
1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Producer 1 produced 39
Buffer 39
~~Enter~~ 1.Producer
 2. Consumer
 3. exit
Enter your choice: 2
Consumer 1 consumed: 39
 buffer : 0 .
```

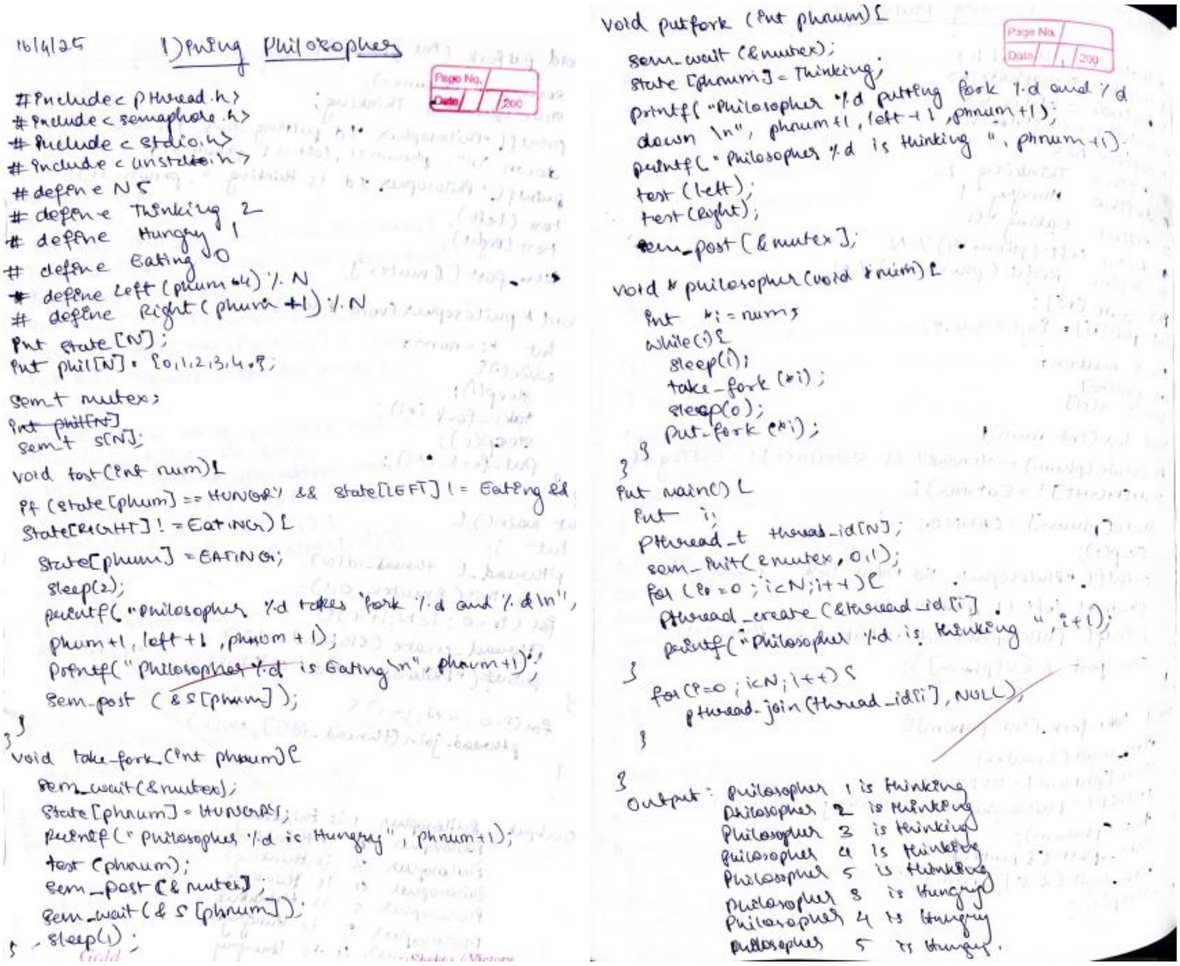
6. Write a C program to simulate the concept of Dining Philosophers problem.

```
#include <stdio.h>
#include <pthread.h>
#include <semaphore.h>
#include <unistd.h>  // For usleep

#define N 5
#define THINKING 2
#define HUNGRY 1
#define EATING 0
#define LEFT (i + 4) % N
#define RIGHT (i + 1) % N

int state[N];
int phil[N] = {0, 1, 2, 3, 4};
sem_t mutex;
sem_t S[N];

void test(int i) {
    if (state[i] == HUNGRY && state[LEFT] != EATING && state[RIGHT] != EATING) {
        state[i] = EATING;
        usleep(2000000);  // Simulate eating time (2 seconds)
        printf("Philosopher %d takes fork %d and %d\n", i + 1, LEFT + 1, i + 1);
        printf("Philosopher %d is Eating\n", i + 1);
        sem_post(&S[i]);
    }
}

void take_fork(int i) {
    sem_wait(&mutex);
    state[i] = HUNGRY;
    printf("Philosopher %d is Hungry\n", i + 1);
    test(i);
    sem_post(&mutex);
    sem_wait(&S[i]);
    usleep(1000000);  // Simulate thinking time (1 second)
}


void put_fork(int i) {
    sem_wait(&mutex);
    state[i] = THINKING;
    printf("Philosopher %d putting fork %d and %d down\n", i + 1, LEFT + 1, i + 1);
    printf("Philosopher %d is thinking\n", i + 1);
    test(LEFT);
    test(RIGHT);
    sem_post(&mutex);
}
void* philosopher(void* num) {
    while (1) {
        int* i = num;
        usleep(1000000);  // Simulate thinking before trying to eat
        take_fork(*i);
        usleep(1000000);  // Simulate time spent eating
        put_fork(*i);
    }
}



int main() {
    int i;
    pthread_t thread_id[N];
    sem_init(&mutex, 0, 1);
    for (i = 0; i < N; i++) {
        sem_init(&S[i], 0, 0);
    }


    for (i = 0; i < N; i++) {
        pthread_create(&thread_id[i], NULL, philosopher, &phil[i]);
        printf("Philosopher %d is thinking\n", i + 1);
    }


    for (i = 0; i < N; i++) {
        pthread_join(thread_id[i], NULL);
    }

    return 0;
}
```

Output:



```
DiningPhilosopher.c:25:9: warning: implicit declaration of function 'sleep' [-Wimplicit-function-declaration]
   25 |         sleep(2);
      |         ^~~~~
Philosopher 1 is thinking
Philosopher 2 is thinking
Philosopher 3 is thinking
Philosopher 1 is Hungry
Philosopher 2 is Hungry
Philosopher 3 is Hungry
Philosopher 3 takes fork 2 and 3
Philosopher 3 is Eating
Philosopher 3 putting fork 2 and 3 down
Philosopher 3 is thinking
Philosopher 2 takes fork 1 and 2
Philosopher 2 is Eating
Philosopher 3 is Hungry
Philosopher 2 putting fork 1 and 2 down
Philosopher 2 is thinking
Philosopher 1 takes fork 3 and 1
Philosopher 1 is Eating
Philosopher 2 is Hungry
Philosopher 1 putting fork 3 and 1 down
Philosopher 1 is thinking
Philosopher 3 takes fork 2 and 3
Philosopher 3 is Eating
Philosopher 1 is Hungry
Philosopher 3 putting fork 2 and 3 down
Philosopher 3 is thinking
Philosopher 2 takes fork 1 and 2
Philosopher 2 is Eating
Philosopher 3 is Hungry
Philosopher 2 putting fork 1 and 2 down
Philosopher 2 is thinking
```



16/4/25 1) Dining Philosophers

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```
#include<pthread.h>
#include<semaphore.h>
#include<stdio.h>
#include<unistd.h>
#define N 5
#define Thinking 2
#define Hungry 1
#define Eating 0
#define Left (phnum+4) % N
#define Right (phnum +1) % N
int state[N];
int phil[N] = {0,1,2,3,4};

sem_t mutex;
~~int phil[N]~~
sem_t s[N];
void test(int num){
 if (state[phnum] == HUNGRY && state[LEFT] != Eating &&
 State[RIGHT] != EATING) {
   State[phnum] = EATING;
   sleep(2);
   printf("Philosopher %d takes fork %d and %d\n",
   phnum+1, left+1, phnum + 1);
   printf("Philosopher %d is Eating\n", phnum+1);
   sem_post (&s[phnum]);
 }
}
void take_fork(int phnum){
   sem_wait(&mutex);
   State[phnum] = HUNGRY;
   printf("Philosopher %d is Hungry", phnum+1);
   test (phnum);
   sem_post(&mutex);
   sem_wait(& s [phnum]);
   sleep(1);
}
```

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```
void putfork (int phnum){
  sem_wait (&mutex);
  State [phnum] = Thinking;
  printf("Philosopher %d putting fork %d and %d
  down \n", phnum+1, left+1, phnum+1);
  printf(" Philosopher %d is thinking ", phnum+1).
  test (left);
  test (Right);
  sem_post (&mutex);

void * philosopher(void *num){
  int *i = num;
  while(1){
    sleep(1);
    take_fork (*i);
    sleep(0);
    put_fork (*i);
  }
}
int main() {
  int i;
  pthread_t thread_id[N];
  sem_init(&mutex, 0,1);
  for (i = 0 ; i<N; i++){
    pthread_create (&thread_id[i]
    printf(" Philosopher %d is thinking ", i+1);
  }
  for (i=0 ; i<N; i++) {
      pthread_join (thread_id[i], NULL);
  }

}
```

Output: Philosopher 1 is thinking
Philosopher 2 is thinking
Philosopher 3 is thinking
Philosopher 4 is thinking
Philosopher 5 is thinking
Philosopher 3 is Hungry
Philosopher 4 is Hungry
Philosopher 5 is Hungry.

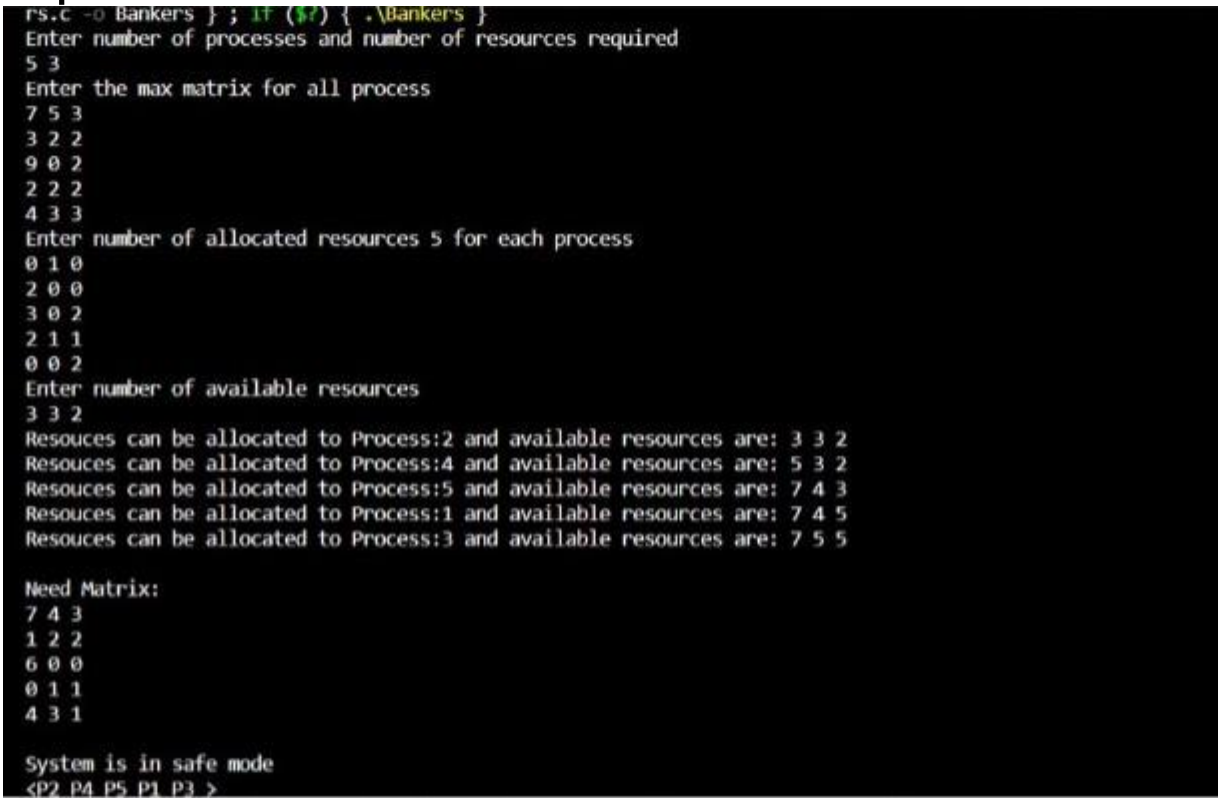
7. Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.

```
#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];
    int max[n][m];
    int available[m];
    int need[n][m];
    int finish[n], safeSeq[n], index = 0;
    printf("Enter the Allocation Matrix:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < m; j++)
        {
            scanf("%d", &allocation[i][j]);
        }
    }
    printf("Enter the MAX Matrix:\n");
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < m; j++)
        {
            scanf("%d", &max[i][j]);
        }
    }
    printf("Enter the Available Resources:\n");
    for (i = 0; i < m; i++)
    {
        scanf("%d", &available[i]);
    }
    for (i = 0; i < n; i++)
    {
        for (j = 0; j < m; j++)
        {
            need[i][j] = max[i][j] - allocation[i][j];
        }
    }
    for (i = 0; i < n; i++)
    {
```

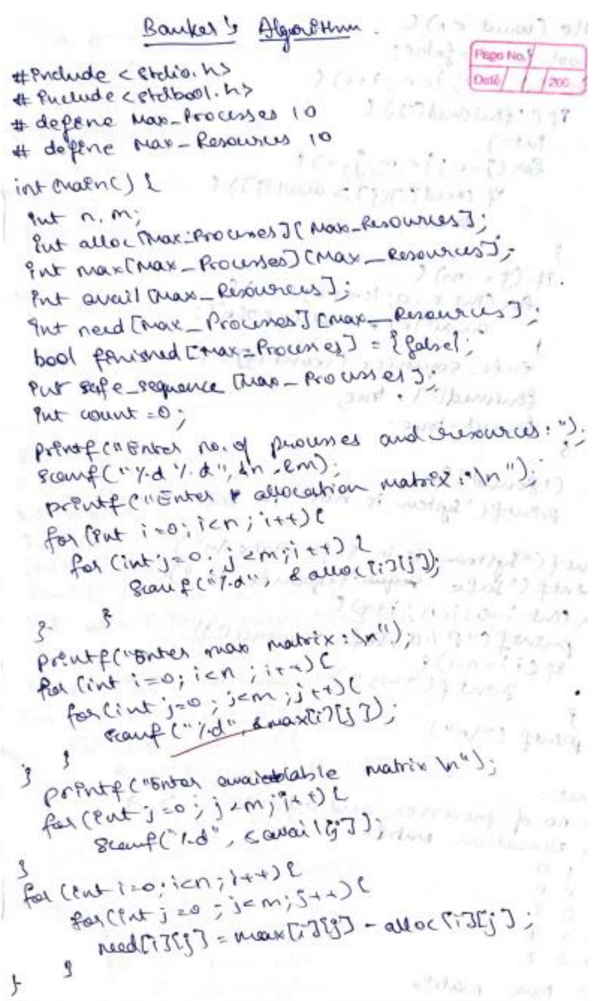
```
    finish[i] = 0;
}
for (k = 0; k < n; k++)
{
    for (i = 0; i < n; i++)
    {
        if (finish[i] == 0)
        {
            int flag = 1;
            for (j = 0; j < m; j++)
            {
                if (need[i][j] > available[j])
                {
                    flag = 0;
                    break;
                }
            }
            if (flag == 1)
            {
                safeSeq[index++] = i;
                for (j = 0; j < m; j++)
                {
                    available[j] += allocation[i][j];
                }
                finish[i] = 1;
            }
        }
    }
}
int allFinished = 1;
for (i = 0; i < n; i++)
{
    if (finish[i] == 0)
    {
        allFinished = 0;
        break;
    }
}
if (allFinished)
{
    printf("Following is the SAFE Sequence:\n");
    for (i = 0; i < n - 1; i++)
    {
        printf("P%d -> ", safeSeq[i]);
    }
```

```
        printf("P%d\n", safeSeq[n - 1]);
    }
    else
    {
        printf("The system is NOT in a safe state.\n");
    }

    return 0;
}
```

Output:

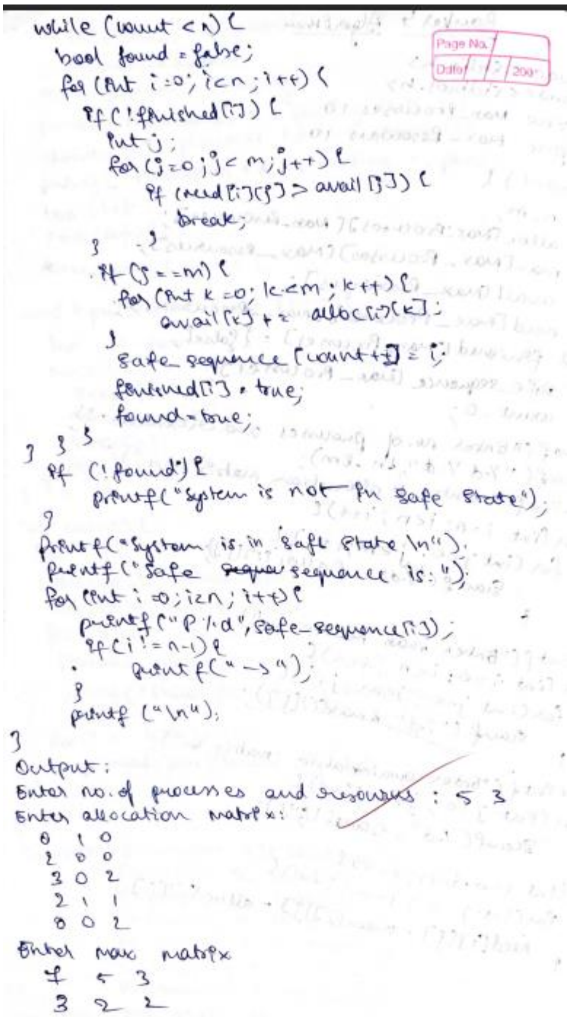


```
rs.c -o Bankers } ; if ($?) { .\Bankers }
Enter number of processes and number of resources required
5 3
Enter the max matrix for all process
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Enter number of allocated resources 5 for each process
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter number of available resources
3 3 2
Resouces can be allocated to Process:2 and available resources are: 3 3 2
Resouces can be allocated to Process:4 and available resources are: 5 3 2
Resouces can be allocated to Process:5 and available resources are: 7 4 3
Resouces can be allocated to Process:1 and available resources are: 7 4 5
Resouces can be allocated to Process:3 and available resources are: 7 5 5

Need Matrix:
7 4 3
1 2 2
6 0 0
0 1 1
4 3 1

System is in safe mode
<P2 P4 P5 P1 P3 >
```



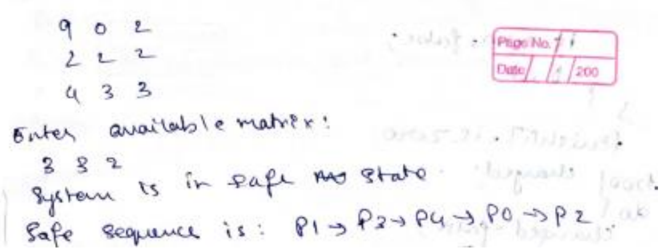
Banker's Algorithm

```
#include <stdio.h>
#include <stdbool.h>
#define Max_Processes 10
#define Max_Resources 10
int main() {
 int n, m;
 int alloc[Max_Processes][Max_Resources];
 int max[Max_Processes][Max_Resources];
 int avail[Max_Resources];
 int need[Max_Processes][Max_Resources];
 bool finished[Max_Processes] = {false};
 int safe_sequence[Max_Processes];
 int count = 0;
 printf("Enter no. of processes and resources: ");
 scanf("%d %d", &n, &m);
 printf("Enter allocation matrix:\n");
 for (int i=0; i<n; i++) {
   for (int j=0; j<m; i++) {
       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 j=0; j<m; j++) {
       scanf("%d", &avail[j]);
 }
 for (int i=0; i<n; i++) {
     for (int j=0 ; j<m; j++) {
       need[i][j] = max[i][j] - alloc[i][j];
     }
 }
```



```
while (count < n) {
  bool found = false;
  for (int i=0; i<n; i++) {
    if (!finished[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];
        }
        safe_sequence[count++] = i;
        finished[i] = true;
        found = true;
      }
    }
  }
  if (!found) {
      printf("System is not in safe state");
  }
  printf("System is in safe state\n");
  printf("Safe ~~sequ~~ sequence is: ");
  for (int i=0; i<n; i++) {
     printf("P%d", safe_sequence[i]);
     if (i != n-1) {
         printf(" -> ");
     }
  }
  printf("\n");
}
```

```
Output:
Enter no. 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 ~~no~~ state
Safe sequence is: P1 -> P3 -> P4 -> P0 -> P2
```

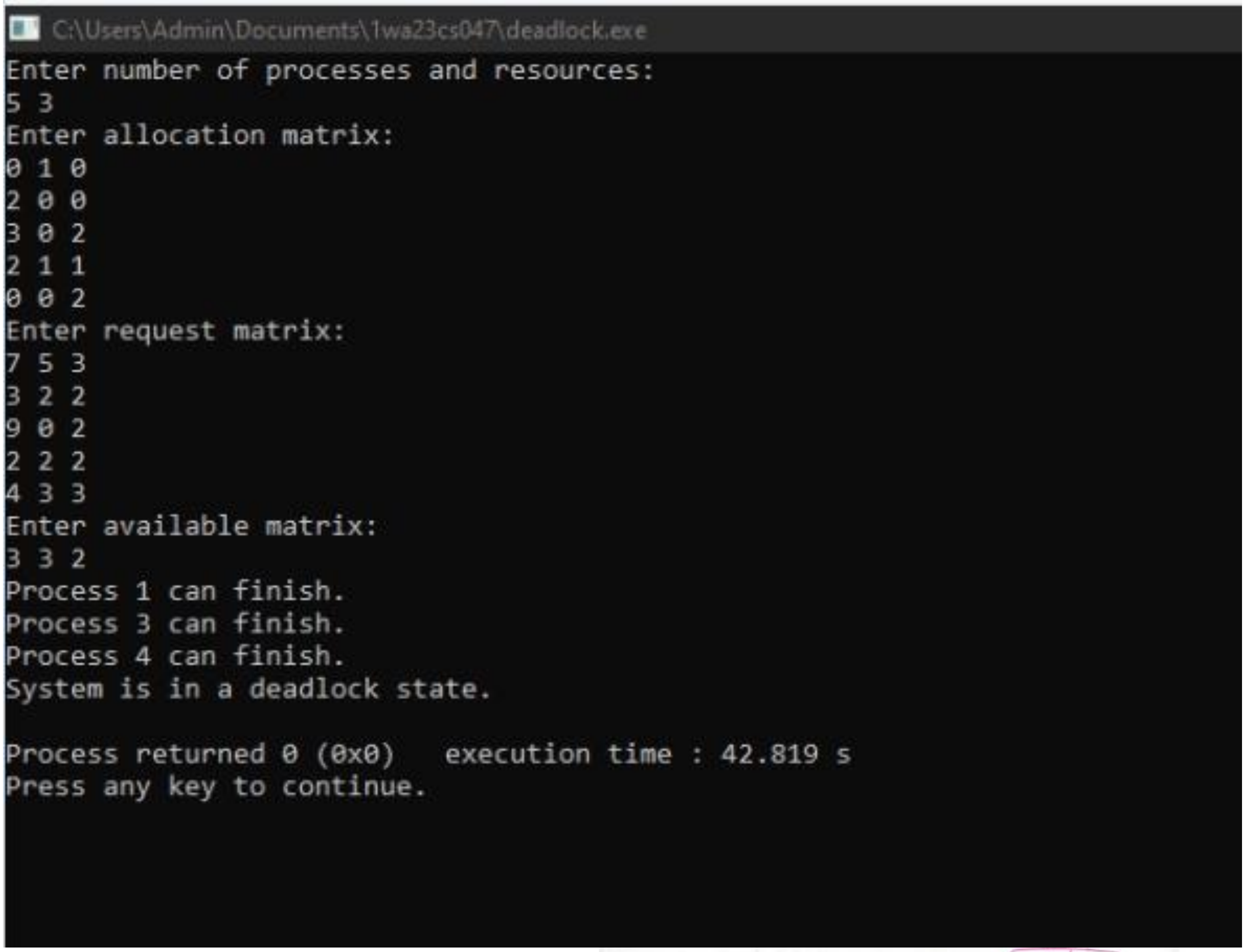
8.Write a C program to simulate deadlock detection

```
#include <stdio.h>
static int mark[20];
int i, j, np, nr;
int main()
{
    int alloc[10][10], request[10][10], avail[10], r[10], w[10];
    printf("\nEnter the number of processes: ");
    scanf("%d", &np);
    printf("\nEnter the number of resources: ");
    scanf("%d", &nr);
```

```
for (i = 0; i < nr; i++)
{
    printf("Total amount of Resource R%d: ", i + 1);
    scanf("%d", &r[i]);
}
printf("\nEnter the Request Matrix:\n");
for (i = 0; i < np; i++)
{
    for (j = 0; j < nr; j++)
    {
    scanf("%d", &request[i][j]);
    }
}
printf("\nEnter the Allocation Matrix:\n");
for (i = 0; i < np; i++)
{
    for (j = 0; j < nr; j++)
    {
        scanf("%d", &alloc[i][j]);
    }
}
for (j = 0; j < nr; j++)
{
    avail[j] = r[j];
    for (i = 0; i < np; i++)
    {
        avail[j] -= alloc[i][j];
    }
}
for (i = 0; i < np; i++)
{
    int count = 0;
    for (j = 0; j < nr; j++)
    {
        if (alloc[i][j] == 0)
            count++;
        else
            break;
    }
    if (count == nr)
        mark[i] = 1;
}
for (j = 0; j < nr; j++)
    w[j] = avail[j];
for (i = 0; i < np; i++)
```

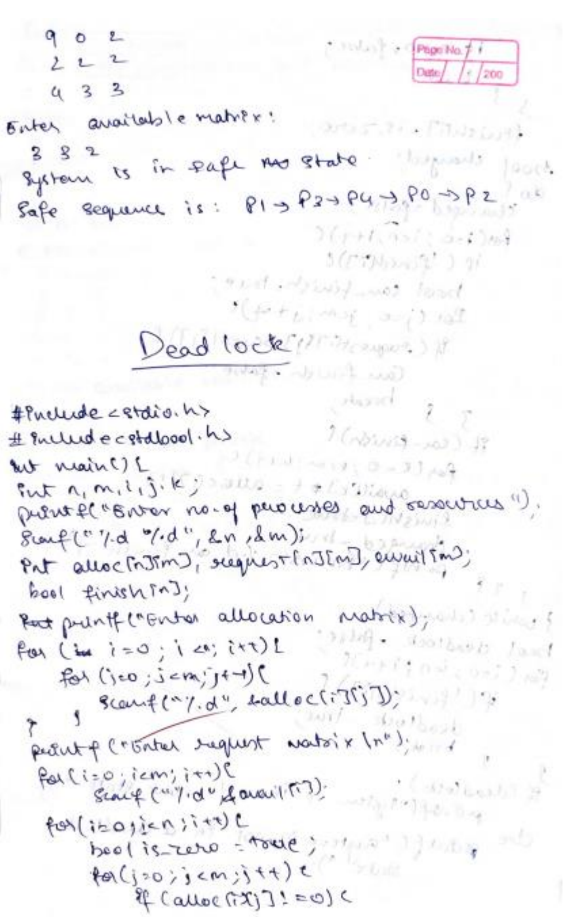
```
    {
        int canBeProcessed = 0;
        if (mark[i] != 1)
        {
            for (j = 0; j < nr; j++)
            {
                if (request[i][j] <= w[j])
                    canBeProcessed = 1;
                else {
                    canBeProcessed = 0;
                    break;
                }
            }
            if (canBeProcessed)
            {
                mark[i] = 1;
                for (j = 0; j < nr; j++)
                    w[j] += alloc[i][j];
            }
        }
    }
    int deadlock = 0;
    for (i = 0; i < np; i++)
    {
        if (mark[i] != 1)
        {
            deadlock = 1;
            break;
        }
    }

    if (deadlock)
        printf("\nDeadlock detected.\n");
    else
        printf("\nNo Deadlock possible.\n");

    return 0;
}
```

Output:



C:\Users\Admin\Documents\1wa23cs047\deadlock.exe

```
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.

Process returned 0 (0x0)   execution time : 42.819 s
Press any key to continue.
```



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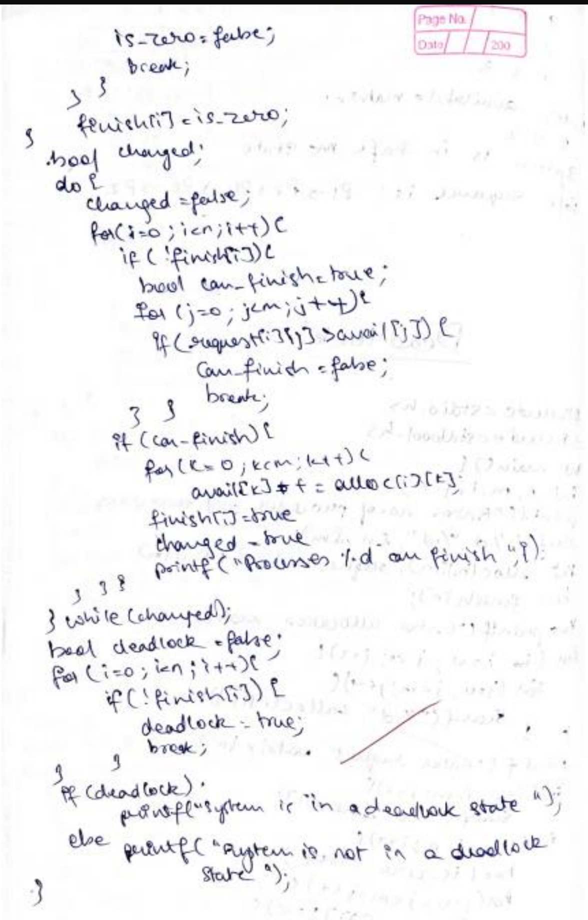
```
   9 0 2
   2 2 2
   4 3 3
Enter available matrix:
 3 3 2
System is in safe ~~no~~ state
Safe sequence is: P1 -> P3 -> P4 -> P0 -> P2
```

Dead lock

```
#include<stdio.h>
#include<stdbool.h>
int main(){
 int n,m,i,j,k;
 printf("Enter no.of processes and resources");
 scanf("%d %d",&n,&m);
 int alloc[n][m], request[n][m], avail[m];
 bool finish[n];
 printf("Enter allocation matrix);
 for (~~int~~ i=0; i<n; i++){
     for (j=0;j<m;j++){
         scanf("%d",&alloc[i][j]);
     }
 }
 printf("Enter request matrix \n");
 for(i=0;i<m;i++){
      scanf("%d",&avail[i]);
 for(i=0;i<n;i++){
      bool is_zero = true;
      for(j=0;j<m;j++){
          if (alloc[i][j]!=0){
```



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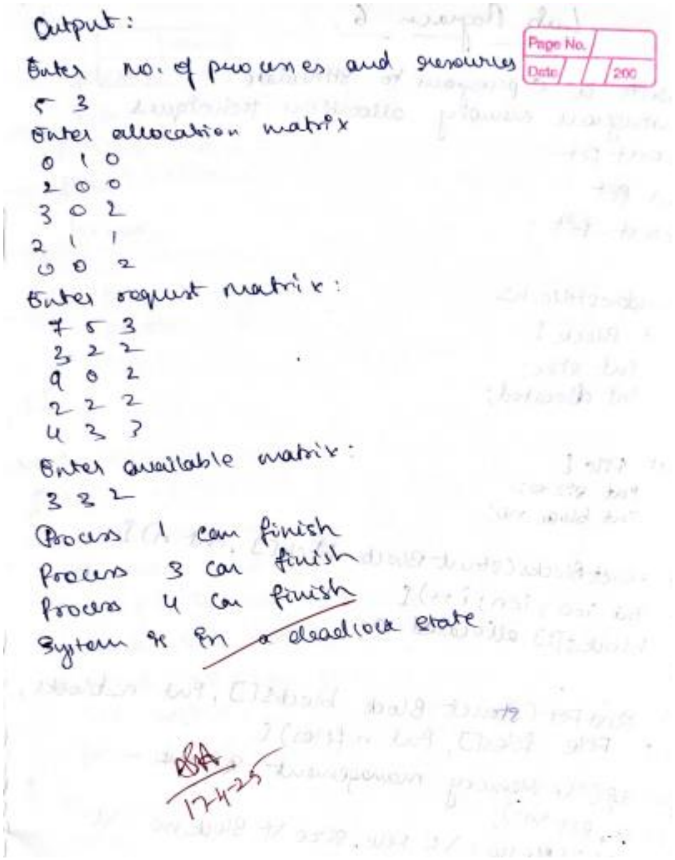
```
             is_zero=false;
             break;
         } }
      finish[i]=is_zero;
 }
 bool changed;
 do{
   changed=false;
   for(i=0;i<n;i++){
      if (!finish[i]){
        bool can_finish=true;
        for (j=0;j<m;j++){
          if(request[i][j]>avail[j]){
              can_finish=false;
              break;
        } }
      if (can_finish){
        for(k=0;k<m;k++){
              avail[k]+=alloc[i][k];
        finish[i]=true
        changed=true
        printf("Processes %d can finish",i);
   } } }
 } while(changed);
 bool deadlock=false;
 for(i=0;i<n;i++){
      if(!finish[i]){
         deadlock=true;
         break;
      }
 }
 if(deadlock)
      printf("system is in a deadlock state");
  else printf("system is not in a deadlock
               state");
}
```



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```
Output:
Enter no. 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.
```

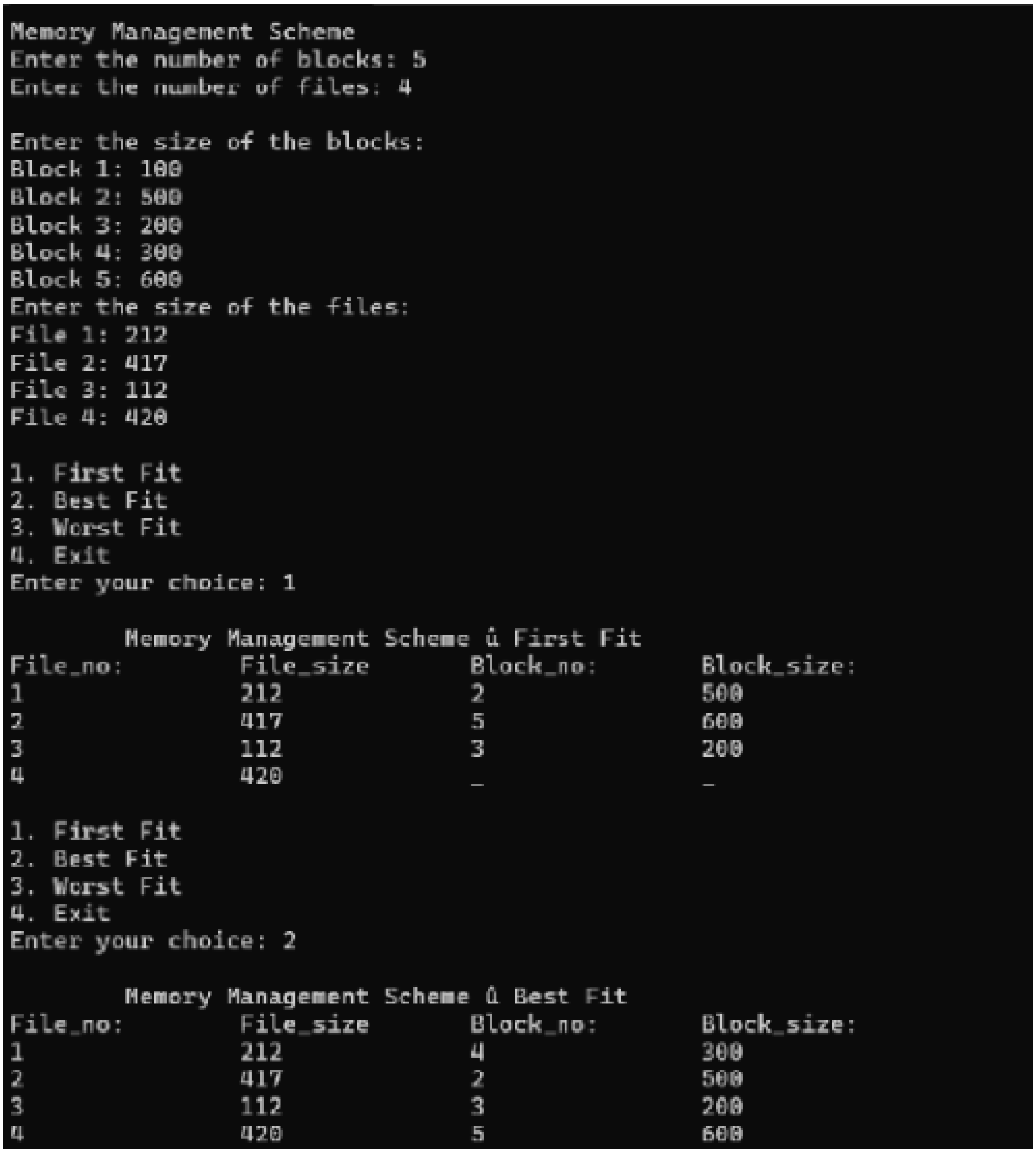
17-4-25

9.Write a C program to simulate the following contiguous memory allocation techniques a) Worst-fit
b) Best-fit
c) First-fit

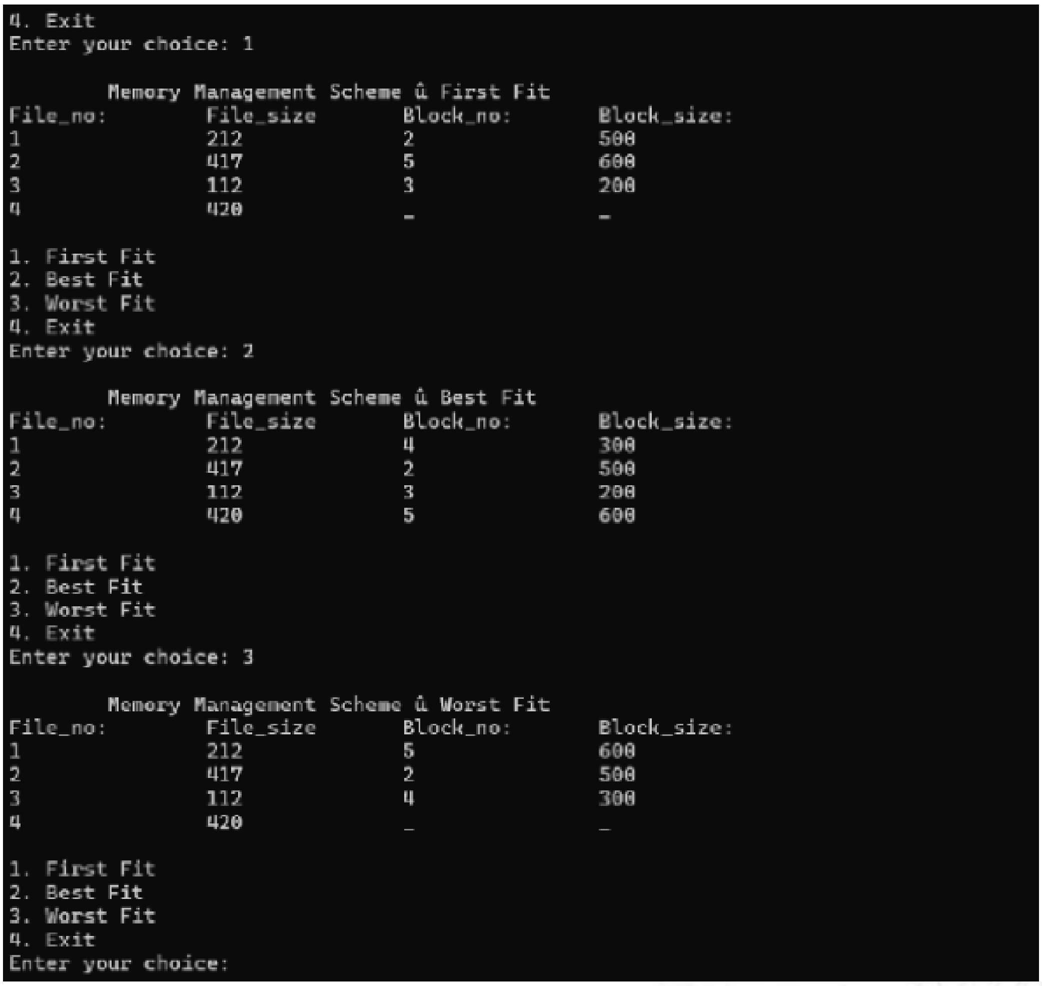
```
 #include <stdio.h>
#define MAX 25

void firstFit(int b[], int nb, int f[], int nf);
void worstFit(int b[], int nb, int f[], int nf);
void bestFit(int b[], int nb, int f[], int nf);

int main() {
    int b[MAX], f[MAX], nb, nf;
    printf("Memory Management Schemes\n");
    printf("\nEnter the number of blocks: ");
    scanf("%d", &nb);
    printf("Enter the number of files: ");
    scanf("%d", &nf);
    printf("\nEnter the size of the blocks:\n");
    for (int i = 0; i < nb; i++)
    {
        printf("Block %d: ", i + 1);
        scanf("%d", &b[i]);
    }

    printf("\nEnter the size of the files:\n");
    for (int i = 0; i < nf; i++)
    {
        printf("File %d: ", i + 1);
        scanf("%d", &f[i]);
    }

    printf("\nMemory Management Scheme - First Fit");
    firstFit(b, nb, f, nf);

    printf("\n\nMemory Management Scheme - Worst Fit");
    worstFit(b, nb, f, nf);

    printf("\n\nMemory Management Scheme - Best Fit");
    bestFit(b, nb, f, nf);

    return 0;
}

void firstFit(int b[], int nb, int f[], int nf)
{
    int bf[MAX] = {0}, ff[MAX] = {0}, frag[MAX];

    for (int i = 0; i < nf; i++)
    {
        ff[i] = -1;
        for (int j = 0; j < nb; j++)
        {
            if (!bf[j] && b[j] >= f[i])
            {
                ff[i] = j;
                bf[j] = 1;
                frag[i] = b[j] - f[i];
                break;
            }
        }
    }

    printf("\nFile_no:\tFile_size:\tBlock_no:\tBlock_size:\tFragment");
    for (int i = 0; i < nf; i++)
    {
        if (ff[i] != -1)
```

```
            printf("\n%d\t\t%d\t\t%d\t\t%d\t\t%d", i + 1, f[i], ff[i] + 1, b[ff[i]], frag[i]);
        else
            printf("\n%d\t\t%d\t\tNot Allocated", i + 1, f[i]);
    }
}

void worstFit(int b[], int nb, int f[], int nf)
{
    int bf[MAX] = {0}, ff[MAX] = {0}, frag[MAX];

    for (int i = 0; i < nf; i++)
    {
        int worstIdx = -1;
        for (int j = 0; j < nb; j++)
        {
            if (!bf[j] && b[j] >= f[i])
            {
                if (worstIdx == -1 || b[j] - f[i] > b[worstIdx] - f[i])
                {
                    worstIdx = j;
                }
            }
        }
        ff[i] = worstIdx;
        if (worstIdx != -1)
        {
            bf[worstIdx] = 1;
            frag[i] = b[worstIdx] - f[i];
        }
    }

    printf("\nFile_no:\tFile_size:\tBlock_no:\tBlock_size:\tFragment");
    for (int i = 0; i < nf; i++)
    {
        if (ff[i] != -1)
            printf("\n%d\t\t%d\t\t%d\t\t%d\t\t%d", i + 1, f[i], ff[i] + 1, b[ff[i]], frag[i]);
        else
            printf("\n%d\t\t%d\t\tNot Allocated", i + 1, f[i]);
    }
}

void bestFit(int b[], int nb, int f[], int nf)
{
    int bf[MAX] = {0}, ff[MAX] = {0}, frag[MAX];
    for (int i = 0; i < nf; i++)
    {
        int bestIdx = -1;
        for (int j = 0; j < nb; j++)
        {
            if (!bf[j] && b[j] >= f[i])
            {
                if (bestIdx == -1 || b[j] - f[i] < b[bestIdx] - f[i])
                {
                    bestIdx = j;
                }
            }
        }
        ff[i] = bestIdx;
        if (bestIdx != -1)
        {
            bf[bestIdx] = 1;
            frag[i] = b[bestIdx] - f[i];
        }
    }

    printf("\nFile_no:\tFile_size:\tBlock_no:\tBlock_size:\tFragment");
    for (int i = 0; i < nf; i++)
    {
        if (ff[i] != -1)
            printf("\n%d\t\t%d\t\t%d\t\t%d\t\t%d", i + 1, f[i], ff[i] + 1, b[ff[i]], frag[i]);
        else
            printf("\n%d\t\t%d\t\tNot Allocated", i + 1, f[i]);
    }
}
```

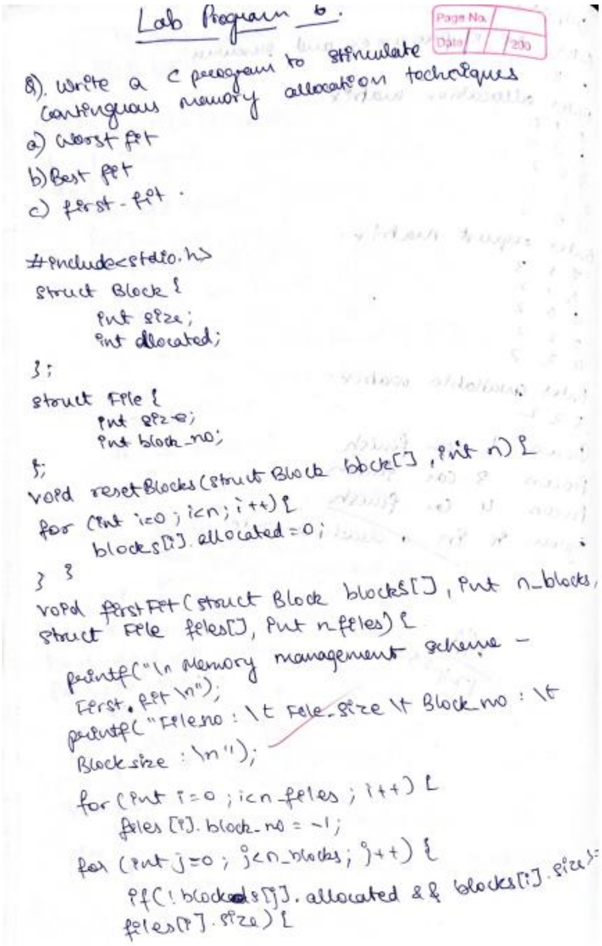
Output:



```
Memory Management Scheme
Enter the number of blocks: 5
Enter the number of files: 4

Enter the size of the blocks:
Block 1: 100
Block 2: 500
Block 3: 200
Block 4: 300
Block 5: 600
Enter the size of the files:
File 1: 212
File 2: 417
File 3: 112
File 4: 420

1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 1

        Memory Management Scheme û First Fit
File_no:        File_size       Block_no:       Block_size:
1               212             2               500
2               417             5               600
3               112             3               200
4               420             -               -

1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 2

        Memory Management Scheme û Best Fit
File_no:        File_size       Block_no:       Block_size:
1               212             4               300
2               417             2               500
3               112             3               200
4               420             5               600
```



```
4. Exit
Enter your choice: 1

        Memory Management Scheme û First Fit
File_no:        File_size       Block_no:       Block_size:
1               212             2               500
2               417             5               600
3               112             3               200
4               420             _               _

1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 2

        Memory Management Scheme û Best Fit
File_no:        File_size       Block_no:       Block_size:
1               212             4               300
2               417             2               500
3               112             3               200
4               420             5               600

1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 3

        Memory Management Scheme û Worst Fit
File_no:        File_size       Block_no:       Block_size:
1               212             5               600
2               417             2               500
3               112             4               300
4               420             _               _

1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice:
```



Lab Program 6.

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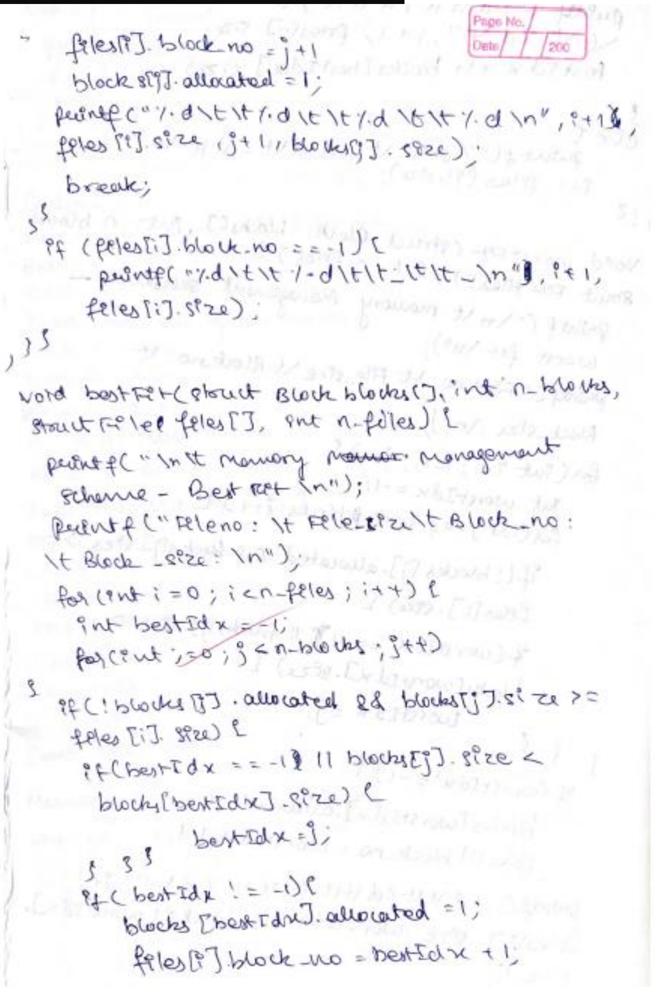
Q). Write a C program to simulate contiguous memory allocation techniques
a) worst fit
b) Best fit
c) first - fit .

```
#include<stdio.h>
 struct Block {
        int size;
        int allocated;
 };
 struct File {
        int size;
        int block_no;
 };
void resetBlocks(struct Block block[] ,int n) {
 for (int i=0 ; i<n; i++) {
        blocks[i]. allocated = 0;
 } }
void firstFit (struct Block blocks[] , int n_blocks,
struct File files[], int n_files) {
   printf("\n Memory management scheme -
   First. fit \n");
   printf("Fileno : \t File_size \t Block_no : \t
   Block size : \n");
   for (int i=0 ; i<n_files ; i++) {
        files [i]. block_no = -1;
   for (int j=0 ; j<n_blocks; j++) {
        if(!blocks[j]. allocated && blocks[i]. size>=
        files[i]. size) {
```



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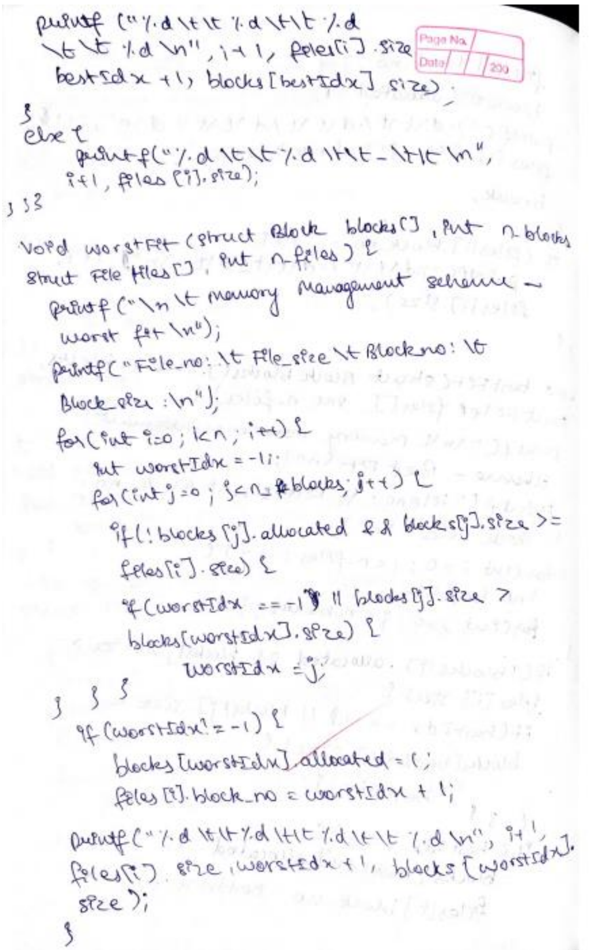
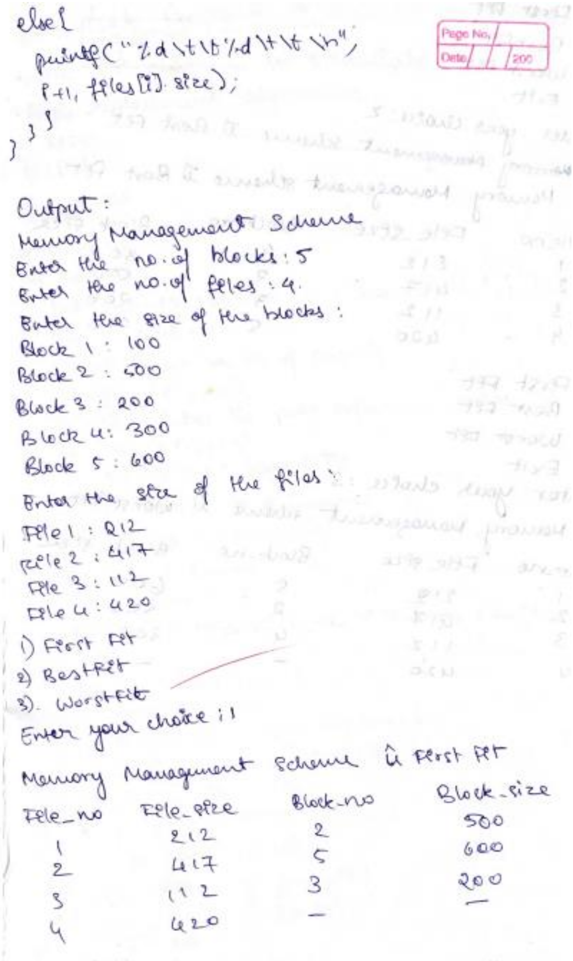
```
    files[i]. block_no = j+1
    blocks[j]. allocated = 1;
   printf("%d\t\t%d\t\t%d \t\t %d \n", i+1,
   files [i]. size ,j+1, blocks[j] . size) ;
    break;
 }}
 if (files[i].block_no == -1) {
    printf( "%d\t\t %-d\t\t_\t\t_\n", i+1,
    files[i]. size) ;
}}
void bestFit(struct Block blocks[], int n_blocks,
 struct Filel files[], int n_files) {
  printf(" \n\t memory ~~mamor~~ management
   scheme - Best fit \n");
  printf("Fileno : \t File_size\t Block_no :
 \t Block _size : \n");
  for (int i = 0 ; i<n_files ; i++) {
   int bestIdx = -1;
   for(int j=0 ; j < n_blocks ; j++)
{
  if(!blocks[j] . allocated && blocks[j].size >=
   files [i]. size) {
    if(bestIdx == -1 || blocks[j]. size <
     blocks[bestIdx].size) {
             bestIdx = j;
    } } }
   if( bestIdx != -1) {
      blocks [bestIdx]. allocated = 1;
       files[i] block_no = bestIdx + 1;
```

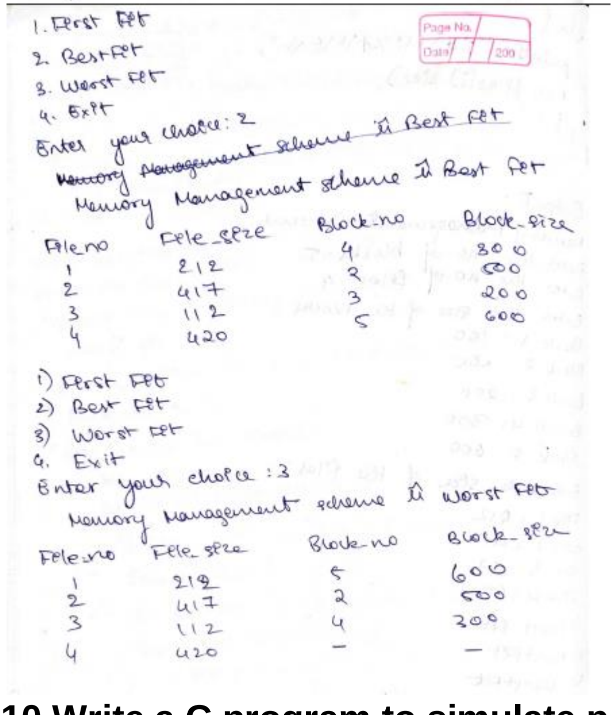


```
printf ("%d\t\t %d\t\t %d
\t\t %d \n", i+1, files[i].size
bestIdx +1, blocks[bestIdx] size);
}
else {
   printf("%d \t\t %d \t\t - \t\t \n",
  i+1, files [i].size);
} }}

void worstFit (struct Block blocks[] , int n_blocks
struct File files[] , int n_files ) {
   printf ("\n \t memory Management scheme -
   worst fit \n");
   printf("File_no: \t File_size \t Block_no: \t
   Block_size :\n");
   for(int i=0 ; i<n ; i++) {
      int worstIdx = -1;
      for(int j=0 ; j<n_blocks; j++) {
        if(!blocks[j].allocated && blocks[j].size >=
        files[i].size) {
        if(worstIdx ==-1 || blocks[j].size >
        blocks[worstIdx].size) {
              worstIdx =j;
 }  }  }
   if (worstIdx!=-1) {
      blocks [worstIdx].allocated = 1;
      files [i].block_no = worstIdx + 1;

  printf("%d \t\t %d \t\t %d \t\t %d \n", i+1,
  files[i] size ,worstIdx +1, blocks [worstIdx].
   size );
  }
```



```
else{
 printf("%d \t\t %d \t\t \n",
 i+1, files[i].size);
 } }
}
```

```
Output :
Memory Management Scheme
Enter the no.of blocks: 5
Enter the no.of files : 4.
Enter the size of the blocks :
Block 1 : 100
Block 2 : 500
Block 3 : 200
Block 4: 300
Block 5 : 600
Enter the size of the files :
File 1 : 212
File 2 : 417
File 3 : 112
File 4 : 420
1) First Fit
2) BestFit
3). WorstFit
Enter your choice :1
Memory Management Scheme is First Fit
File_no     File_size     Block_no     Block_size
  1            212            2            500
  2            417            5            600
  3            112            3            200
  4            420            -             -
```

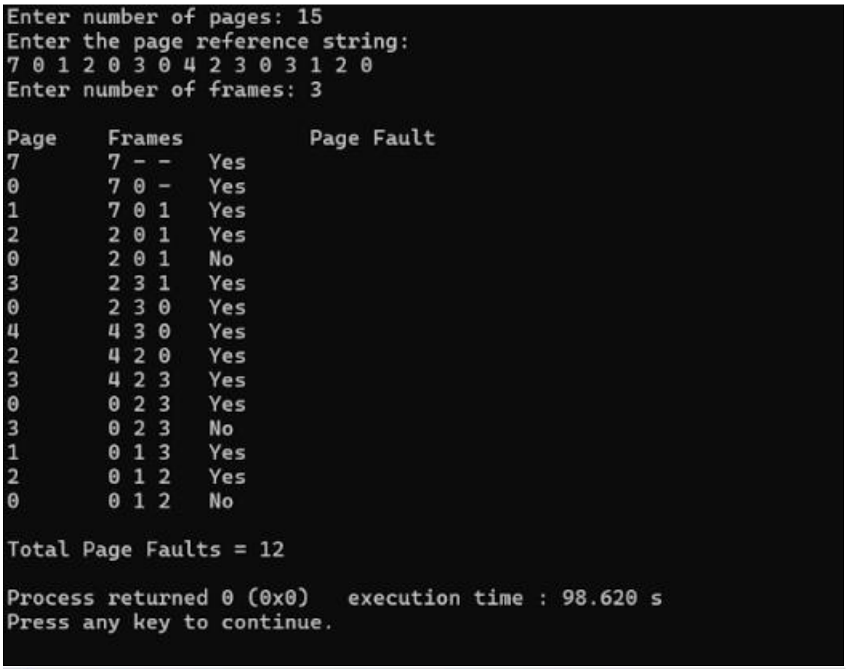


```
1. First Fit
2. BestFit
3. Worst Fit
4. Exit
Enter your choice: 2
~~Memory Management scheme is Best Fit~~
  Memory Management scheme is Best Fit
File no     File_size     Block_no     Block_size
  1            212            4            300
  2            417            2            500
  3            112            3            200
  4            420            5            600

1) First Fit
2) Best Fit
3) Worst Fit
4. Exit
Enter your choice :3
  Memory Management scheme is Worst Fit
File_no     File_size     Block_no     Block_size
  1            212            5            600
  2            417            2            500
  3            112            4            300
  4            420            -             -
```

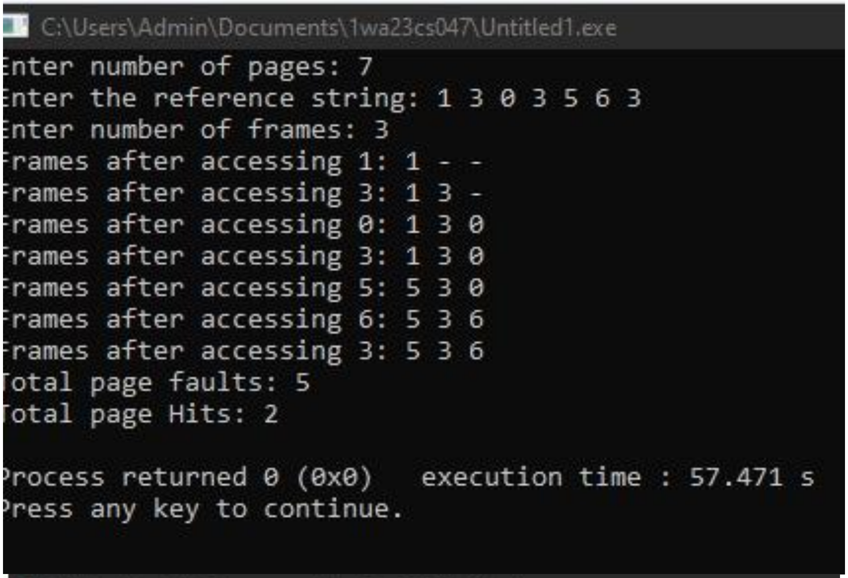
10.Write a C program to simulate page replacement algorithms LRU-Optimal-FIFO

```
#include <stdio.h>

int n, f, i, j, k;
int in[100];
int p[50];
int hit = 0;
int pgfaultcnt = 0;

void getData() {
    printf("\nEnter length of page reference sequence: ");
    scanf("%d", &n);
    printf("\nEnter the page reference sequence: ");
    for(i = 0; i < n; i++)
        scanf("%d", &in[i]);
    printf("\nEnter number of frames: ");
    scanf("%d", &f);
}

void initialize() {
    pgfaultcnt = 0;
    for(i = 0; i < f; i++)
        p[i] = 9999;
}

int isHit(int data) {
    hit = 0;
    for(j = 0; j < f; j++) {
        if(p[j] == data) {
            hit = 1;
            break;
        }
    }
    return hit;
}

void dispPages() {
    for (k = 0; k < f; k++) {
        if(p[k] != 9999)
            printf(" %d", p[k]);
    }
    printf("\n");
}

void dispPgFaultCnt() {
    printf("\nTotal number of page faults: %d\n", pgfaultcnt);
}

void fifo() {
    initialize();
    int index = 0;
    for(i = 0; i < n; i++) {
        printf("For %d :", in[i]);
        if(isHit(in[i]) == 0) {
            p[index] = in[i];
            index = (index + 1) % f;
            pgfaultcnt++;
            printf(" Page Fault ->");
            dispPages();
        } else {
            printf(" No page fault\n");
        }
    }
    dispPgFaultCnt();
}

void optimal() {
    initialize();
    int near[50];
    for(i = 0; i < n; i++) {
        printf("For %d :", in[i]);
        if(isHit(in[i]) == 0) {
            for(j = 0; j < f; j++) {
                int pg = p[j];
                int found = 0;
                for(k = i + 1; k < n; k++) {
                    if(pg == in[k]) {
                        near[j] = k;
                        found  =  1;
                        break;
                    }
                }
                if(!found)
                    near[j] = 9999;
            }
            int max = -1, repindex = -1;
            for(j = 0; j < f; j++) {
                if(near[j] > max) {
                    max = near[j];
                    repindex = j;
                }
            }
            p[repindex] = in[i];
            pgfaultcnt++;
            printf(" Page Fault ->");
            dispPages();
        } else {
            printf(" No page fault\n");
        }
    }
    dispPgFaultCnt();
}
void lru() {
    initialize();
    int least[50];
    for(i = 0; i < n; i++) {
        printf("For %d :", in[i]);
        if(isHit(in[i]) == 0) {
            for(j = 0; j < f; j++) {
                int pg = p[j];
                int found = 0;
                for(k = i - 1; k >= 0; k--) {
                    if(pg == in[k]) {
                        least[j] = k;
                        found = 1;
                        break;
                    }
                }
                if(!found)
                    least[j] = -1;
            }
            int min = 9999, repindex = -1;
            for(j = 0; j < f; j++) {
                if(least[j] < min) {
                    min = least[j];
                    repindex = j;
                }
            }
            p[repindex] = in[i];
            pgfaultcnt++;
            printf(" Page Fault ->");
            dispPages();
        } else {
            printf(" No page fault\n");
        }
    }
    dispPgFaultCnt();
}

int main() {
    int choice;
    while(1) {
        printf("\nPage Replacement Algorithms\n");
        printf("1. Enter data\n");
        printf("2. FIFO\n");
        printf("3. Optimal\n");
        printf("4. LRU\n");
        printf("5. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);
        switch(choice) {
            case 1: getData(); break;
            case 2: fifo(); break;
            case 3: optimal(); break;
            case 4: lru(); break;
            case 5: return 0;
            default: printf("Invalid choice. Try again.\n");
        }
    }
}
```

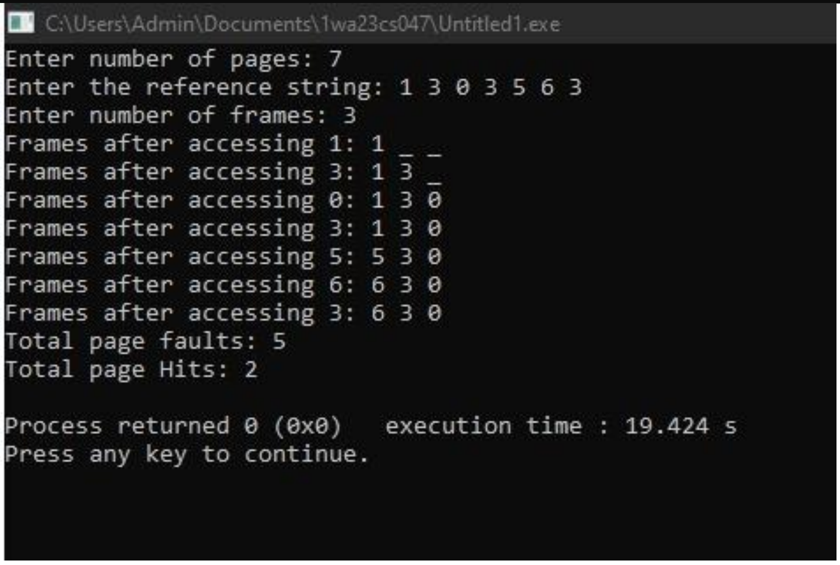
Output:



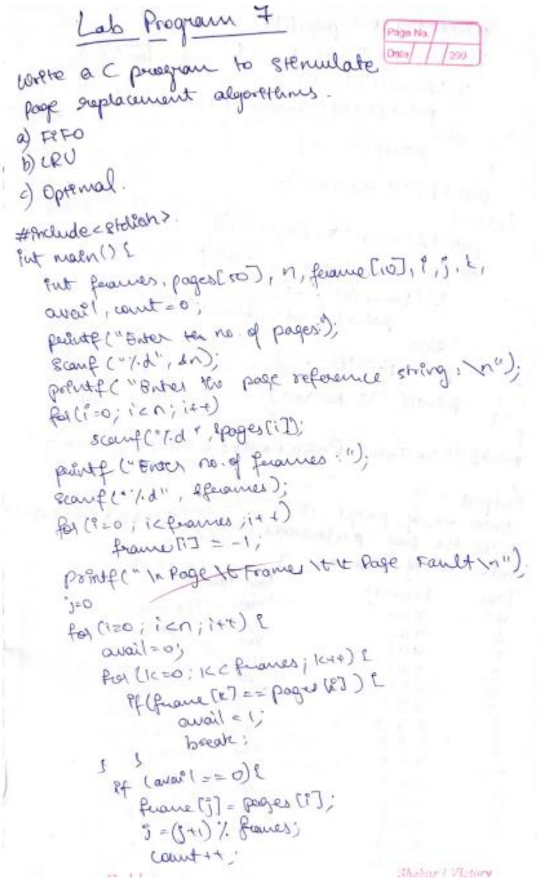
```
Enter number of pages: 15
Enter the page reference string:
7 0 1 2 0 3 0 4 2 3 0 3 1 2 0
Enter number of frames: 3

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

Process returned 0 (0x0)   execution time : 98.620 s
Press any key to continue.
```



```
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

Process returned 0 (0x0)   execution time : 57.471 s
Press any key to continue.
```



```
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

Process returned 0 (0x0)   execution time : 19.424 s
Press any key to continue.
```

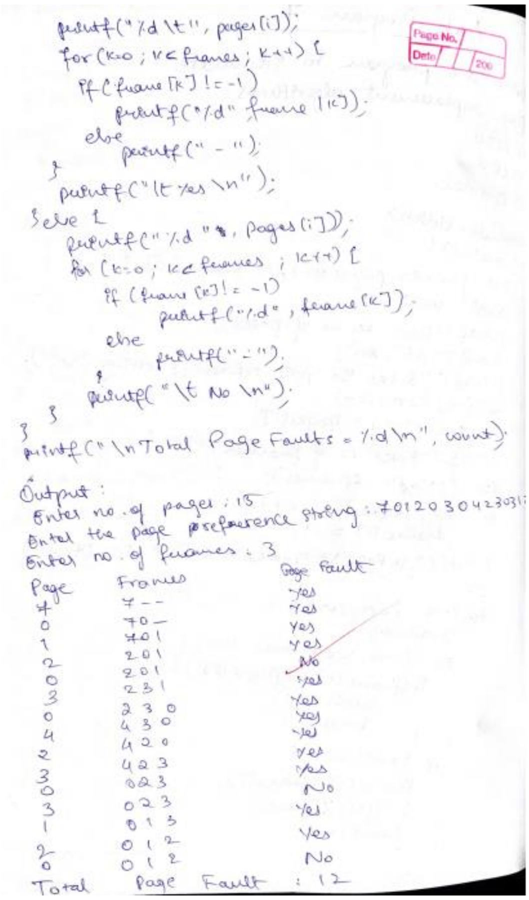


Lab Program 7

Write a C program to simulate page replacement algorithms.

a) FIFO
b) LRU
c) Optimal.

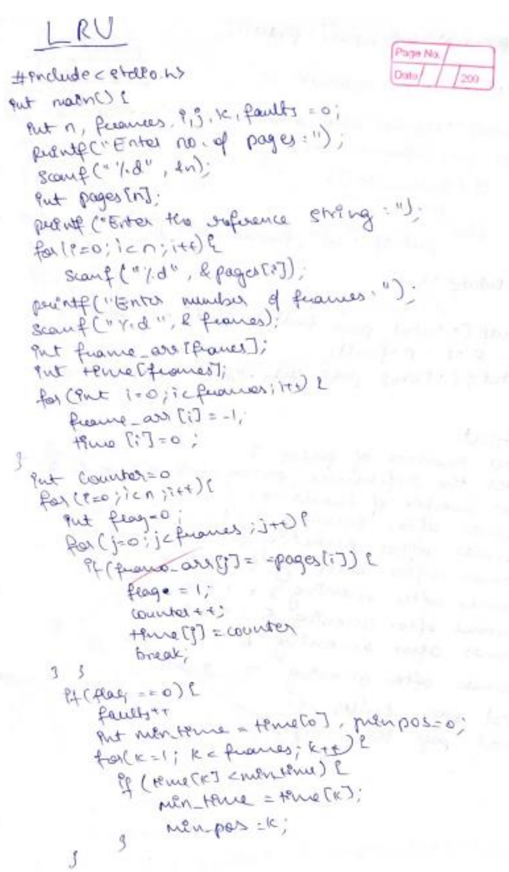
```
#include<stdio.h>
int main() {
  int frames, pages[50], n, frame[10], i, j, k,
  avail, count=0;
  printf("Enter the no. of pages");
  scanf("%d", &n);
  printf("Enter the page reference string:\n");
  for(i=0; i<n; i++)
       scanf("%d", &pages[i]);
  printf("Enter no. of frames :");
  scanf("%d", &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 ", pages[i]));
    for (k=0; k<frames ; k++) {
       if (frame[k]!= -1)
           printf("%d", frame[k]);
       else
           printf("-").
       }
       printf( "\t No \n").
  }
}
printf("\nTotal Page Faults = %d\n", count).
```

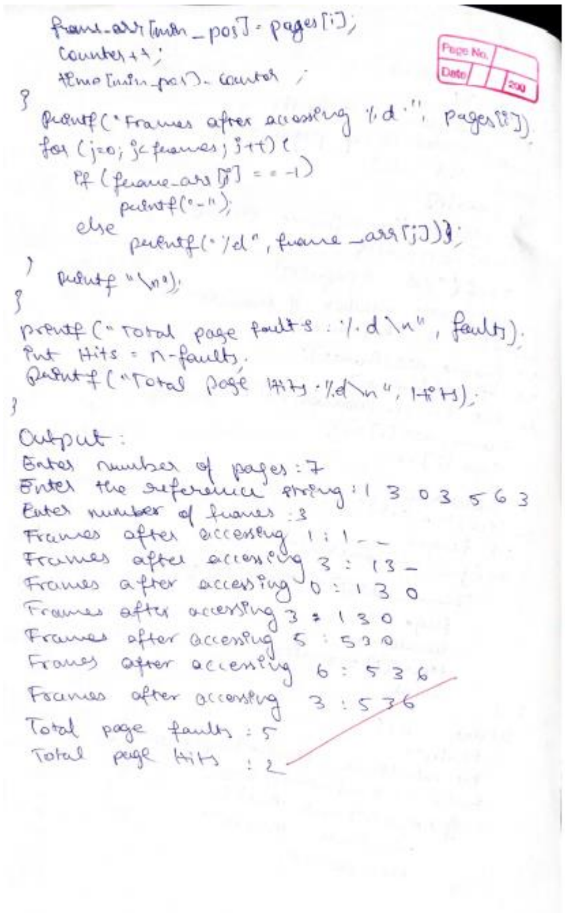
Output :

```
Enter no. of pages : 15
Enter the page preference string : 70120304230317
Enter no. of frames : 3
Page    Frames        Page Fault
                      Yes
7       7 - -         Yes
0       7 0 -         Yes
1       7 0 1         Yes
2       2 0 1         No
0       2 0 1         Yes
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          No
3       0 2 3         Yes
1       0 1 3         Yes
2       0 1 2         No
0       0 1 2
Total   Page  Fault  : 12
```



LRU

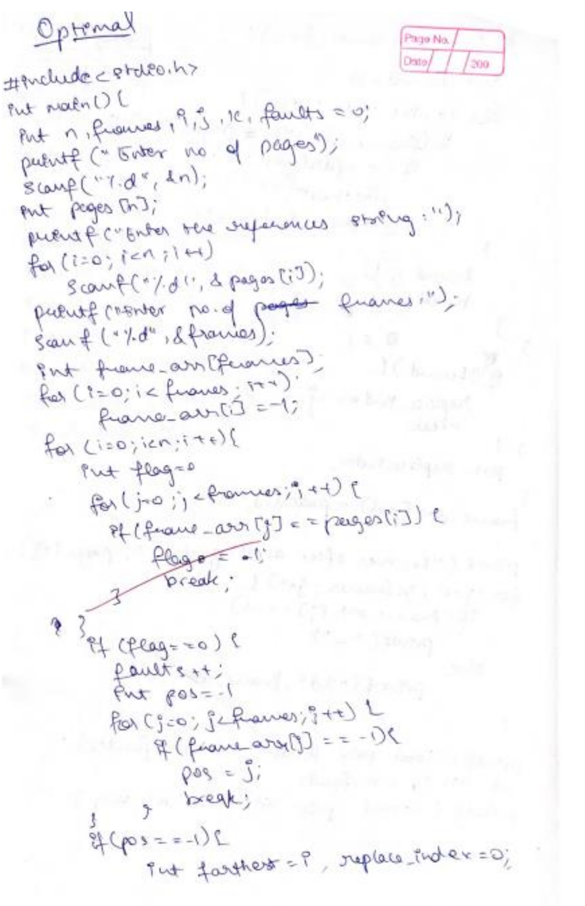
```
#include<stdio.h>
int main() {
  int n, frames, i, j, k, faults = 0;
  printf("Enter no. of pages :");
  scanf("%d", &n);
  int pages[n];
  printf("Enter the reference string :");
  for(i=0; i<n; i++){
     scanf("%d", &pages[i]);
  printf("Enter number of frames :");
  scanf("%d", & frames);
  int frame_arr[frames];
  int time[frames];
  for(int 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 mintime = time[0], minpos=0;
     for(k=1; k<frames; k++) {
       if (time[k] <mintime) {
           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);
}
```

Output :

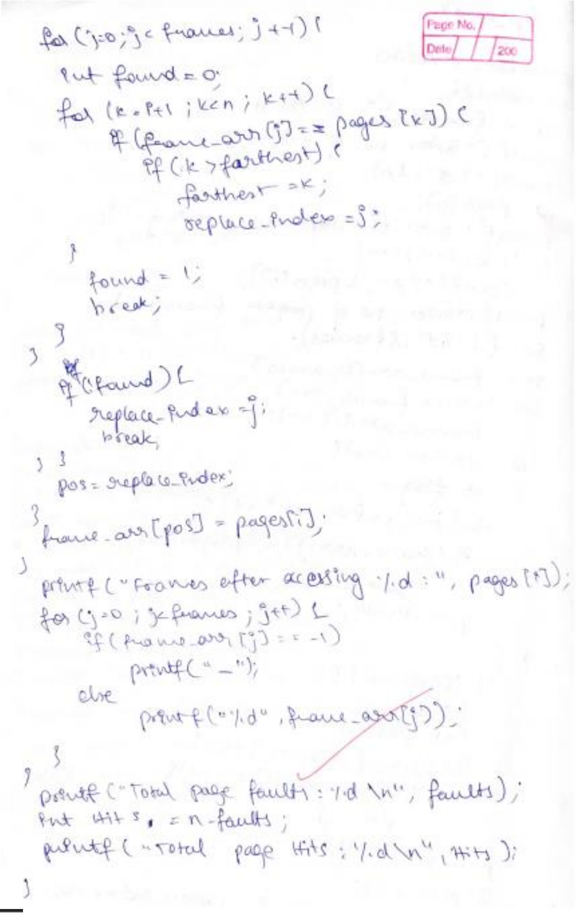
```
Enter number of pages : 7
Enter the reference string : 1 3 0 3 5 6 3
Enter number of frames : 3
Frames after accessing 1 : 1 - -
Frames after accessing 3 : 1 3 -
Frames after accessing 0 : 1 3 0
Frames after accessing 3 : 1 3 0
Frames after accessing 5 : 5 3 0
Frames after accessing 6 : 5 3 6
Frames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



Optimal

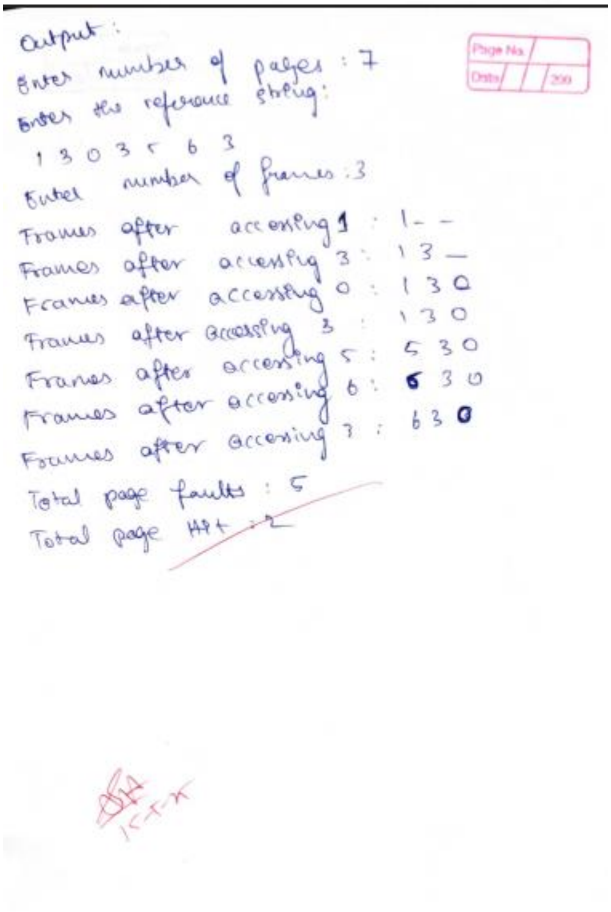
Page No. / Date / / 200

```
#include<stdio.h>
int main(){
 int n,frames,i,j,k,faults=0;
 printf("Enter no of pages");
 scanf("%d",&n);
 int pages[n];
 printf("Enter tere references string:");
 for(i=0;i<n;i++)
     scanf("%d",&pages[i]);
 printf("Enter no.of ~~pages~~ 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;
```



Page No. / Date / / 200

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



Output:

Page No. / Date / / 200

```
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 Hit : 2
```