VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Kamataka.

LAB REPORT
on

OPERATING SYSTEMS

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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Bull Temple Road, Bangalore 560019

(Affiliated To Visvesvaraya Technological University, Belgaum)

Department of Computer Science and Engineering

CERTIFICATE

This is to certify that the Lab work entitled "OPERATING SYSTEMS – 23CS4PCOPS" carried out by DHRUTHI VIJAY (1BM23CS369), who is Bonafide student of B. M. S. College of Engineering. It is in partial fulfilment for the award of Bachelor of Engineering in Computer Science and Engineering of the Visvesvaraya Technological University, Belgaum during the year Feb 2025- June 2025. The Lab report has been approved as it satisfies the academic requirements in respect of a

OPERATING SYSTEMS - (23CS4PCOPS) work prescribed for the said degree.

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Index Sheet

Course Outcomes

C01	Apply the different concepts and functionalities of Operating System
C02	Analyze various Operating system strategies and techniques
C03	Demonstrate the different functionalities of Operating System.
C04	Conduct practical experiments to implement the functionalities of Operating system.

Program -1

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

→FCFS

→ SJF (pre-emptive & Non-preemptive)

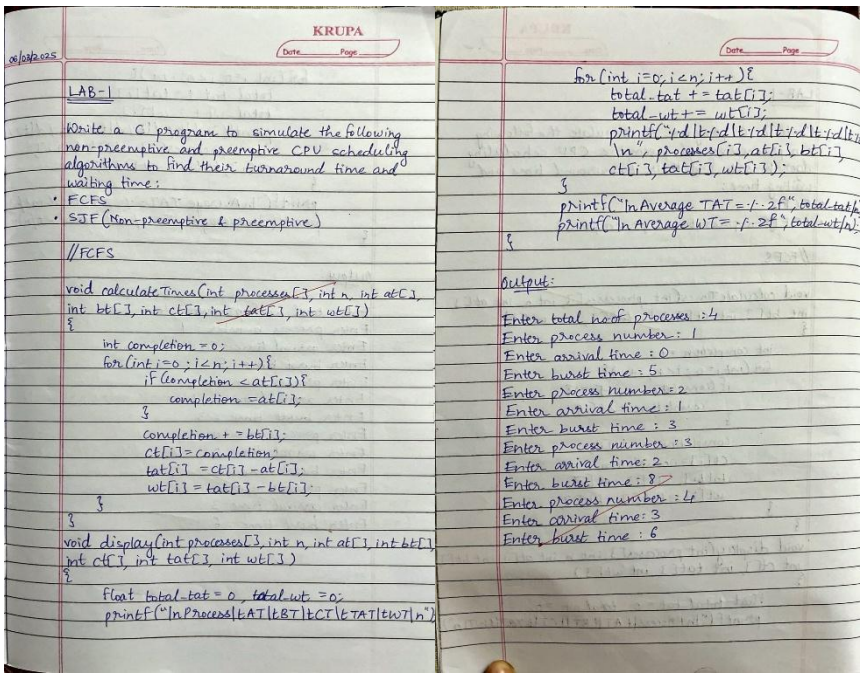
=>FCFS:

```
#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 total number of processes: ");
    scanf("%d", &n);

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

```
    int ct[n], tat[n], wt[n];
    calculateTimes(processes, n, at, bt, ct, tat, wt);
    displayResults(processes, n, at, bt, ct, tat, wt);

    return 0;
}
```

RESULT:

```
PS C:\Users\Admin\Documents\OSLAB> cd "c:\Users\Admin\Documents\OSLAB\" ; if ($?) { gcc fcfs.c -o fcfs } ; if ($?) { .\fcfs }
enter total number of processes: 4
enter process number: 1
enter arrival time: 0
enter burst time: 5
enter process number: 2
enter arrival time: 1
enter burst time: 3
enter process number: 3
enter arrival time: 2
enter burst time: 8
enter process number: 4
enter arrival time: 3
enter burst time: 6

Process AT      BT      CT      TAT     WT
1       0       5       5       5       0
2       1       3       8       7       4
3       2       8       16      14      6
4       3       6       22      19      13

Average Turnaround Time = 11.25
Average Waiting Time = 5.75
```



KRUPA

06/02/2025

LAB-1

Write a C program to simulate the following non-preemptive and preemptive CPU scheduling algorithms to find their turnaround time and waiting time:

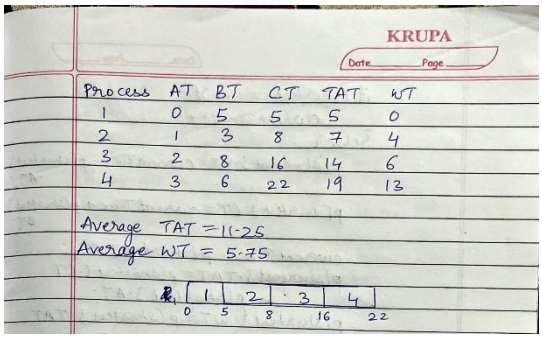
- FCFS
- SJF (Non-preemptive & preemptive)

//FCFS

```
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 display(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 TAT = %.2f", total_tat/n);
    printf("\nAverage WT = %.2f", total_wt/n);
}
```

Output:

```
Enter total no of process : 4
Enter process number : 1
Enter arrival time : 0
Enter burst time : 5
Enter process number : 2
Enter arrival time : 1
Enter burst time : 3
Enter process number : 3
Enter arrival time : 2
Enter burst time : 8
Enter process number : 4
Enter arrival time : 3
Enter burst time : 6
```



KRUPA

Process	AT	BT	CT	TAT	WT
1	0	5	5	5	0
2	1	3	8	7	4
3	2	8	16	14	6
4	3	6	22	19	13

Average TAT = 11.25

Average WT = 5.75

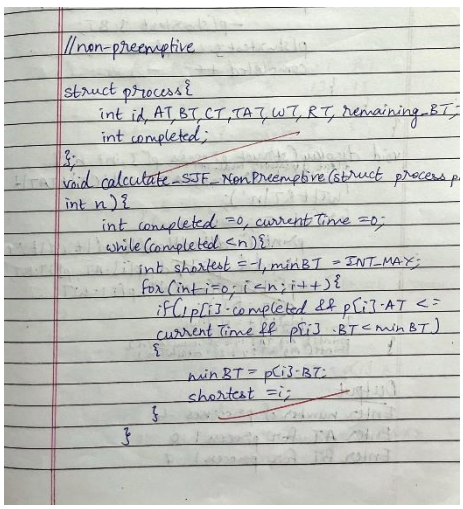
=>SJF(Non-preemptive):

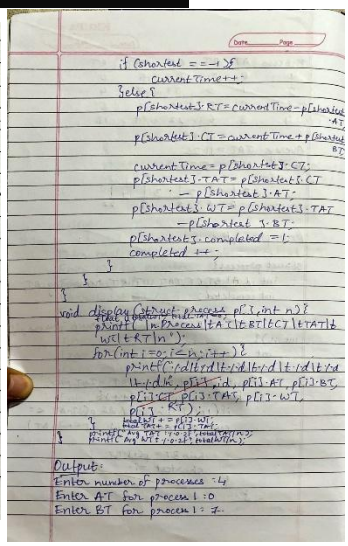
```
#include <stdio.h>
#include <limits.h>
#define MAX 10

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_SJF_NonPreemptive(struct process p[], int n) {
    int completed = 0, currentTime = 0;
    while (completed < n) {
        int shortest = -1, minBT = INT_MAX;
        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].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++;
        }
    }
}
void display(struct process p[], int n) {
    printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t%d\t%d\t%d\t%d\t%d\n",
               p[i].id, p[i].AT, p[i].BT, p[i].CT, p[i].TAT, p[i].WT, p[i].RT);
```

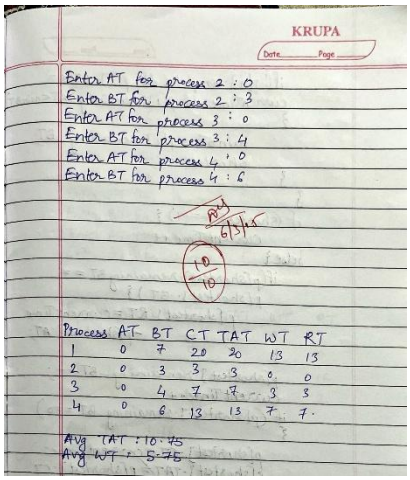
```
    }
}

int main() {
    struct process p[MAX];
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);

    for (int i = 0; i < n; i++) {
        p[i].id = i + 1;
        printf("Enter Arrival Time (AT) for process %d: ", i + 1);
        scanf("%d", &p[i].AT);
        printf("Enter Burst Time (BT) for process %d: ", i + 1);
        scanf("%d", &p[i].BT);
        p[i].completed = 0;
    }
    calculate_SJF_NonPreemptive(p, n);
    display(p, n);

    return 0;
}
```

RESULT:

```
Enter number of processes: 4
Enter Arrival Time (AT) for process 1: 0
Enter Burst Time (BT) for process 1: 7
Enter Arrival Time (AT) for process 2: 0
Enter Burst Time (BT) for process 2: 3
Enter Arrival Time (AT) for process 3: 0
Enter Burst Time (BT) for process 3: 4
Enter Arrival Time (AT) for process 4: 0
Enter Burst Time (BT) for process 4: 6

Process AT      BT      CT      TAT     WT      RT
1       0       7       20      20      13      13
2       0       3       3       3       0       0
3       0       4       7       7       3       3
4       0       6       13      13      7       7

Process returned 0 (0x0)   execution time : 36.770 s
Press any key to continue.
```







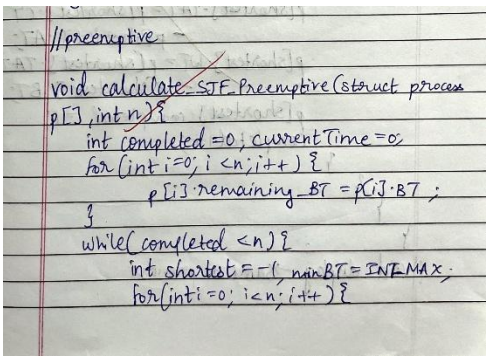
=>SJF(Preemptive):

```
#define MAX 1
struct process {
   int id, AT, BT, CT, TAT, WT, RT, remaining_BT;
   int completed;
};
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 = INT_MAX;
      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++;
         }
      }
   }
}
void display(struct process p[], int n) {
   float total_tat = 0, total_wt = 0;
   printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\tRT\n");
   for (int i = 0; i < n; i++) {
      printf("%d\t%d\t%d\t%d\t%d\t%d\t%d\n",
            p[i].id, p[i].AT, p[i].BT, p[i].CT, p[i].TAT, p[i].WT, p[i].RT);
      total_tat += p[i].TAT;
      total_wt += p[i].WT;
   }
   printf("\nAvg TAT = %.2f", total_tat / n);
   printf("\nAvg WT  = %.2f\n", total_wt / n);
}
```

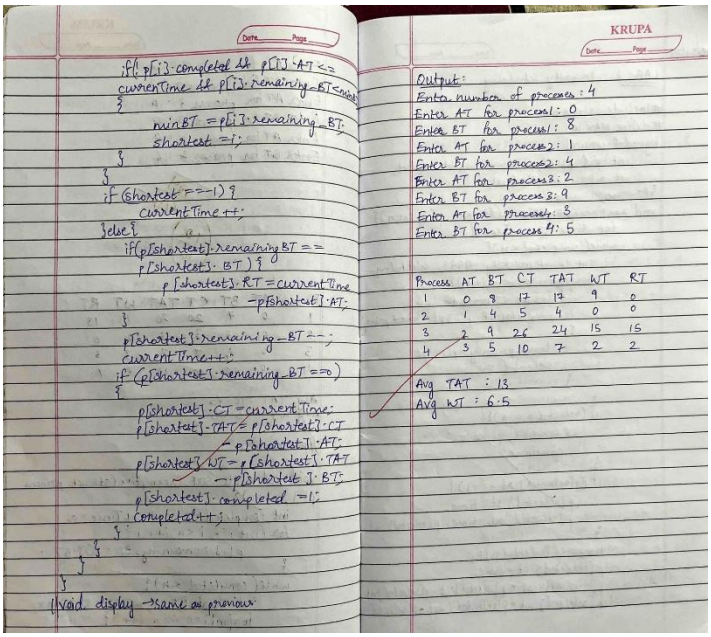
```
int main() {
    struct process p[MAX];
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    for (int i = 0; i < n; i++) {
        p[i].id = i + 1;
        printf("Enter Arrival Time (AT) for process %d: ", i + 1);
        scanf("%d", &p[i].AT);
        printf("Enter Burst Time (BT) for process %d: ", i + 1);
        scanf("%d", &p[i].BT);
        p[i].completed = 0;
    }
    calculate_SJF_Preemptive(p, n);
    display(p, n);

    return 0;
}
```

Result:

```
Enter number of processes: 4
Enter Arrival Time (AT) for process 1: 0
Enter Burst Time (BT) for process 1: 8
Enter Arrival Time (AT) for process 2: 1
Enter Burst Time (BT) for process 2: 4
Enter Arrival Time (AT) for process 3: 2
Enter Burst Time (BT) for process 3: 9
Enter Arrival Time (AT) for process 4: 3
Enter Burst Time (BT) for process 4: 5

Process AT      BT      CT      TAT     WT      RT
1       0       8       17      17      9       0
2       1       4       5       4       0       0
3       2       9       26      24      15      15
4       3       5       10      7       2       2

avg tat= 13.00
avg wt= 6.50
Process returned 0 (0x0)   execution time : 11.644 s
Press any key to continue.
```



```
//preemptive
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=INT_MAX;
        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].remainingBT ==
    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++;
    }
}
}
//void display -same as previous
```

```
Output:
Enter number of process: 4
Enter AT for process1: 0
Enter BT for process1: 8
Enter AT for process2: 1
Enter BT for process2: 4
Enter AT for process3: 2
Enter BT for process3: 9
Enter AT for process4: 3
Enter BT for process 4: 5

Process AT BT CT TAT WT RT
1       0  8  17 17  9  0
2       1  4  5  4   0  0
3       2  9  26 24  15 15
4       3  5  10 7   2  2

Avg TAT : 13
Avg WT : 6.5
```

Program -2

Write a C program to simulate the following CPU scheduling algorithm to find turnaround time and waiting time.
→ Priority (pre-emptive & Non-preemptive)

=>CPU SCHEDULING:

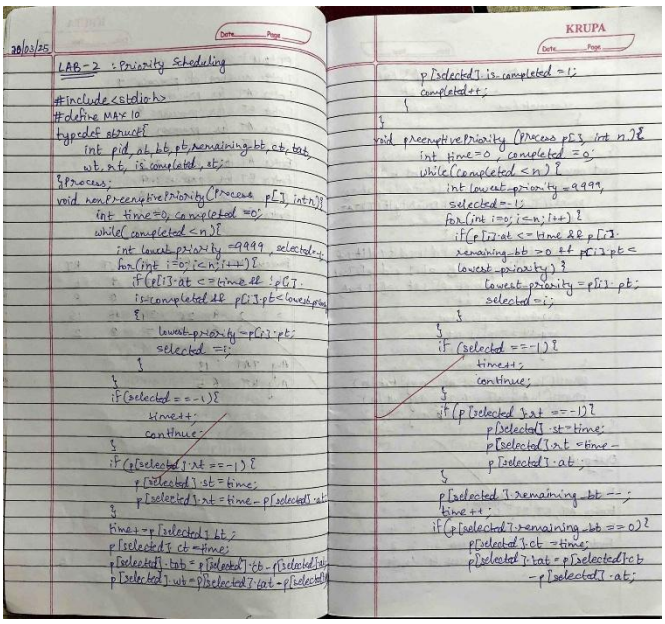
```
#include <stdio.h>
#define MAX 10
typedef struct {
    int pid, at, bt, pt, remaining_bt, ct, tat, wt, rt, is_completed, st;
} Process;
void nonPreemptivePriority(Process p[], int n) {
    int time = 0, completed = 0;
    while (completed < n) {
        int lowest_priority = 9999, selected = -1;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

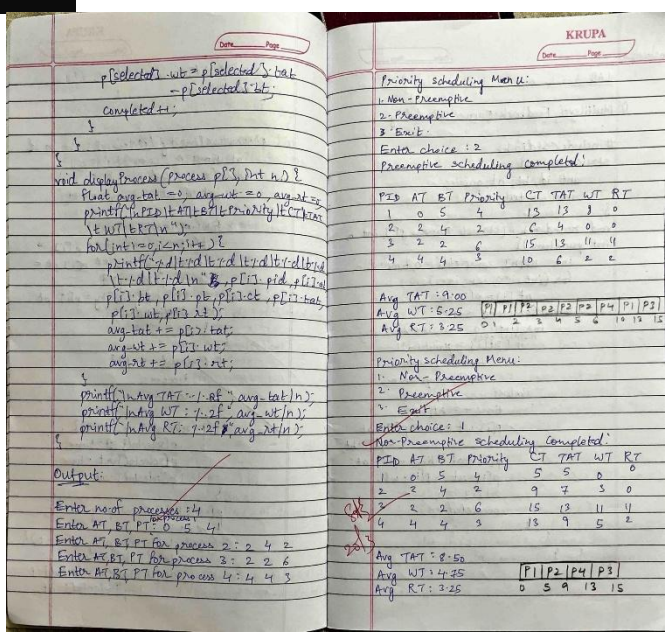
```
            for (int i = 0; i < n; i++) {
            if (p[i].at <= time && p[i].remaining_bt > 0 && p[i].pt < lowest_priority) {
                lowest_priority = p[i].pt;
                selected = i;
            }
        }
        if (selected == -1) {
            time++;
            continue;
        }
        if (p[selected].rt == -1) {
            p[selected].st = time;
            p[selected].rt = time - p[selected].at;
        }
        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 (lower number means higher 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;
}
```

RESULT:

```
Enter the number of processes: 4

Enter Arrival Time, Burst Time, and Priority for Process 1:
Arrival Time: 0
Burst Time: 5
Priority (lower number means higher priority): 4

Enter Arrival Time, Burst Time, and Priority for Process 2:
Arrival Time: 2
Burst Time: 4
Priority (lower number means higher priority): 2

Enter Arrival Time, Burst Time, and Priority for Process 3:
Arrival Time: 2
Burst Time: 2
Priority (lower number means higher priority): 6

Enter Arrival Time, Burst Time, and Priority for Process 4:
Arrival Time: 4
Burst Time: 4
Priority (lower number means higher priority): 3

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

PID     AT      BT      Priority        CT      TAT     WT      RT
1       0       5       4               13      13      8       0
2       2       4       2               6       4       0       0
3       2       2       6               15      13      11      11
4       4       4       3               10      6       2       2

Average TAT: 9.00
Average WT: 5.25
Average RT: 3.25

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       5       4               5       5       0       0
2       2       4       2               9       7       3       0
3       2       2       6               15      13      11      11
4       4       4       3               13      9       5       2

Average TAT: 8.50
Average WT: 4.75
Average RT: 3.25

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





Program - 3

Write a C program to simulate a 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.

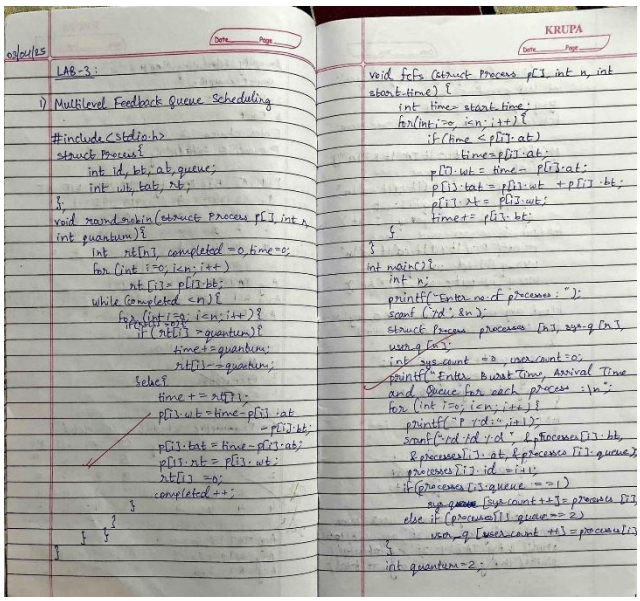
=>MULTI LEVEL SCHEDULING

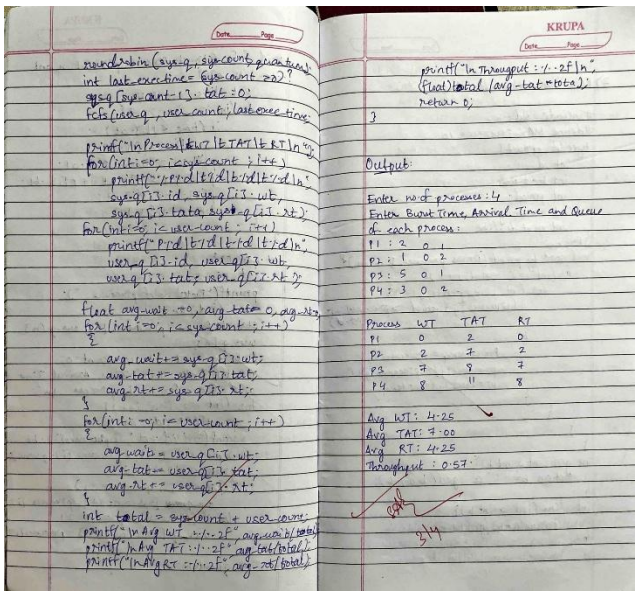
```
#include <stdio.h>
struct Process {
    int id, burst_time, arrival_time, queue;
    int waiting_time, turnaround_time, response_time;
};
void round_robin(struct Process p[], int n, int quantum) {
    int remaining_time[n], completed = 0, time = 0;
    for (int i = 0; i < n; i++) remaining_time[i] = p[i].burst_time;
    while (completed < n) {
        for (int i = 0; i < n; i++) {
            if (remaining_time[i] > 0) {
                if (remaining_time[i] > quantum) {
                    time += quantum;
                    remaining_time[i] -= quantum;
                } else {
                    time += remaining_time[i];
                    p[i].waiting_time = time - p[i].arrival_time - p[i].burst_time;
                    p[i].turnaround_time = time - p[i].arrival_time;
                    p[i].response_time = p[i].waiting_time;
                    remaining_time[i] = 0;
                    completed++;
                }
            }
        }
    }
}
void fcfs(struct Process p[], int n, int start_time) {
    int time = start_time;
    for (int i = 0; i < n; i++) {
        if (time < p[i].arrival_time)
            time = p[i].arrival_time;

        p[i].waiting_time = time - p[i].arrival_time;
        p[i].turnaround_time = p[i].waiting_time + p[i].burst_time;
        p[i].response_time = p[i].waiting_time;
        time += p[i].burst_time;
    }
}
int main() {
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
```

```
    struct Process processes[n], system_queue[n], user_queue[n];
    int sys_count = 0, user_count = 0;

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

        if (processes[i].queue == 1)
            system_queue[sys_count++] = processes[i];
        else if (processes[i].queue == 2)
            user_queue[user_count++] = processes[i];
    }
    int quantum = 2;
    round_robin(system_queue, sys_count, quantum);
    int last_exec_time = (sys_count > 0) ? system_queue[sys_count - 1].turnaround_time : 0;
    fcfs(user_queue, user_count, last_exec_time);

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

    for (int i = 0; i < user_count; i++)
        printf("P%d\t%d\t\t%d\t\t\t%d\n",user_queue[i].id,user_queue[i].waiting_time,
user_queue[i].turnaround_time, user_queue[i].response_time);

    float avg_wait = 0, avg_tat = 0, avg_resp = 0;
    for (int i = 0; i < sys_count; i++) {
        avg_wait += system_queue[i].waiting_time;
        avg_tat += system_queue[i].turnaround_time;
        avg_resp += system_queue[i].response_time;
    }
    for (int i = 0; i < user_count; i++) {
        avg_wait += user_queue[i].waiting_time;
        avg_tat += user_queue[i].turnaround_time;
        avg_resp += user_queue[i].response_time;
    }
    int total = sys_count + user_count;
    printf("\nAverage Waiting Time: %.2f", avg_wait / total);
    printf("\nAverage Turn Around Time: %.2f", avg_tat / total);
    printf("\nAverage Response Time: %.2f", avg_resp / total);
    printf("\nThroughput: %.2f\n", (float)total / avg_tat * total);
    return 0;
}
```

RESULT:

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

Process Waiting Time    Turn Around Time        Response Time
P1      0               2                       0
P3      2               7                       2
P2      7               8                       7
P4      8               11                      8

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

Process returned 0 (0x0)   execution time : 15.237 s
Press any key to continue.
```





Program -4

Write a C program to simulate Real-Time CPU Scheduling algorithms:
a) Rate- Monotonic
b) Earliest-deadline First

=> Rate Monotonic

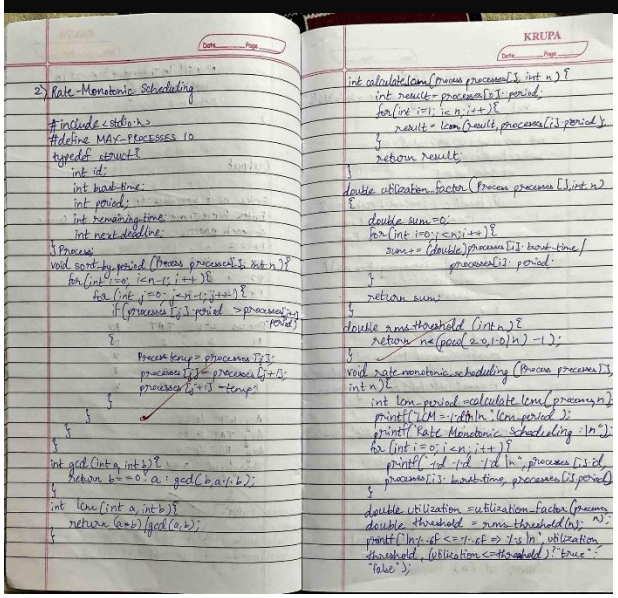
```
#include <stdio.h>
#define MAX_PROCESSES 10
typedef struct {
    int id;
    int burst_time;
    int period;
    int remaining_time;
    int next_deadline;
} Process;
void sort_by_period(Process processes[], int n) {
    for (int i = 0; i < n - 1; i++) {
        for (int j = 0; j < n - i - 1; j++) {
            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);
```

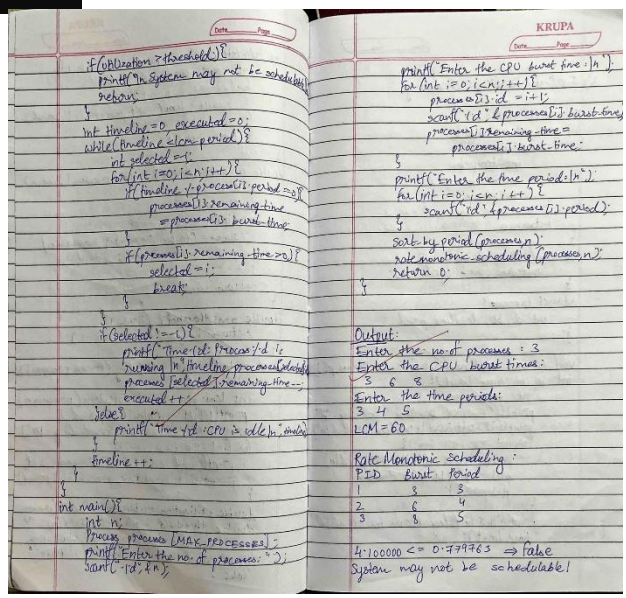
```
    printf("LCM=%d\n\n", lcm_period);
    printf("Rate Monotone Scheduling:\n");
    printf("PID  Burst  Period\n");
    for (int i = 0; i < n; i++) {
        printf("%d    %d      %d\n", processes[i].id, processes[i].burst_time, processes[i].period);
    }
    double utilization = utilization_factor(processes,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

RESULT:

```
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 : 34.908 s
Press any key to continue.
```





=> Earliest Deadline

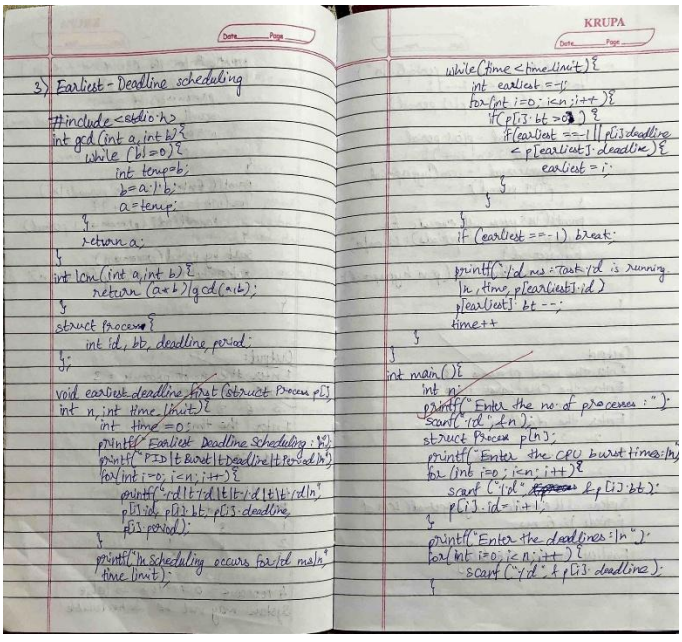
```
#include <stdio.h>
int gcd(int a, int b) {
    while (b != 0) {
        int temp = b;
        b = a % b;
        a = temp;
    }
    return a;
```

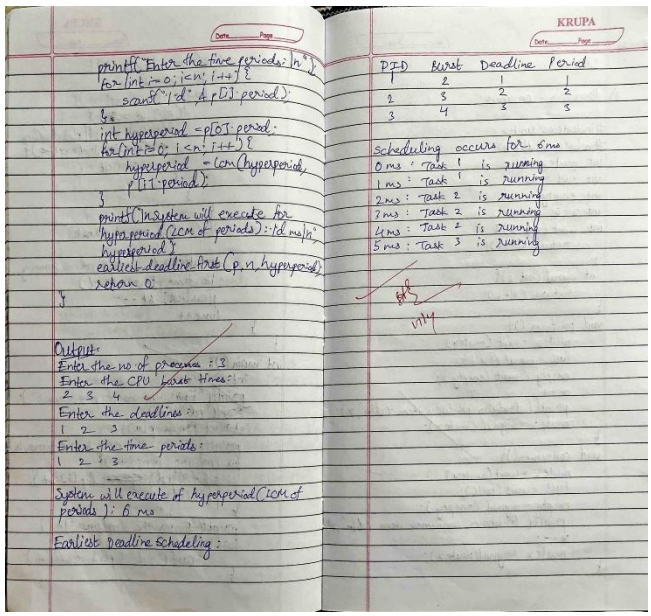
```
}
int lcm(int a, int b) {
    return (a * b) / gcd(a, b);
}
struct Process {
    int id, burst_time, deadline, period;
};
void earliest_deadline_first(struct Process p[], int n, int time_limit) {
    int time = 0;


    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;
}
```

RESULT:

```
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 : 9.656 s
Press any key to continue.
```





Program 5

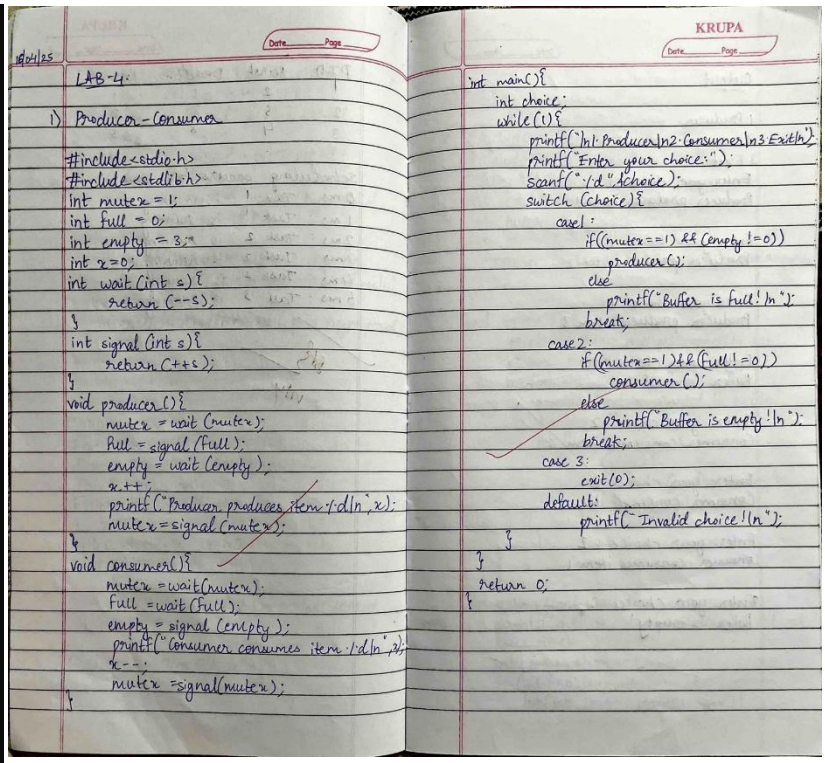
Write a C program to simulate producer-consumer problem using semaphores.

```
#include <stdio.h>
#include <stdlib.h>
int mutex = 1;
int full = 0;
int empty = 3;
int x = 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("Producer produces item %d\n", x);
   mutex = signal(mutex);
}
void consumer() {
   mutex = wait(mutex);
   full = wait(full);
   empty = signal(empty);
   printf("Consumer consumes item %d\n", x);
   x--;
   mutex = signal(mutex);
}
int main() {
   int choice;
   while (1) {
      printf("\n1. Producer\n2. Consumer\n3. Exit\n");
      printf("Enter your choice: ");
      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);

    default:
        printf("Invalid choice!\n");
    }
  }
  return 0;
}
```

RESULT:

```
1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Producer produces item 1

1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Producer produces item 2

1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Producer produces item 3

1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Buffer is full!

1. Producer
2. Consumer
3. Exit
Enter your choice: 2
Consumer consumes item 3

1. Producer
2. Consumer
3. Exit
Enter your choice: 1
Producer produces item 3

1. Producer
2. Consumer
3. Exit
Enter your choice: 2
Consumer consumes item 3

1. Producer
2. Consumer
3. Exit
Enter your choice: 2
Consumer consumes item 2

1. Producer
2. Consumer
3. Exit
Enter your choice: 2
Consumer consumes item 1

1. Producer
2. Consumer
3. Exit
Enter your choice: 2
Buffer is empty!

1. Producer
2. Consumer
```



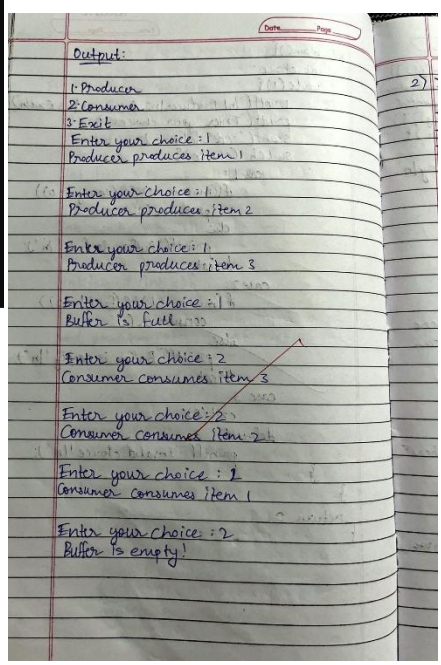
LAB-4:

1) Producer-Consumer

```
#include<stdio.h>
#include<stdlib.h>
int mutex = 1;
int full = 0;
int empty = 3;
int x=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("Producer produces item:%d\n",x);
    mutex=signal(mutex);
}
void consumer(){
    mutex =wait(mutex);
    full =wait(full);
    empty = signal(empty);
    printf("Consumer consumes item:%d\n",x);
    x--;
    mutex =signal(mutex);
}
```

KRUPA

```
int main(){
  int choice;
  while(1){
    printf("\n1: Producer\n2: Consumer\n3 Exit\n");
    printf("Enter your choice:");
    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);
      default:
        printf("Invalid choice!\n");
    }
  }
  return 0;
}
```



Output:

```
1. Producer
2. Consumer
3. Exit
Enter your choice : 1
Producer produces item 1

Enter your choice : 1
Producer produces item 2

Enter your choice : 1
Producer produces item 3

Enter your choice : 1
Buffer is full

Enter your choice : 2
Consumer consumes item 3

Enter your choice : 2
Consumer consumes item 2

Enter your choice : 1
Consumer consumes item 1

Enter your choice : 2
Buffer is empty!
```

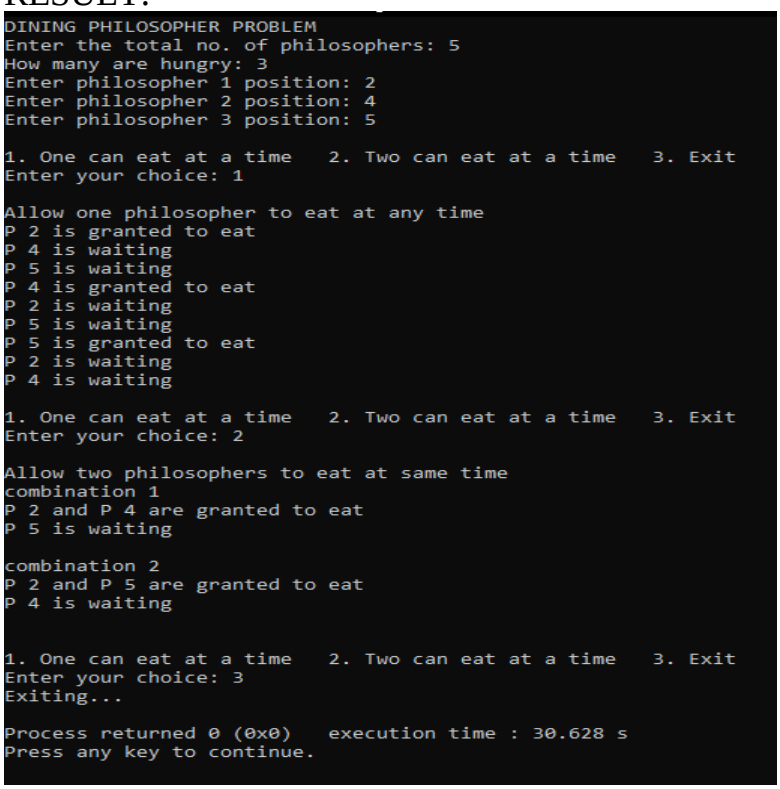
Program 6

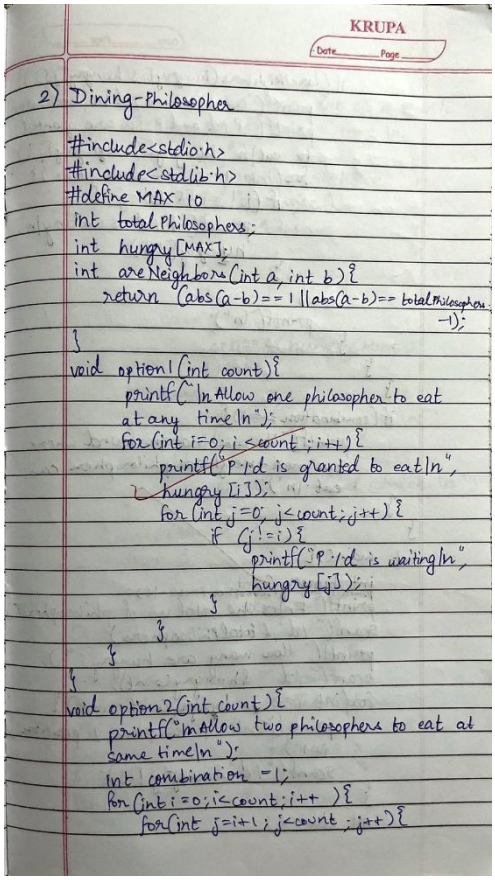
Write a C program to simulate the concept of Dining Philosophers problem

```
#include <stdio.h>
#include <stdlib.h>
#define MAX 10
int totalPhilosophers;
int hungry[MAX];
int areNeighbors(int a, int b) {
   return (abs(a - b) == 1 || abs(a - b) == totalPhilosophers - 1);
}
void option1(int count) {
   printf("\nAllow one philosopher to eat at any time\n");

   for (int i = 0; i < count; i++) {
      printf("P %d is granted to eat\n", hungry[i]);
      for (int j = 0; j < count; j++) {
         if (j != i) {
            printf("P %d is waiting\n", hungry[j]);
         }
      }
   }
}
void option2(int count) {
   printf("\nAllow two philosophers to eat at same time\n");
   int combination = 1;
   for (int i = 0; i < count; i++) {
      for (int j = i + 1; j < count; j++) {
         if (!areNeighbors(hungry[i], hungry[j])) {
            printf("combination %d\n", combination++);
            printf("P %d and P %d are granted to eat\n", hungry[i], hungry[j]);
            for (int k = 0; k < count; k++) {
               if (k != i && k != j) {
                  printf("P %d is waiting\n", hungry[k]);
               }
            }
            printf("\n");
         }
      }
   }
   if (combination == 1) {
      printf("No combinations found where two non-neighbor philosophers can eat.\n");
   }
}
int main() {
   int hungryCount;
   printf("DINING PHILOSOPHER PROBLEM\n");
   printf("Enter the total no. of philosophers: ");
   scanf("%d", &totalPhilosophers);
   printf("How many are hungry: ");
   scanf("%d", &hungryCount);
```

```
    for (int i = 0; i < hungryCount; i++) {
        printf("Enter philosopher %d position: ", i + 1);
        scanf("%d", &hungry[i]);
    }
    int choice;
    do {
        printf("\n1. One can eat at a time   2. Two can eat at a time   3. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        switch (choice) {
        case 1:
            option1(hungryCount);
            break;
        case 2:
            option2(hungryCount);
            break;
        case 3:
            printf("Exiting...\n");
            break;
        default:
            printf("Invalid choice!\n");
        }
    } while (choice != 3);

    return 0;
}
```

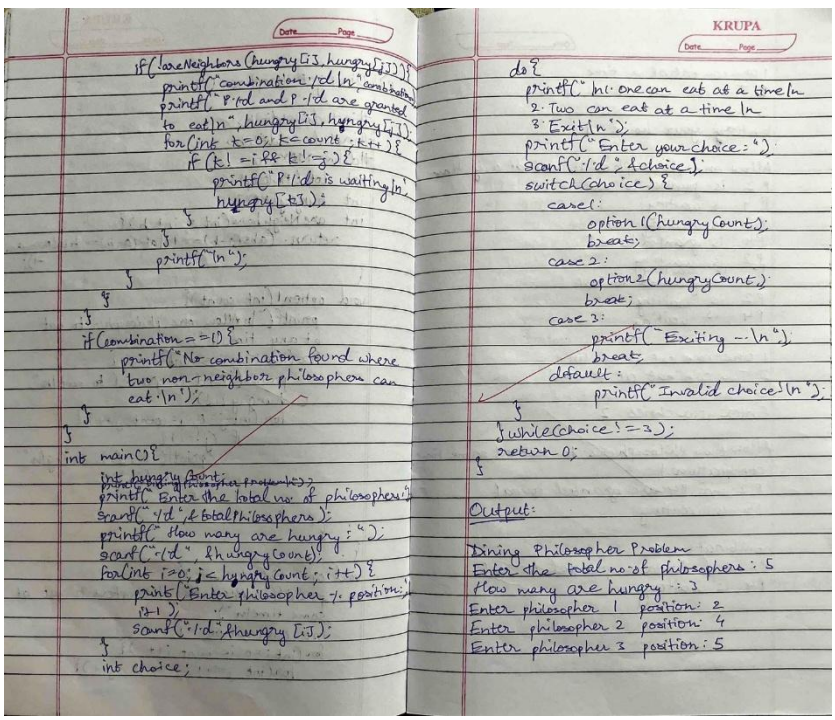
RESULT:





2) Dining-Philosopher

```
#include<stdio.h>
#include<stdlib.h>
#define MAX 10
int totalPhilosophers;
int hungry[MAX];
int areNeighbors(int a, int b){
    return (abs(a-b)==1||abs(a-b)==totalPhilosophers-1);
}
void option1(int count){
    printf("\nAllow one philosopher to eat at any time\n");
    for(int i=0; i<count; i++){
        printf("P:%d is granted to eat\n", hungry[i]);
        for(int j=0; j<count; j++){
            if(j!=i){
                printf("P:%d is waiting\n", hungry[j]);
            }
        }
    }
}
void option2(int count){
    printf("\nAllow two philosophers to eat at same time\n");
    int combination=1;
    for(int i=0; i<count; i++){
        for(int j=i+1; j<count; j++){
```



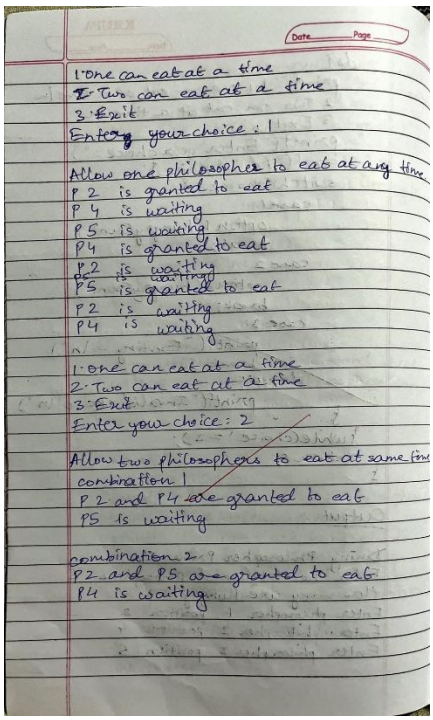
```
            if(areNeighbors(hungry[i],hungry[j])){
                printf("combination:%d\n", combination++);
                printf("P:%d and P:%d are granted to eat\n", hungry[i], hungry[j]);
                for(int k=0; k<count; k++){
                    if(k!=i && k!=j){
                        printf("P:%d is waiting\n", hungry[k]);
                    }
                }
                printf("\n");
            }
        }
    }
    if(combination==1){
        printf("No combination found where two non-neighbors philosophers can eat\n");
    }
}
int main(){
    int hungryCount;
    printf("Enter the total no of philosophers: ");
    scanf("%d", &totalPhilosophers);
    printf("How many are hungry: ");
    scanf("%d", &hungryCount);
    for(int i=0; i<hungryCount; i++){
        printf("Enter philosopher %d position: ", i+1);
        scanf("%d", &hungry[i]);
    }
    int choice;
```



```
    do{
        printf("\n1.One can eat at a time\n2.Two can eat at a time\n3.Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);
        switch(choice){
            case 1:
                option1(hungryCount);
                break;
            case 2:
                option2(hungryCount);
                break;
            case 3:
                printf("Exiting...\n");
                break;
            default:
                printf("Invalid choice!\n");
        }
    }while(choice!=3);
    return 0;
}
```

Output:

```
Dining Philosopher Problem
Enter the total no of philosophers: 5
How many are hungry: 3
Enter philosopher 1 position: 2
Enter philosopher 2 position: 4
Enter philosopher 3 position: 5
```



```
1.One can eat at a time
2.Two can eat at a time
3.Exit
Enter your choice: 1

Allow one philosopher to eat at any time
P 2 is granted to eat
P 4 is waiting
P 5 is waiting
P 4 is granted to eat
P 2 is waiting
P 5 is granted to eat
P 2 is waiting
P 4 is waiting

1.One can eat at a time
2.Two can eat at a time
3.Exit
Enter your choice: 2

Allow two philosophers to eat at same time
combination 1
P 2 and P 4 are granted to eat
P 5 is waiting

combination 2
P 2 and P 5 are granted to eat
P 4 is waiting
```

Program 7

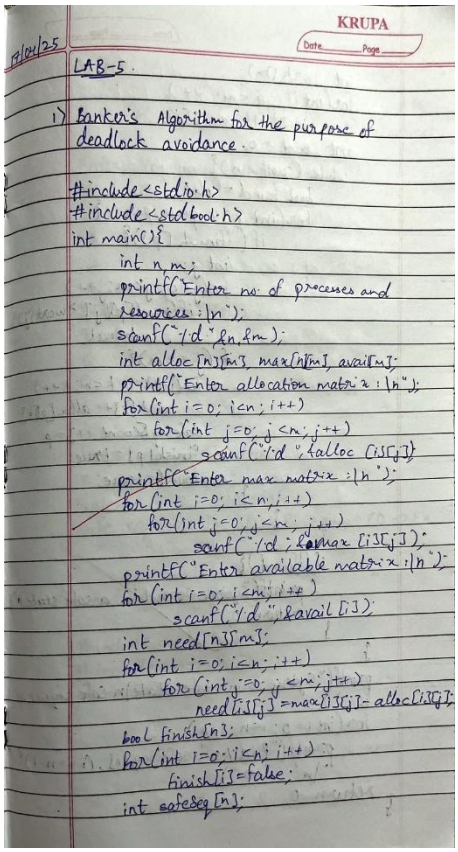
Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.

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

                    safeSeq[count++] = p;
                    finish[p] = true;
                    found = true;
                }
            }
        }
```

```
        if (!found) {
            printf("System is not in a safe state.\n");
            return 0;
        }
    }
    printf("System is in safe state.\nSafe sequence is: ");
    for (int i = 0; i < n; i++)
        printf("P%d%s", safeSeq[i], (i == n - 1) ? "\n" : " -> ");
    return 0;
}
```

RESULT:

```
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

Process returned 0 (0x0)   execution time : 77.126 s
Press any key to continue.
```

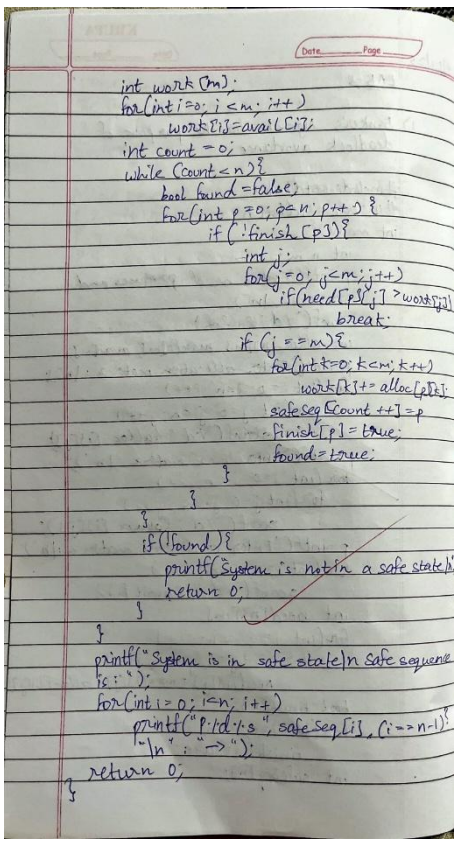

KRUPA

7/04/25

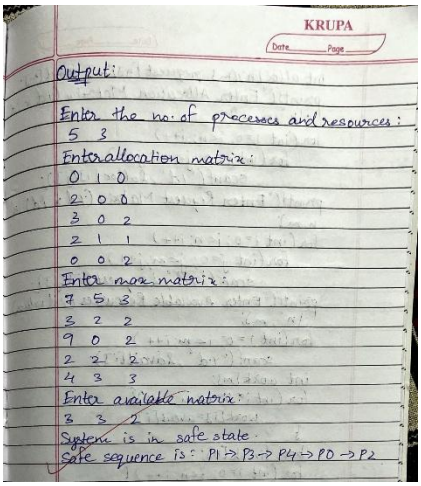
LAB-5

1) Banker's Algorithm for the purpose of deadlock avoidance.

```
#include<stdio.h>
#include<stdbool.h>
int main(){
    int n,m;
    printf("Enter no. 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 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];
    bool finish[n];
    for(int i=0; i<n; i++)
        finish[i]=false;
    int safeSeq[n];
```



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


KRUPA

Output:

```
Enter the 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 state
Safe sequence is: P1 -> P3 -> P4 -> P0 -> P2
```

Program 8

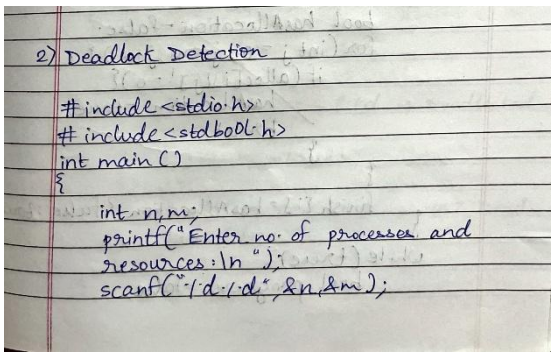
Write a C program to simulate deadlock detection

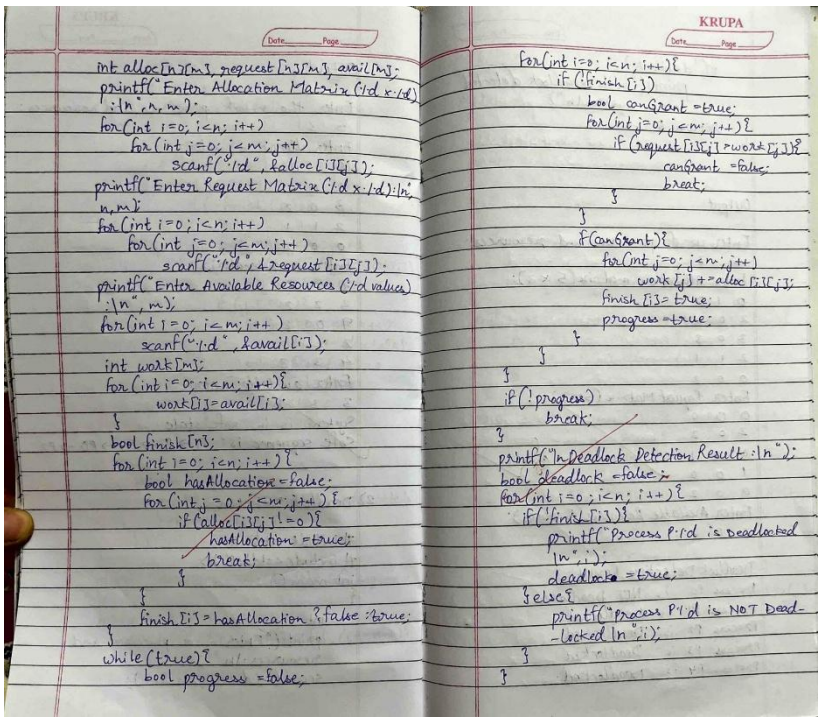
```
#include <stdio.h>
#include <stdbool.h>
int main() {
    int n, m;
    printf("Enter number of processes and number of resources:\n");
    scanf("%d %d", &n, &m);
    int alloc[n][m], request[n][m], avail[m];
    printf("Enter Allocation Matrix (%d x %d):\n", n, m);
    for (int i = 0; i < n; i++)
        for (int j = 0; j < m; j++)
            scanf("%d", &alloc[i][j]);
    printf("Enter Request Matrix (%d x %d):\n", n, m);
    for (int i = 0; i < n; i++)
        for (int j = 0; j < m; j++)
            scanf("%d", &request[i][j]);

    printf("Enter Available Resources (%d values):\n", m);
    for (int i = 0; i < m; i++)
        scanf("%d", &avail[i]);
    int work[m];
    for (int i = 0; i < m; i++)
        work[i] = avail[i];
    bool finish[n];
    for (int i = 0; i < n; i++) {
        bool hasAllocation = false;
        for (int j = 0; j < m; j++) {
            if (alloc[i][j] != 0) {
                hasAllocation = true;
                break;
            }
        }
        finish[i] = hasAllocation ? false : true;
    }
    while (true) {
        bool progress = false;

        for (int i = 0; i < n; i++) {
            if (!finish[i]) {
                bool canGrant = true;

                for (int j = 0; j < m; j++) {
                    if (request[i][j] > work[j]) {
                        canGrant = false;
                        break;
                    }
                }

                if (canGrant) {
```

```
                for (int j = 0; j < m; j++)
                    work[j] += alloc[i][j];
                finish[i] = true;
                progress = true;
            }
        }
    }

    if (!progress)
        break;
  }
  printf("\nDeadlock Detection Result:\n");
  bool deadlock = false;

  for (int i = 0; i < n; i++) {
    if (!finish[i]) {
        printf("Process P%d is DEADLOCKED\n", i);
        deadlock = true;
    } else {
        printf("Process P%d is NOT deadlocked\n", i);
    }
  }
  if (!deadlock)
    printf("\nNo deadlock detected in the system.\n");

  return 0;
}
```

RESULT:

```
Enter number of processes and number of resources:
5 3
Enter Allocation Matrix (5 x 3):
0 1 0
2 0 0
3 0 3
2 1 1
0 0 2
Enter Request Matrix (5 x 3):
0 0 0
2 0 2
0 0 1
1 0 0
0 0 2
Enter Available Resources (3 values):
0 0 0

Deadlock Detection Result:
Process P0 is NOT deadlocked
Process P1 is DEADLOCKED
Process P2 is DEADLOCKED
Process P3 is DEADLOCKED
Process P4 is DEADLOCKED

Process returned 0 (0x0)   execution time : 44.041 s
Press any key to continue.
```





```
int alloc[n][m], request[n][m], avail[m];
printf("Enter Allocation Matrix (%d x %d)
:\n", n, m);
for(int i=0; i<n; i++)
    for(int j=0; j<m; j++)
        scanf("%d", &alloc[i][j]);
printf("Enter Request Matrix (%d x %d):\n",
n,m);
for(int i=0; i<n; i++)
    for(int j=0; j<m; j++)
        scanf("%d", &request[i][j]);
printf("Enter Available Resources (%d values)
:\n", m);
for(int i=0; i<m; i++)
    scanf("%d", &avail[i]);
int work[m];
for(int i=0; i<m; i++){
    work[i]=avail[i];
}
bool finish[n];
for(int i=0; i<n; i++){
    bool hasAllocation=false;
    for(int j=0; j<m; j++){
        if(alloc[i][j]!=0){
            hasAllocation=true;
            break;
        }
    }
    finish[i]=hasAllocation?false:true;
}
while(true){
    bool progress=false;
```

KRUPA

```
for(int i=0; i<n; i++){
    if(!finish[i])
        bool canGrant=true;
        for(int j=0; j<m; j++){
            if(request[i][j]>work[j]){
                canGrant=false;
                break;
            }
        }
        if(canGrant){
            for(int j=0; j<m; j++)
                work[j]+=alloc[i][j];
            finish[i]=true;
            progress=true;
        }
    }
}
if(!progress)
    break;
}
printf("\nDeadlock Detection Result:\n");
bool deadlock=false;
for(int i=0; i<n; i++){
    if(!finish[i]){
        printf("Process P%d is deadlocked
        \n",i);
        deadlock=true;
    }else{
        printf("Process P%d is NOT Dead-
        -locked\n",i);
    }
}
```

```
if(!deadlock)
    printf("\nNo deadlock detected
    in the system\n");
return 0;
}
```

Output:

```
Enter no of processes and resources:
5 3
Enter Allocation matrix (5 x 3):
0 1 0
2 0 0
3 0 3
2 1 1
0 0 2
Enter Request Matrix (5x3):
0 0 0
2 0 2
0 0 1
1 0 0
0 0 2
Enter Available Resources (3 values):
0 0 0

Deadlock Detection Result:
Process P0 is NOT Deadlocked
Process P1 is Deadlocked
Process P2 is Deadlocked
Process P3 is Deadlocked
Process P4 is Deadlocked.
```

Program 9:

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

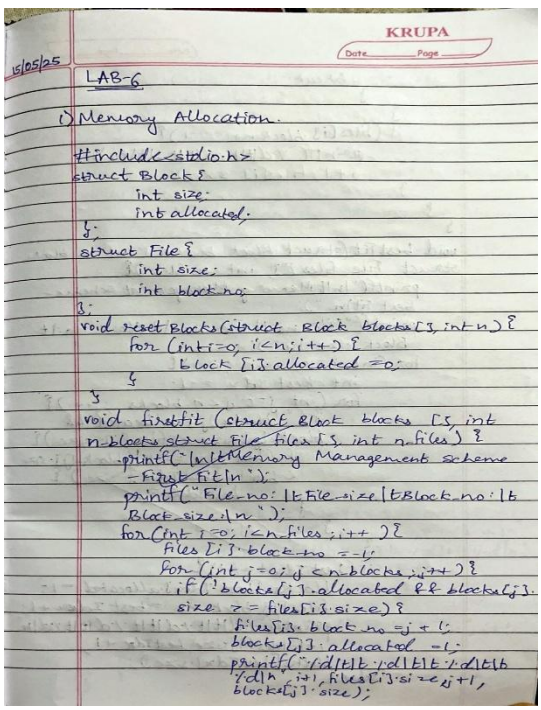
```
#include <stdio.h>
struct Block {
   int size;
   int allocated;
};

struct File {
   int size;
   int block_no;
};

void resetBlocks(struct Block blocks[], 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\tMemory Management Scheme – First Fit\n");
   printf("File_no:\tFile_size\tBlock_no:\tBlock_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[j].size >= files[i].size) {
            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 File files[], int n_files) {
   printf("\n\tMemory Management Scheme – Best Fit\n");
   printf("File_no:\tFile_size\tBlock_no:\tBlock_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\tMemory Management Scheme – Worst Fit\n");
    printf("File_no:\tFile_size\tBlock_no:\tBlock_size:\n");

    for (int i = 0; i < n_files; 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_\t\t_\n", i + 1, files[i].size);
        }
    }
}

int main() {
    int n_blocks, n_files, choice;

    printf("Memory Management Scheme\n");

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

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

```
    struct Block blocks[n_blocks];
    struct File files[n_files];

    printf("\nEnter the size of the blocks:\n");
    for (int i = 0; i < n_blocks; i++) {
        printf("Block %d: ", i + 1);
        scanf("%d", &blocks[i].size);
        blocks[i].allocated = 0;
    }

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

    do {
        printf("\n1. First Fit\n2. Best Fit\n3. Worst Fit\n4. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);

        resetBlocks(blocks, n_blocks); // Reset block allocation before each strategy

        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 4:
                printf("\nExiting...\n");
                break;
            default:
                printf("Invalid choice.\n");
        }
    } while (choice != 4);

    return 0;
}
```

RESULT:

```
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

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:
```



KRUPA

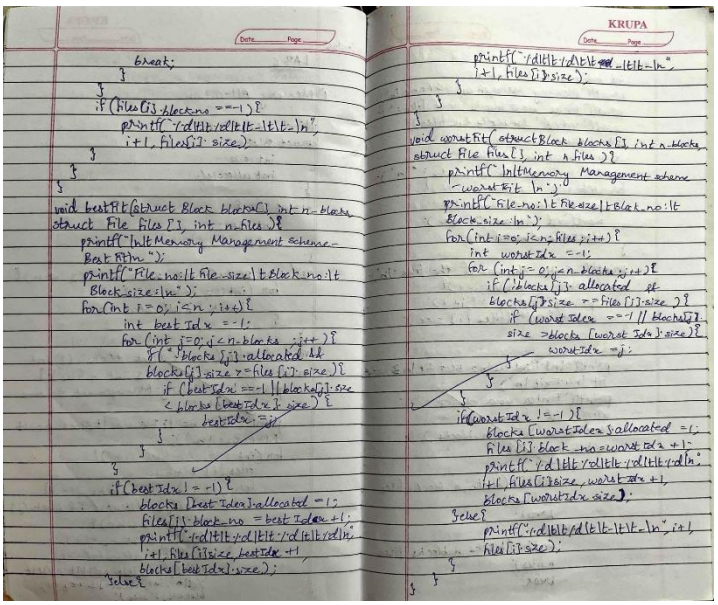
Date Page

15/05/25

LAB-6

1) Memory Allocation.

```
#include<stdio.h>
struct Block{
    int size;
    int allocated;
};
struct File{
    int size;
    int block_no;
};
void resetBlocks(struct Block blocks[], int n){
    for(int i=0; i<n; i++){
        block[i].allocated=0;
    }
}
void firstfit(struct Block blocks[], int
n_blocks, struct File files[], int n_files){
    printf("\n\tMemory Management Scheme
    -First fit\n");
    printf("File_no:\tFile_size\tBlock_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[j].
            size >= files[i].size){
                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[j].blockno == -1){
    printf("%d\t\t%d\t\t%d\t\t-\t\t-\n",
    i+1, files[i].size);
}
}
}
void bestFit(struct Block blocks[], int n_blocks,
struct File files[], int n_files){
    printf("\n\tMemory Management Scheme -
    Best Fit\n");
    printf("File_no:\tFile_size\tBlock_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{
```

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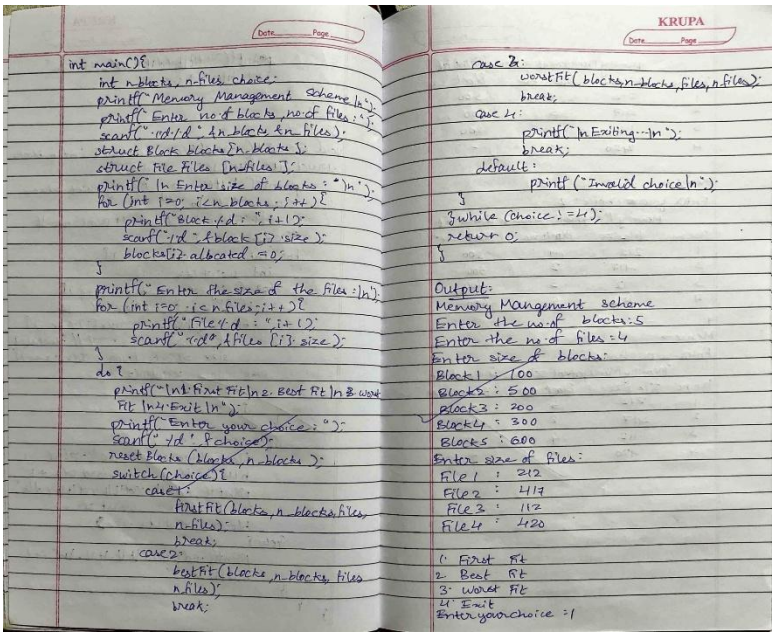
```
            printf("%d\t\t%d\t\t-\t\t-\n",
            i+1, files[i].size);
        }
    }
}
void worstFit(struct Block blocks[], int n_blocks,
struct File files[], int n_files){
    printf("\n\tMemory Management scheme
    - worst fit\n");
    printf("File_no:\tFile_size\tBlock_no:\t
    Block_size:\n");
    for(int i=0; i<n_files; 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-\t\t-\n", i+1,
            files[i].size);
        }
    }
}
```



```
int main(){
    int n_blocks, n_files, choice;
    printf("Memory Management Scheme\n");
    printf("Enter no of blocks, no of files:");
    scanf("%d%d", &n_blocks, &n_files);
    struct Block blocks[n_blocks];
    struct File files[n_files];
    printf("\n Enter size of blocks:\n");
    for(int i=0; i<n_blocks; i++){
        printf("Block %d: ", i+1);
        scanf("%d", &blocks[i].size);
        blocks[i].allocated = 0;
    }
    printf("Enter the size of the files:\n");
    for(int i=0; i<n_files; i++){
        printf("File %d: ", i+1);
        scanf("%d", &files[i].size);
    }
    do{
        printf("\n1. First Fit\n2. Best Fit\n3. Worst
        Fit\n4. Exit\n");
        printf("Enter your choice:");
        scanf("%d", &choice);
        resetBlocks(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;
```

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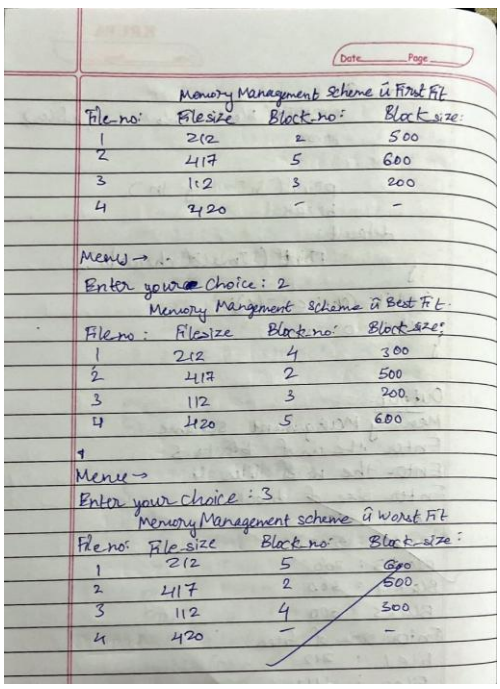
```
            case 3:
                worstFit(blocks, n_blocks, files, n_files);
                break;
            case 4:
                printf("\nExiting...\n");
                break;
            default:
                printf("Invalid choice\n");
        }
    }while(choice != 4);
    return 0;
}
```

Output:

```
Memory Mangement scheme
Enter the no of blocks: 5
Enter the no of files: 4
Enter size of blocks:
Block 1 : 100
Block 2 : 500
Block 3 : 200
Block 4 : 300
Block 5 : 600
Enter size of files:
File 1 : 212
File 2 : 417
File 3 : 112
File 4 : 426

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



Memory Management Scheme – First Fit

File_no:	Filesize	Block_no:	Block_size:
1	212	2	500
2	417	5	600
3	112	3	200
4	426	-	-

Menu →

Enter your choice: 2

Memory Mangement scheme – Best Fit

File_no:	Filesize	Block_no:	Block_size:
1	212	4	300
2	417	2	500
3	112	3	200
4	426	5	600

1

Menu →

Enter your choice : 3

Memory Management scheme – Worst Fit

File_no:	File_size	Block_no:	Block_size:
1	212	5	600
2	417	2	500
3	112	4	300
4	426	-	-

Program 10

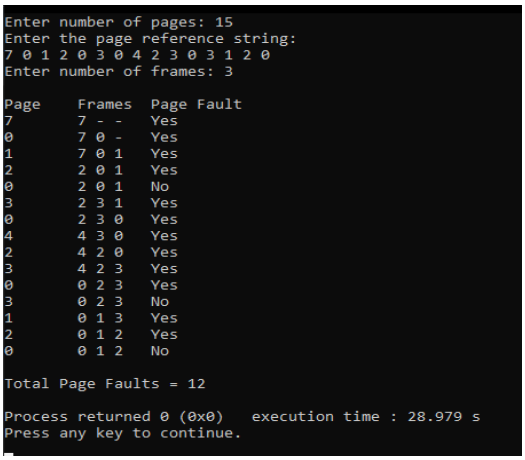
Write a C program to simulate page replacement algorithms
a) FIFO
b) LRU
c) Optimal

=>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\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;
}
```

RESULT:

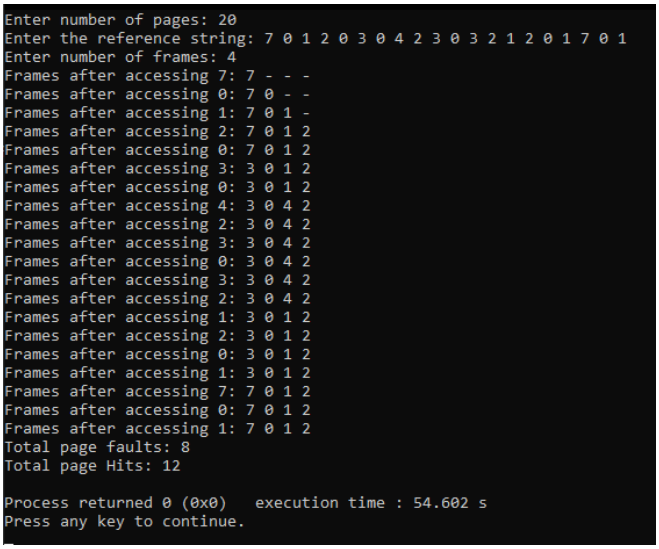


=>LRU:

```
#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];
    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;
}
```

RESULT:



=>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;
}
```

RESULT:

```
Enter number of pages: 20
Enter the reference string: 7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
Enter number of frames: 4
7: 7 _ _ _
0: 7 0 _ _
1: 7 0 1 _
2: 7 0 1 2
0: 7 0 1 2
3: 3 0 1 2
0: 3 0 1 2
4: 3 0 4 2
2: 3 0 4 2
3: 3 0 4 2
0: 3 0 4 2
3: 3 0 4 2
2: 3 0 4 2
1: 1 0 4 2
2: 1 0 4 2
0: 1 0 4 2
1: 1 0 4 2
7: 1 0 7 2
0: 1 0 7 2
1: 1 0 7 2
Total page faults: 8
Total page Hits: 12

Process returned 0 (0x0)   execution time : 29.373 s
Press any key to continue.
```

KRUPA

Date Page

LAB-7

1) Page Replacement - FIFO.

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

Output:

```
Enter the no of pages : 15
Enter the page reference string:
7 0 1 2 0 3 0 4 2 3 0 3 1 2 0
Enter no 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

2) 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 no 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 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("Frame 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 no of pages : 20
Enter the reference string:
7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
Enter no of frames : 4
Frames after accessing 7 : 7 - - -
Frames after accepting 0 : 7 0 - -
Frames after accepting 1 : 7 0 1 -
Frames after accepting 2 : 7 0 1 2
Frames after accepting 0 : 7 0 1 2
Frames after accepting 3 : 3 0 1 2
Frames after accepting 0 : 3 0 1 2
Frames after accepting 4 : 3 0 4 2
Frames after accepting 2 : 3 0 4 2
Frames after accepting 3 : 3 0 4 2
Frames after accepting 0 : 3 0 4 2
Frames after accepting 3 : 3 0 4 2
Frames after accepting 2 : 3 0 4 2
```

3) Optimal.

```
#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 no of frames: ");
    scanf("%d", &frames);
    int frame_arr[frames];
    for(j=0; j<frames; j++)
        frame_arr[j] = -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 no of pages : 20
Enter the reference strings:
7 0 1 2 0 3 0 4 2 3 0 3 2 1 2 0 1 7 0 1
Enter no of frames : 4
7: 7 - - -
0: 7 0 - -
1: 7 0 1 -
2: 7 0 1 2
0: 7 0 1 2
3: 3 0 1 2
0: 3 0 1 2
4: 3 0 4 2
2: 3 0 4 2
3: 3 0 4 2
0: 3 0 4 2
3: 3 0 4 2
2: 3 0 4 2
```

1	1 0 4 2
2	1 0 4 2
0	1 0 4 2
1	1 0 4 2
7	1 0 7 2
0	1 0 7 2
1	1 0 7 2

Total page faults: 9
Total page hits: 11