VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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LAB REPORT

on

OPERATING SYSTEMS

Submitted by

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in partial fulfillment for the award of the degree of

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CERTIFICATE

This is to certify that the Lab work entitled "OPERATING SYSTEMS – 23CS4PCOPS" carried out by Venugopal M(1WA23CS038), 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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10.	Write a C program to simulate page replacement algorithms a) FIFO b) LRU c) Optimal	95-105

Course Outcomes

C01	Apply the different concepts and functionalities of Operating System
C02	Analyse 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.

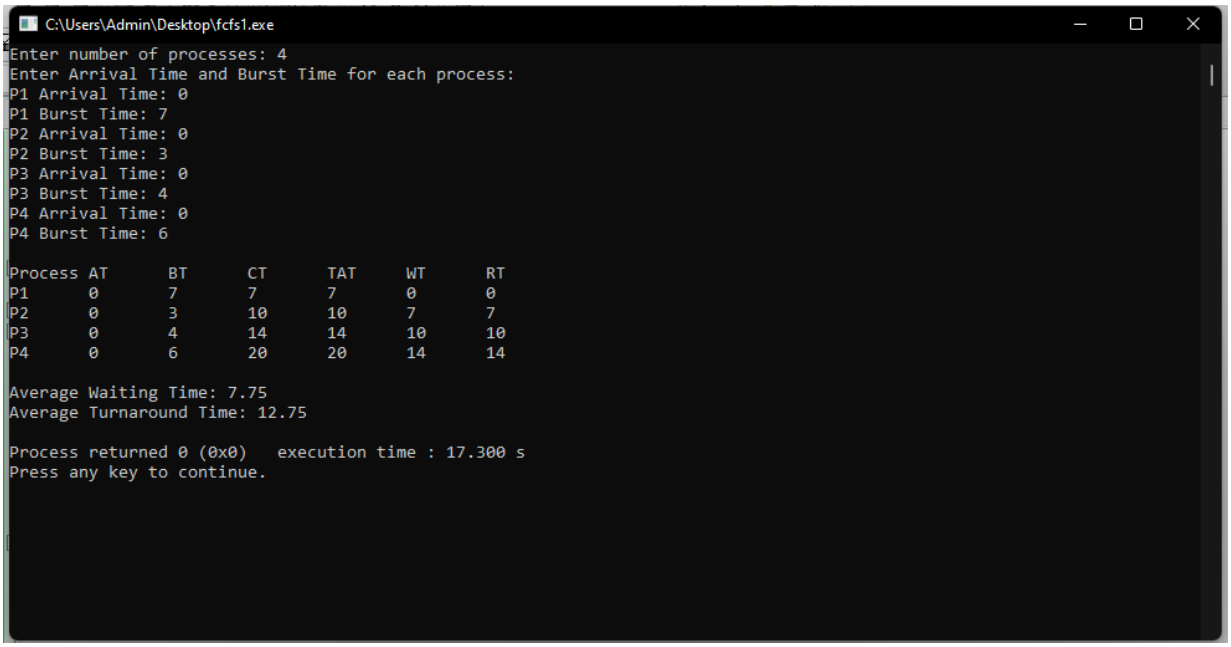
→FCFS

→ SJF (pre-emptive & Non-preemptive)

→FCFS

```
#include <stdio.h>

struct Process {
    int at;
    int bt;
    int ct;
    int tat;
    int wt;
    int rt;
};

void calculateFCFS(struct Process proc[], int n) {
    int time = 0;
    for (int i = 0; i < n; i++) {
        if (time < proc[i].at) {
            time = proc[i].at;
        }
        proc[i].ct = time + proc[i].bt;
        proc[i].tat = proc[i].ct - proc[i].at;
        proc[i].wt = proc[i].tat - proc[i].bt;
        proc[i].rt = time - proc[i].at;
        time = proc[i].ct;
    }
}
int main() {
```

```
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    struct Process proc[n];
    printf("Enter Arrival Time and Burst Time for each process:\n");
    for (int i = 0; i < n; i++) {
        printf("P%d Arrival Time: ", i + 1);
        scanf("%d", &proc[i].at);
        printf("P%d Burst Time: ", i + 1);
        scanf("%d", &proc[i].bt);
    }
    calculateFCFS(proc, n);
    printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++) {
        printf("P%d\t%d\t%d\t%d\t%d\t%d\t%d\n", i + 1, proc[i].at, proc[i].bt, proc[i].ct, proc[i].tat,
proc[i].wt, proc[i].rt);
    }
    float totalWT = 0, totalTAT = 0;
    for (int i = 0; i < n; i++) {
        totalWT += proc[i].wt;
        totalTAT += proc[i].tat;
    }
    printf("\nAverage Waiting Time: %.2f", totalWT / n);
    printf("\nAverage Turnaround Time: %.2f\n", totalTAT / n);
    return 0;
}
```


C:\Users\Admin\Desktop\fcfs1.exe
Enter number of processes: 4
Enter Arrival Time and Burst Time for each process:
P1 Arrival Time: 0
P1 Burst Time: 7
P2 Arrival Time: 0
P2 Burst Time: 3
P3 Arrival Time: 0
P3 Burst Time: 4
P4 Arrival Time: 0
P4 Burst Time: 6
Process AT BT CT TAT WT RT
P1 0 7 7 7 0 0
P2 0 3 10 10 7 7
P3 0 4 14 14 10 10
P4 0 6 20 20 14 14
Average Waiting Time: 7.75
Average Turnaround Time: 12.75
Process returned 0 (0x0) execution time : 17.300 s
Press any key to continue.

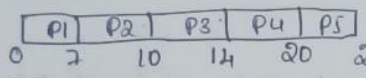
① write a c program to stimulate the following CPU scheduling algorithm to find average turnaround time and waiting time

i) FCFS
ii) SJF (non preemptive & preemptive)

Q

Process	AT	BT	CT	TAT	WT	RT
1	0	7	7	7	0	0
2	0	3	10	10	7	7
3	0	4	14	14	10	10
4	0	6	20	20	14	14
5	0	5	25	25	20	20

Gantt Chart



Program

```
#include<stdio.h>
struct Process {
    int at;
    int bt;
    int ct;
    int tat;
    int wt;
    int rt;
};
void calculateFCFS (struct process Proc[], int n) {
    int time = 0;
    for (int i=0; i<n; i++){
        if (time < proc[i].at){
            time = proc[i].at;
        }
    proc[i].ct = time + proc[i].bt;
    proc[i].tat = proc[i].ct - proc[i].at;
```

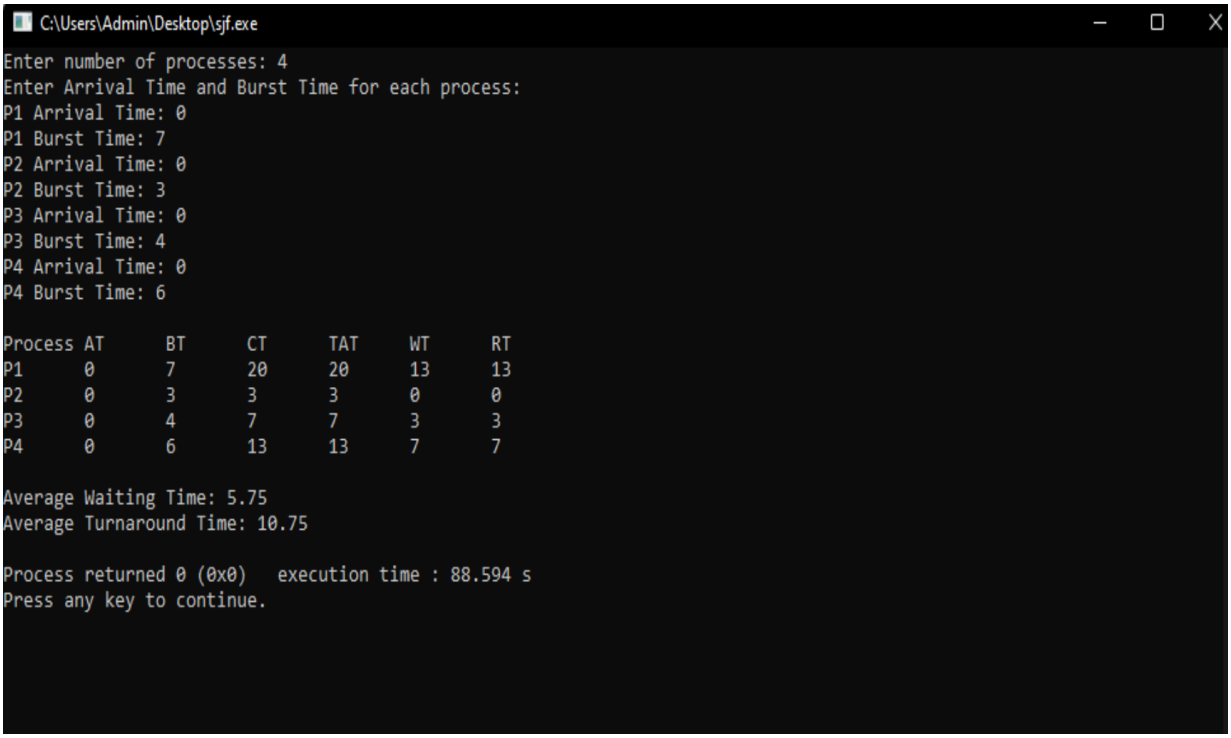
```
        proc[i].wt = proc[i].tat - proc[i].bt;
        proc[i].rt = time - proc[i].at;
        time = proc[i].ct;
    }
}

int main(){
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    struct Process Proc[n];
    printf("Enter Arrival time and Burst time \n");
    for(int i=0; i<n; i++){
        printf("P%d Arrival time: ", i+1);
        scanf("%d", &proc[i].at);
        printf("P%d Burst time: ", i+1);
        scanf("%d", &proc[i].bt);
    }
    Calculate FCFS(Proc, n);
    printf("\n Process \t AT \t BT \t CT \t WT \t RT \n");
    for(int i=0; i<n; i++){
        printf("P%d \t %d \t %d \t %d \t %d \t %d
          \t %d \n", i+1, proc[i].at, proc[i].bt,
          proc[i].ct, proc[i].tat, proc[i].wt, proc[i].rt);
    }
    float totalWT=0, totalTAT=0;
    for(int i=0; i<n; i++){
        totalWT += proc[i].wt;
        totalTAT += proc[i].tat;
    }
    printf("\n Average Waiting Time: %.2f", totalWT/n);
    printf("\n Average Turnaround time: %.2f", totalTAT/n)
    return 0;
}
```

→SJF(Non Preemptive)

```
#include <stdio.h>
#include <limits.h>
struct Process {
    int at;
    int bt;
    int ct;
    int tat;
    int wt;
    int rt;
    int pid;
};
void calculateSJF(struct Process proc[], int n) {
    int time = 0;
    int completed = 0;
    int min_index;
    int is_completed[n];
    for (int i = 0; i < n; i++) {
        is_completed[i] = 0;
    }
    while (completed < n) {
        min_index = -1;
        int min_bt = INT_MAX;
        for (int i = 0; i < n; i++) {
            if (proc[i].at <= time && !is_completed[i] && proc[i].bt < min_bt) {
                min_bt = proc[i].bt;
                min_index = i;
            }
        }
        if (min_index == -1) {
```

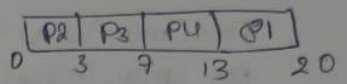
```
            time++;
        } else {
            proc[min_index].ct = time + proc[min_index].bt;
            proc[min_index].tat = proc[min_index].ct - proc[min_index].at;
            proc[min_index].wt = proc[min_index].tat - proc[min_index].bt;
            proc[min_index].rt = time - proc[min_index].at;
            time = proc[min_index].ct;
            is_completed[min_index] = 1;
            completed++;
        }
    }
}
int main() {
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    struct Process proc[n];
    printf("Enter Arrival Time and Burst Time for each process:\n");
    for (int i = 0; i < n; i++) {
        proc[i].pid = i + 1;
        printf("P%d Arrival Time: ", i + 1);
        scanf("%d", &proc[i].at);
        printf("P%d Burst Time: ", i + 1);
        scanf("%d", &proc[i].bt);
    }
    calculateSJF(proc, n);
    printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++) {
        printf("P%d\t%d\t%d\t%d\t%d\t%d\t%d\n", proc[i].pid, proc[i].at, proc[i].bt, proc[i].ct, proc[i].tat,
proc[i].wt, proc[i].rt);
```

```
    }
    return 0;
}
```


C:\Users\Admin\Desktop\sjf.exe
Enter number of processes: 4
Enter Arrival Time and Burst Time for each process:
P1 Arrival Time: 0
P1 Burst Time: 7
P2 Arrival Time: 0
P2 Burst Time: 3
P3 Arrival Time: 0
P3 Burst Time: 4
P4 Arrival Time: 0
P4 Burst Time: 6
Process AT BT CT TAT WT RT
P1 0 7 20 20 13 13
P2 0 3 3 3 0 0
P3 0 4 7 7 3 3
P4 0 6 13 13 7 7
Average Waiting Time: 5.75
Average Turnaround Time: 10.75
Process returned 0 (0x0) execution time : 88.594 s
Press any key to continue.

② SJF (Non preemptive)

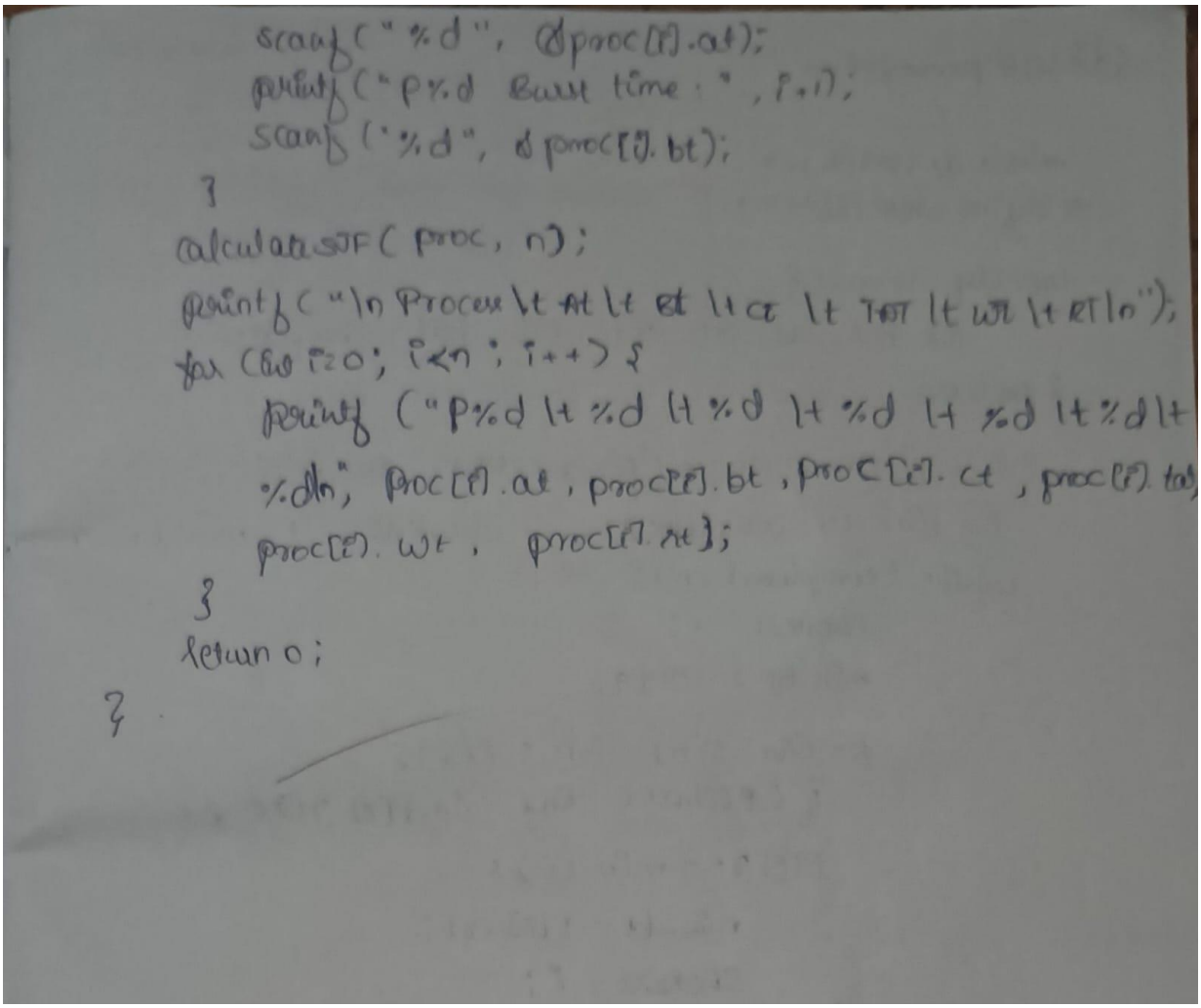
Process	AT	BT	CT	TAT	WT	RT
P1	0	7	20	20	13	13
P0	0	3	3	3	0	0
P2	0	4	7	7	3	3
P4	0	6	13	13	7	7



Average WT : 5.75
Average TAT : 10.75

```
#include <stdio.h>
#include <limits.h>
Struct Process{
    int at;
    int bt;
    int ct;
    int tat;
    int wt;
    int rt;
    int pid;
};
void CalculateSJF (Struct Process Proc[], int n){
    int time =0;
    int completed = 0;
    int min_index;
    int is_completed[n];
    for(int i=0; i<n; i++){
        is_completed[i] = 0;
    }
    while (completed <n){
        min_index = -1;
        int min_bt = INT_MAX;
```

```
for (int i=0; i<n; i++){
    if(proc[i].at <= time && !is_completed[i] &&
       proc[i].bt < min_bt) {
          min_bt = proc[i].bt;
          min_index = i;
       }
    }
    if (min_index == -1) {
        time++;
    } else{
      proc[min_index].ct = time + proc[min_index].at;
      proc[min_index].tat = proc[min_index].ct -
                  proc[min_index].at;
      proc[min_index].wt = proc[min_index].tat -
                  proc[min_index].bt;
      proc[min_index].rt = time - proc[min_index].at;
      time = proc[min_index].ct;
      is_completed[min_index] = 1;
      completed++;
    }
  }
}

int main() {
    int n;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    struct Process Proc[n];
    printf("Enter the arrival time and Burst time for
     each processes : \n");
    for (int i=0; i<n; i++){
        proc[i].pid = i+1;
        printf("P%d Arrival time: ", i+1);
```



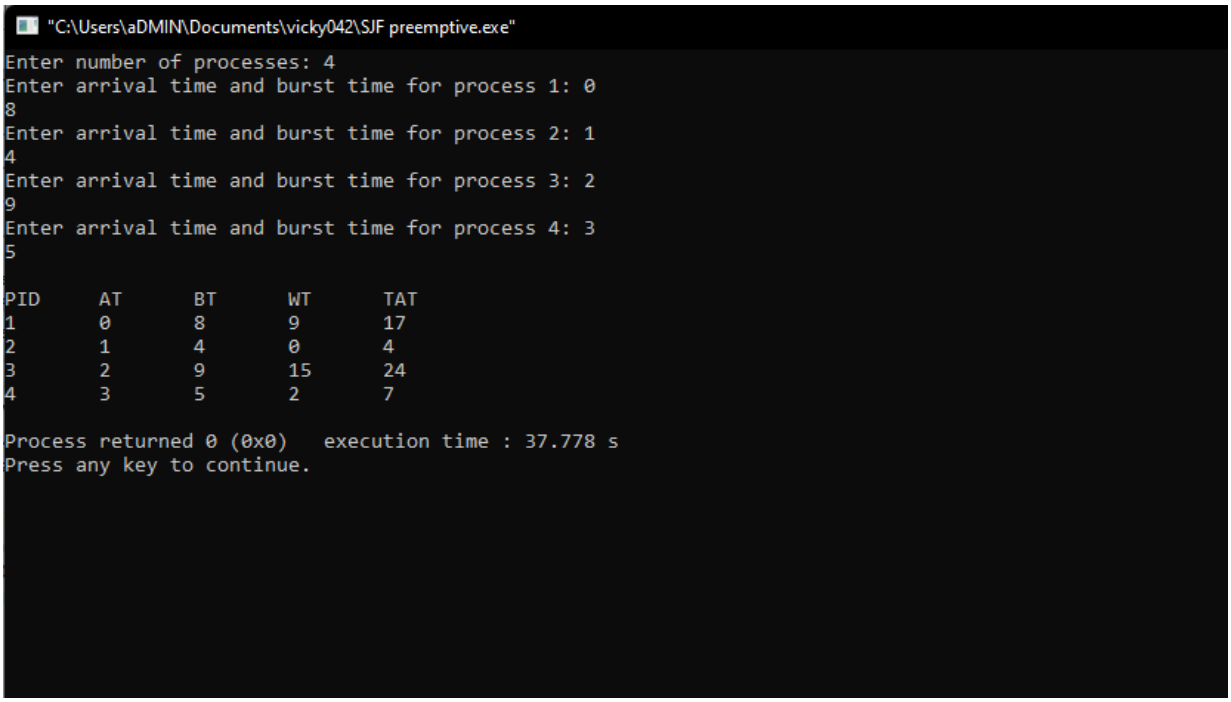
```
        scanf("%d", &proc[i].at);
        printf("P%d Burst time: ", i+1);
        scanf("%d", &proc[i].bt);
    }
    calculateSJF(proc, n);
    printf("\n Process\t AT\t BT\t CT\t TAT\t WT\t RT\n");
    for (int i=0; i<n; i++) {
        printf("P%d\t %d\t %d\t %d\t %d\t %d\t %d\t
        %d\n", proc[i].at, proc[i].bt, proc[i].ct, proc[i].tat,
        proc[i].wt, proc[i].rt);
    }
    return 0;
}
```

→SJF(Pre-emptive)

```
#include <stdio.h>

#define MAX 10

typedef struct {
    int pid, at, bt, rt, wt, tat, completed;
} Process;
```

```
void sjf_preemptive(Process p[], int n) {
    int time = 0, completed = 0, shortest = -1, min_bt = 9999;

    while (completed < n) {
        shortest = -1;
        min_bt = 9999;

        for (int i = 0; i < n; i++) {
            if (p[i].at <= time && p[i].rt > 0 && p[i].rt < min_bt) {
                min_bt = p[i].rt;
                shortest = i;
            }
        }

        if (shortest == -1) {
            time++;
            continue;
        }

        p[shortest].rt--;
        time++;

        if (p[shortest].rt == 0) {
            p[shortest].completed = 1;
            completed++;
            p[shortest].tat = time - p[shortest].at;
            p[shortest].wt = p[shortest].tat - p[shortest].bt;
        }
    }
}
```

```
int main() {
    Process p[MAX];
    int n;

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

    for (int i = 0; i < n; i++) {
        p[i].pid = i + 1;
        printf("Enter arrival time and burst time for process %d: ", p[i].pid);
        scanf("%d %d", &p[i].at, &p[i].bt);
        p[i].rt = p[i].bt;
        p[i].completed = 0;
    }

    sjf_preemptive(p, n);

    printf("\nPID\tAT\tBT\tWT\tTAT\n");
    for (int i = 0; i < n; i++)
        printf("%d\t%d\t%d\t%d\t%d\n", p[i].pid, p[i].at, p[i].bt, p[i].wt, p[i].tat);

    return 0;
}
```


"C:\Users\aDMIN\Documents\vicky042\SJF preemptive.exe"
Enter number of processes: 4
Enter arrival time and burst time for process 1: 0
8
Enter arrival time and burst time for process 2: 1
4
Enter arrival time and burst time for process 3: 2
9
Enter arrival time and burst time for process 4: 3
5
PID AT BT WT TAT
1 0 8 9 17
2 1 4 0 4
3 2 9 15 24
4 3 5 2 7
Process returned 0 (0x0) execution time : 37.778 s
Press any key to continue.

(3) SJF preemptive

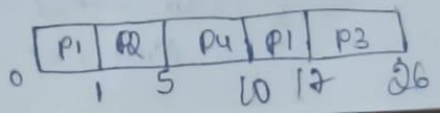
```
#include<stdio.h>
#define MAX 100
typedef struct{
    int PID, at, bt, rt, wt, tat, completed;
}process;
void SJF_Preemptive(process P[], int n){
    int time=0, completed=0, shortest=-1, min_bt=9999;
    while(completed<n){
        shortest=-1;
        min_bt=9999;
        for(int i=0; i<n; i++){
            if(P[i].at<=time && P[i].rt>0 &&
            P[i].rt<min_bt){
                min_bt=P[i].rt;
                shortest=i;
            }
        }
        if(shortest==-1){
            time++;
            continue;
        }
        P[shortest].rt--;
        time++;
        if(P[shortest].rt==0){
            P[shortest].completed=1;
            completed++;
            P[shortest].tat=time-P[shortest].at;
            p[shortest].wt=P[shortest].tat-p[shortest].bt
        }
    }
}
```

```
int main(){
    process P[nmax];
    int n;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    for(int i=0; i<n; i++){
        P[i].pid = i+1;
        printf("Enter arrival time and burst time for
        process %d:", P[i].pid);
        scanf("%d %d", &P[i].at, &P[i].bt);
        P[i].rt = P[i].bt;
        P[i].completed = 0;
    }
    Sjf_preemptive(P, n);
    printf("\nPid\tAT\tBT\tWT\tTAT\n");
    for(int i=0; i<n; i++)
        printf("%d\t%d\t%d\t%d\t%d\n",
    P[i].pid, P[i].at, P[i].bt, P[i].wt, P[i].tat);
    return 0;
}
```

Output

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

PID	AT	BT	WT	TAT
1	0	8	9	17
2	1	4	0	4
3	2	9	15	24
4	3	5	2	7



Program 2:

Write a C program to simulate the following CPU scheduling algorithm to find turnaround time and waiting time.
→ Priority (pre-emptive & Non-pre-emptive)
→Round Robin (Experiment with different quantum sizes for RR algorithm)

→Priority(Non-pre-emptive)

```
#include <stdio.h>


struct Process {
    int pid, at, bt, pr, ct, wt, tat, rt;
    int isCompleted; // Flag to check if process is completed
};


void sortByArrival(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 findPriorityScheduling(struct Process p[], int n) {
    sortByArrival(p, n);
    int time = 0, completed = 0;
    float totalWT = 0, totalTAT = 0;
```

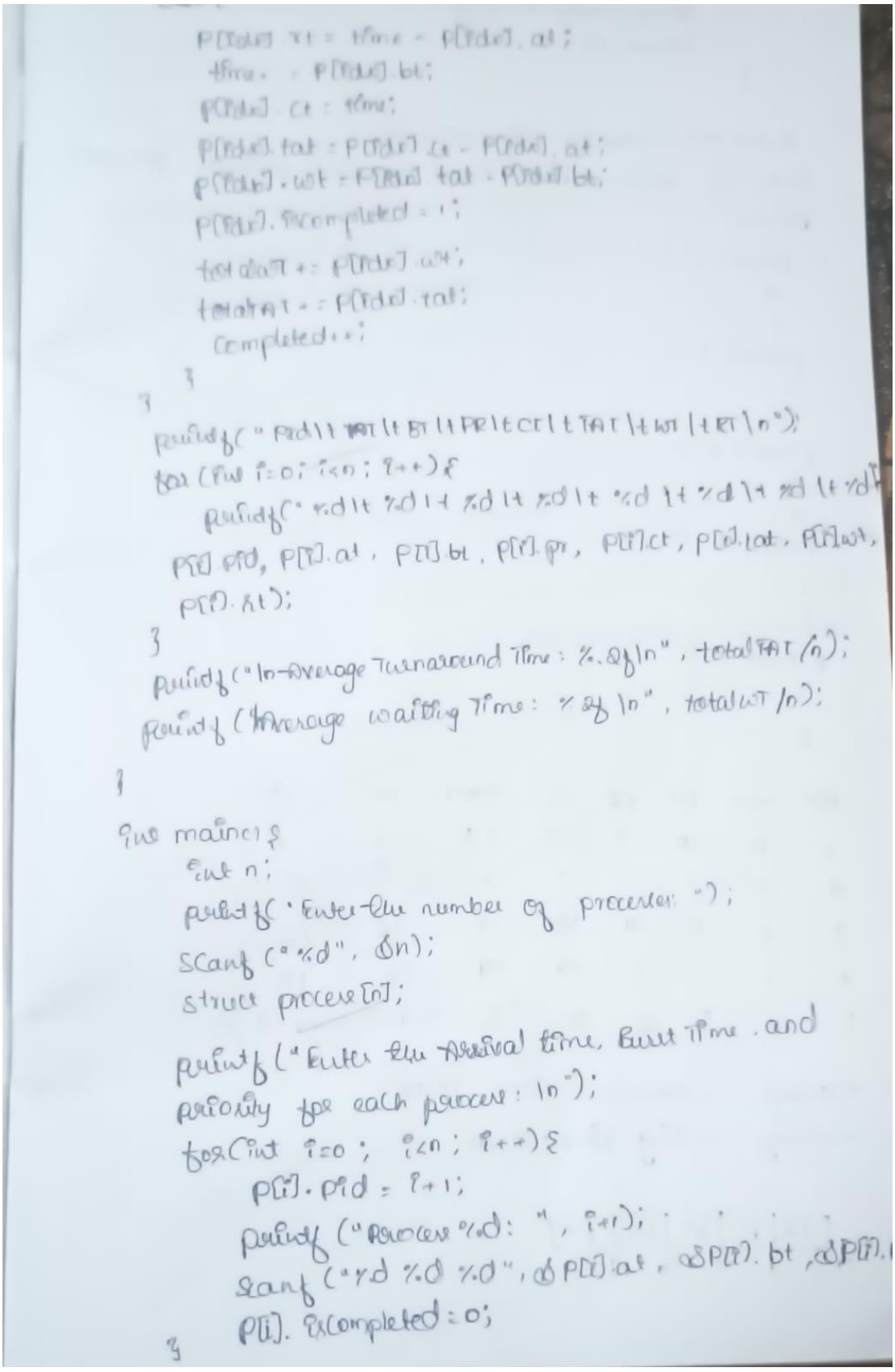
```
while (completed < n) {
    int idx = -1, highestPriority = 9999;

    for (int i = 0; i < n; i++) {
        if (p[i].at <= time && p[i].isCompleted == 0) {
            if (p[i].pr < highestPriority) {
                highestPriority = p[i].pr;
                idx = i;
            }
        }
    }

    if (idx == -1) {
        time++; // CPU idle
    } else {
        p[idx].rt = time - p[idx].at;
        time += p[idx].bt;
        p[idx].ct = time;
        p[idx].tat = p[idx].ct - p[idx].at;
        p[idx].wt = p[idx].tat - p[idx].bt;
        p[idx].isCompleted = 1;

        totalWT += p[idx].wt;
        totalTAT += p[idx].tat;
        completed++;
    }
}

printf("PID\tAT\tBT\tPR\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\t%d\n",
               p[i].pid, p[i].at, p[i].bt, p[i].pr, p[i].ct, p[i].tat, p[i].wt, p[i].rt);
    }

    printf("\nAverage Turnaround Time: %.2f\n", totalTAT / n);
    printf("Average Waiting Time: %.2f\n", totalWT / n);
}

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

    printf("Enter Arrival Time, Burst Time, and Priority for each process:\n");
    for (int i = 0; i < n; i++) {
        p[i].pid = i + 1;
        printf("Process %d: ", i + 1);
        scanf("%d %d %d", &p[i].at, &p[i].bt, &p[i].pr);
        p[i].isCompleted = 0;
    }

    findPriorityScheduling(p, n);
    return 0;
}
```

```
Enter the number of processes: 5
Enter Arrival Time, Burst Time, and Priority for each process:
Process 1: 0
10
3
Process 2: 0
1
1
Process 3: 0
2
4
Process 4: 0
1
5
Process 5: 0
5
2
PID AT  BT  PR  CT  TAT WT  RT
1   0   10  3   16  16  6   6
2   0   1   1   1   1   0   0
3   0   2   4   18  18  16  16
4   0   1   5   19  19  18  18
5   0   5   2   6   6   1   1

Average Turnaround Time: 12.00
Average Waiting Time: 8.20
```

Priority non-preemptive

```
#include<stdio.h>
struct process{
    int Pid, at, bt, pr, ct, wt, tat, rt;
    int iscompleted;
};
void sortByArrival(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 findpriorityscheduling(struct process P[], int n){
    sortByArrival(P,n);
    int time=0, completed=0;
    float totalWT=0; totalTAT=0;
    while(completed<n){
        int idx=-1; highestpriority=9999;
        for(int i=0; i<n; i++){
            if(P[i].at<=time && P[i].iscompleted==0){
                if(P[i].Pr<highestpriority){
                    highestpriority=P[i].Pr;
                    idx=i;
                }
            }
        }
        if(idx==-1){
            time++;
        }
```



```
        p[idx].rt = time - p[idx].at;
        time += p[idx].bt;
        p[idx].ct = time;
        p[idx].tat = p[idx].ct - p[idx].at;
        p[idx].wt = p[idx].tat - p[idx].bt;
        p[idx].iscompleted = 1;
        totalWT += p[idx].wt;
        totalTAT += p[idx].tat;
        completed++;
      }
    }
    printf("Pid\t AT\t BT\t PRI\t CT\t TAT\t WT\t RT\n");
    for(int i=0; i<n; i++){
      printf("%d\t %d\t %d\t %d\t %d\t %d\t %d\t %d\n",
      p[i].pid, p[i].at, p[i].bt, p[i].pr, p[i].ct, p[i].tat, p[i].wt,
      p[i].rt);
    }
    printf("\n Average Turnaround Time: %.2f\n", totalTAT/n);
    printf("Average waiting Time: %.2f\n", totalWT/n);
}

int main(){
    int n;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    struct process p[n];
    printf("Enter the Arrival time, Burst Time and
    priority for each process: \n");
    for(int i=0; i<n; i++){
        p[i].pid = i+1;
        printf("Process %d: ", i+1);
        scanf("%d %d %d", &p[i].at, &p[i].bt, &p[i].
        p[i].iscompleted = 0;
    }
```

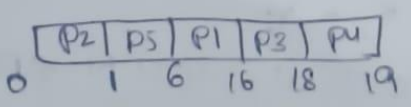
```
    findpriorityscheduling(P, n)
    return 0;
}
```

Enter the number of process : 5
Enter the Arrival Time, Burst Time and priority for each process:

process 1: 0
10
3
process 2: 0
1
1
process 3: 0
2
4
process 4: 0
1
5
process 5: 0
5
2

PID	AT	BT	PR	CT	TAT	WT	RT
1	0	10	3	16	16	6	6
2	0	1	1	1	1	0	0
3	0	2	4	18	18	16	16
4	0	1	5	19	19	18	18
5	0	5	2	6	6	1	1

Average Turnaround time: 12.00
Average waiting time: 8.20



→Priority(Pre-emptive)

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

struct Process {
    int pid, at, bt, pr, ct, wt, tat, rt, remaining;
};

void findPreemptivePriorityScheduling(struct Process p[], int n) {
    int completed = 0, time = 0, min_idx = -1;
    float totalWT = 0, totalTAT = 0;

    for (int i = 0; i < n; i++) {
        p[i].remaining = p[i].bt;
        p[i].rt = -1;
    }

    while (completed != n) {
        int min_priority = INT_MAX;
        min_idx = -1;

        for (int i = 0; i < n; i++) {
            if (p[i].at <= time && p[i].remaining > 0 && p[i].pr < min_priority) {
                min_priority = p[i].pr;
                min_idx = i;
            }
        }

        if (min_idx == -1) {
            time++;
```

```
            continue;
        }

        if (p[min_idx].rt == -1) {
            p[min_idx].rt = time - p[min_idx].at;
        }

        p[min_idx].remaining--;
        time++;

        if (p[min_idx].remaining == 0) {
            completed++;
            p[min_idx].ct = time;
            p[min_idx].tat = p[min_idx].ct - p[min_idx].at;
            p[min_idx].wt = p[min_idx].tat - p[min_idx].bt;
            totalWT += p[min_idx].wt;
            totalTAT += p[min_idx].tat;
        }
    }

    printf("PID\tAT\tBT\tPR\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\t%d\n",
               p[i].pid, p[i].at, p[i].bt, p[i].pr, p[i].ct, p[i].tat, p[i].wt, p[i].rt);
    }

    printf("\nAverage Turnaround Time: %.2f\n", totalTAT / n);
    printf("Average Waiting Time: %.2f\n", totalWT / n);
}
```

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

    printf("Enter Arrival Time, Burst Time, and Priority for each process:\n");
    for (int i = 0; i < n; i++) {
        p[i].pid = i + 1;
        printf("Process %d: ", i + 1);
        scanf("%d %d %d", &p[i].at, &p[i].bt, &p[i].pr);
    }

    findPreemptivePriorityScheduling(p, n);
    return 0;
}
```

Output Clear

```
Enter the number of processes: 7
Enter Arrival Time, Burst Time, and Priority for each process:
Process 1: 0
8
3
Process 2: 1
2
4
Process 3: 3
4
4
Process 4: 4
1
5
Process 5: 5
6
2
Process 6: 6
5
6
Process 7: 7
1
1
PID AT  BT  PR  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   0
6   6   5   6   27  21  16  16
7   7   1   1   8   1   0   0

Average Turnaround Time: 13.71
Average Waiting Time: 9.86
```

Priority - Preemptive

```
#include<stdio.h>
#include<limits.h>
struct Process {
    int pid, at, bt, pr, ct, wt, tat, rt, remaining;
};
void findpreemptivepriorityscheduling(struct process P[], int n){
    int completed=0, time=0, min_idx=-1;
    float totalwt=0, totalTAT=0;
    for(int i=0; i<n; i++){
        P[i].remaining = P[i].bt;
        P[i].rt = -1;
    }
    while(completed!=n){
        int min_priority = INT_MAX;
        min_idx = -1;
        for(int i=0; i<n; i++){
            if(P[i].at<=time && P[i].remaining>0 && P[i].pr<
            min_priority){
                min_priority = P[i].pr;
                min_idx = i;
            }
        }
        if(min_idx==-1){
            time++;
            continue;
        }
        if(P[min_idx].rt==-1){
            P[min_idx].rt = time - P[min_idx].at;
        }
        P[min_idx].remaining--;
        time++;
```

```
if (p[min_idx].remaining == 0) {
        completed++;
        p[min_idx].ct = time;
        p[min_idx].tat = p[min_idx].ct - p[min_idx].at;
        p[min_idx].wt = p[min_idx].tat - p[min_idx].bt;
        totalWT += p[min_idx].wt;
        totalTAT += p[min_idx].tat;
    }
}
printf("PID \t AT \t BT \t PR \t CT \t TAT \t WT \t RT \n");
for (int i=0; i<n; i++) {
    printf("%d \t %d \t %d \t %d \t %d \t %d \t %d \t %d \n",
    p[i].pid, p[i].at, p[i].bt, p[i].pr, p[i].ct,
    p[i].tat, p[i].wt, p[i].rt);
}
printf("\n Average Turnaround Time: %.2f \n", totalTAT/n);
printf("\n Average waiting Time: %.2f \n", totalWT/n);
}
```

output:

Enter the number of processes:-7

Enter AT, BT and priority for each process:

PID	AT	BT	PR	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	18	7	1	0
6	6	5	6	27	21	16	16
7	7	1	1	8	1	0	0

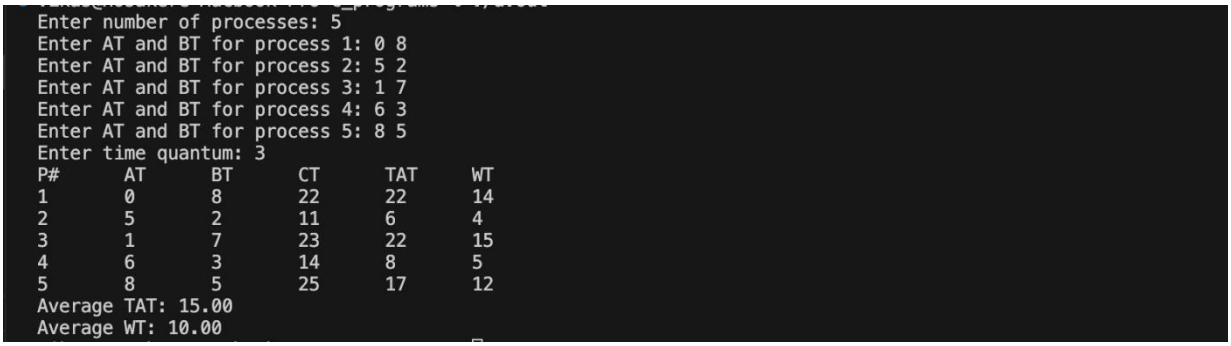
P1	P1	P1	P1	P1	P5	P5	P7	P5	P1	P2	P3	P4	P6
0	1	2	3	4	5	6	7	8	12	15	17	21	22	27

→Round Robin

```
#include <stdio.h>

#define MAX 100

void roundRobin(int n, int at[], int bt[], int quant) {
    int ct[n], tat[n], wt[n], rem_bt[n];
    int queue[MAX], front = 0, rear = 0;
    int time = 0, completed = 0, visited[n];

    for (int i = 0; i < n; i++) {
        rem_bt[i] = bt[i];
        visited[i] = 0;
    }

    queue[rear++] = 0;
    visited[0] = 1;

    while (completed < n) {
        int index = queue[front++];

        if (rem_bt[index] > quant) {
            time += quant;
            rem_bt[index] -= quant;
        } else {
            time += rem_bt[index];
            rem_bt[index] = 0;
            ct[index] = time;
            completed++;
        }
```

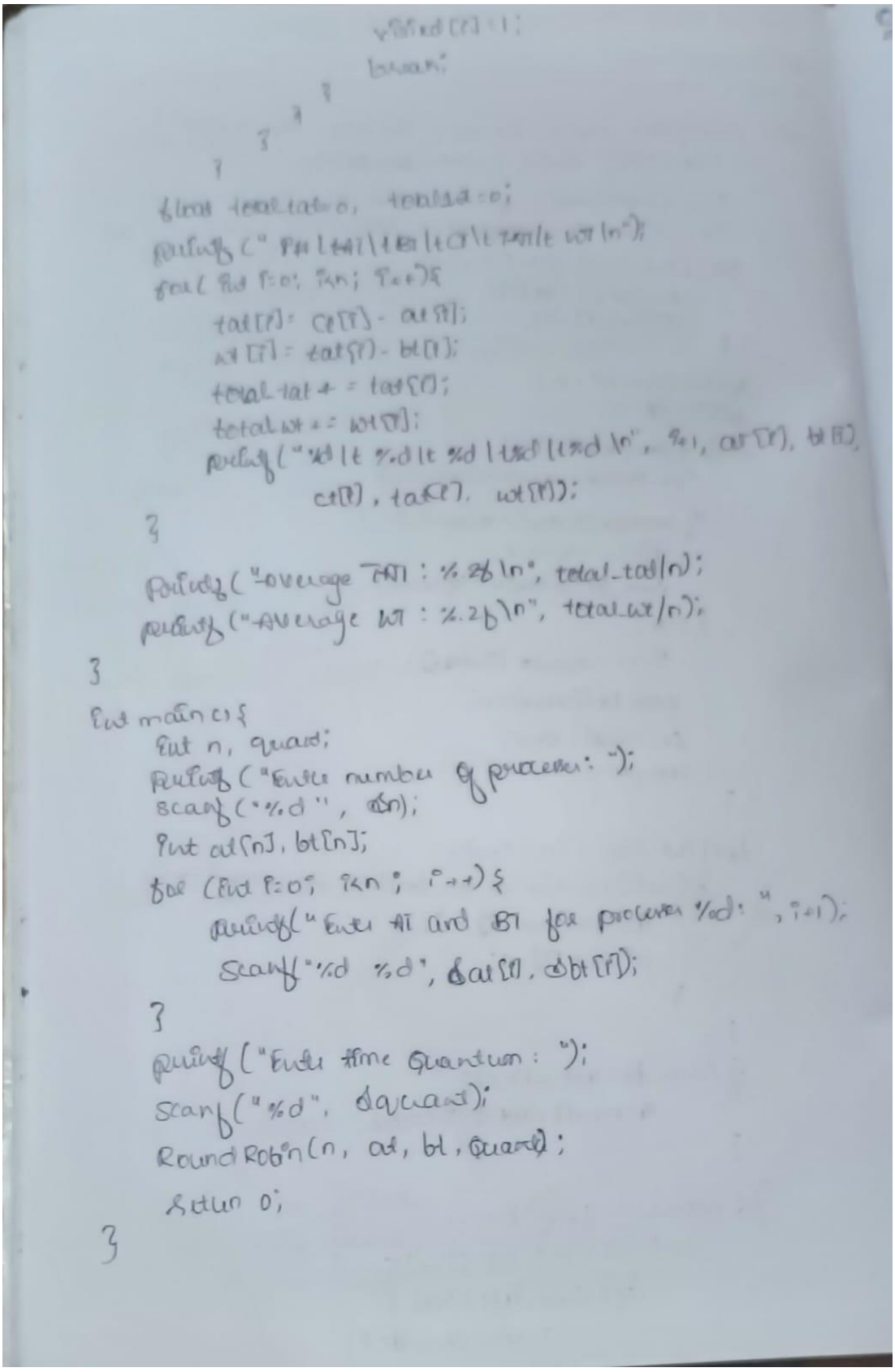
```
    for (int i = 0; i < n; i++) {
        if (at[i] <= time && rem_bt[i] > 0 && !visited[i]) {
            queue[rear++] = i;
            visited[i] = 1;
        }
    }

    if (rem_bt[index] > 0) {
        queue[rear++] = index;
    }

    if (front == rear) {
        for (int i = 0; i < n; i++) {
            if (rem_bt[i] > 0) {
                queue[rear++] = i;
                visited[i] = 1;
                break;
            }
        }
    }
}

float total_tat = 0, total_wt = 0;
printf("P#\tAT\tBT\tCT\tTAT\tWT\n");
for (int i = 0; i < n; i++) {
    tat[i] = ct[i] - at[i];
    wt[i] = tat[i] - bt[i];
    total_tat += tat[i];
    total_wt += wt[i];
```

```
        printf("%d\t%d\t%d\t%d\t%d\t%d\n", i + 1, at[i], bt[i], ct[i], tat[i], wt[i]);
    }

    printf("Average TAT: %.2f\n", total_tat / n);
    printf("Average WT: %.2f\n", total_wt / n);
}

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

    int at[n], bt[n];
    for (int i = 0; i < n; i++) {
        printf("Enter AT and BT for process %d: ", i + 1);
        scanf("%d %d", &at[i], &bt[i]);
    }

    printf("Enter time quantum: ");
    scanf("%d", &quant);

    roundRobin(n, at, bt, quant);
    return 0;
}
```


Enter number of processes: 5
Enter AT and BT for process 1: 0 8
Enter AT and BT for process 2: 5 2
Enter AT and BT for process 3: 1 7
Enter AT and BT for process 4: 6 3
Enter AT and BT for process 5: 8 5
Enter time quantum: 3
P# AT BT CT TAT WT
1 0 8 22 22 14
2 5 2 11 6 4
3 1 7 23 22 15
4 6 3 14 8 5
5 8 5 25 17 12
Average TAT: 15.00
Average WT: 10.00

Round Robin

```
#include <stdio.h>
#define MAX 100

void roundRobin(int n, int at[], int bt[], int quant) {
    int ct[n], tat[n], wt[n], rem_bt[n];
    int queue[MAX], front=0, rear=0;
    int time = 0, completed = 0, visited[n];
    for (int i=0; i<n; i++) {
        rem_bt[i] = bt[i];
        visited[i] = 0;
    }
    queue[rear++] = 0;
    visited[0] = 1;
    while (completed < n) {
        int index = queue[front++];
        if (rem_bt[index] > quant) {
            time += quant;
            rem_bt[index] -= quant;
        } else {
            time += rem_bt[index];
            rem_bt[index] = 0;
            ct[index] = time;
            completed++;
        }
        for (int i=0; i<n; i++) {
            if (at[i] <= time && rem_bt[i] > 0 && !visited[i]) {
                queue[rear++] = i;
                visited[i] = 1;
            }
        }
        if (rem_bt[index] > 0) {
            queue[rear++] = index;
        }
        if (front == rear) {
            for (int i=0; i<n; i++) {
                if (rem_bt[i] > 0) {
                    queue[rear++] = i;
```



```
            visited[i] = 1;
            break;
        }
    }
}
float total_tat = 0, total_wt = 0;
printf("PID\tAT\tBT\tCT\tTAT\tWT\n");
for(int i = 0; i < n; i++) {
    tat[i] = ct[i] - at[i];
    wt[i] = tat[i] - bt[i];
    total_tat += tat[i];
    total_wt += wt[i];
    printf("%d\t%d\t%d\t%d\t%d\t%d\n", i+1, at[i], bt[i],
           ct[i], tat[i], wt[i]);
}
printf("Average TAT : %.2f\n", total_tat/n);
printf("Average WT : %.2f\n", total_wt/n);
}
int main() {
    int n, quant;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    int at[n], bt[n];
    for (int i = 0; i < n; i++) {
        printf("Enter AT and BT for process %d: ", i+1);
        scanf("%d %d", &at[i], &bt[i]);
    }
    printf("Enter time Quantum: ");
    scanf("%d", &quant);
    RoundRobin(n, at, bt, quant);
    return 0;
}
```

Output

Enter number of processes: 5
Enter AT and BT for process1: 0 8
Enter AT and BT for process2: 5 2
Enter AT and BT for process3: 1 7
Enter AT and BT for process4: 6 3
Enter AT and BT for process5: 8 5
Enter time quantum: 3

P#	AT	BT	CT	TAT	WT
1	0	8	22	22	14
2	5	2	11	6	4
3	1	7	23	22	15
4	6	3	14	8	5
5	8	5	25	17	12

Average TAT: 15.00
Average WT: 10.00

Program 3:

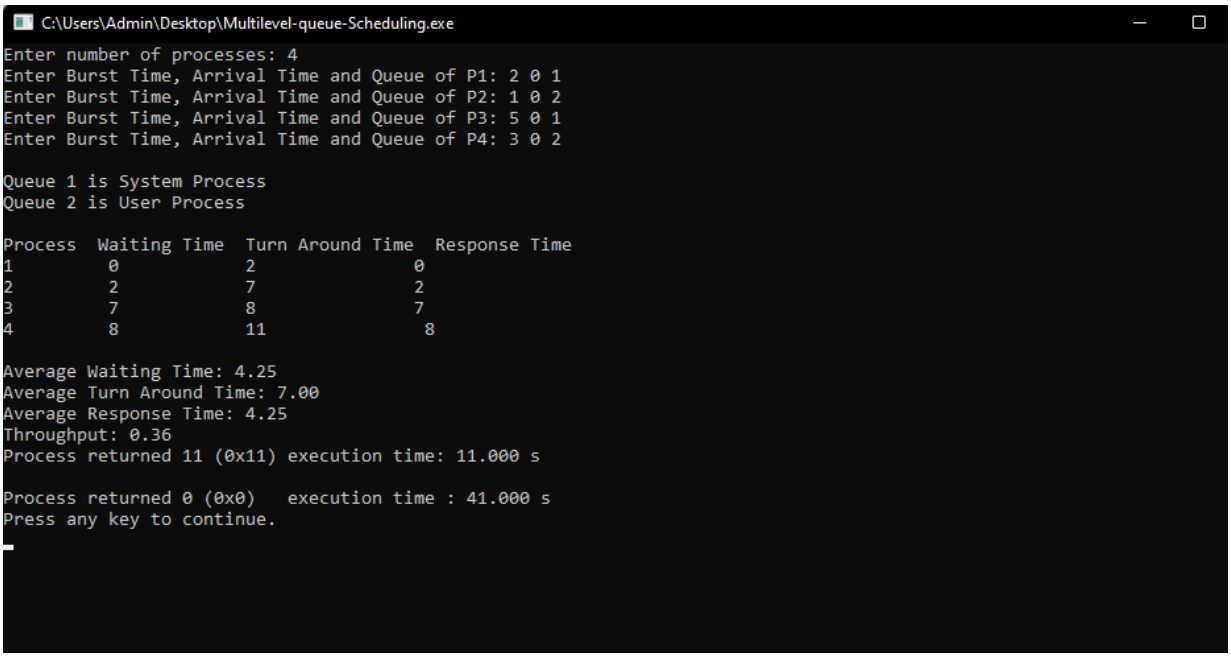
Write a C program to simulate multi-level queue scheduling algorithm considering the following scenario. All the processes in the system are divided into two categories – system processes and user processes. System processes are to be given higher priority than user processes. Use FCFS scheduling for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

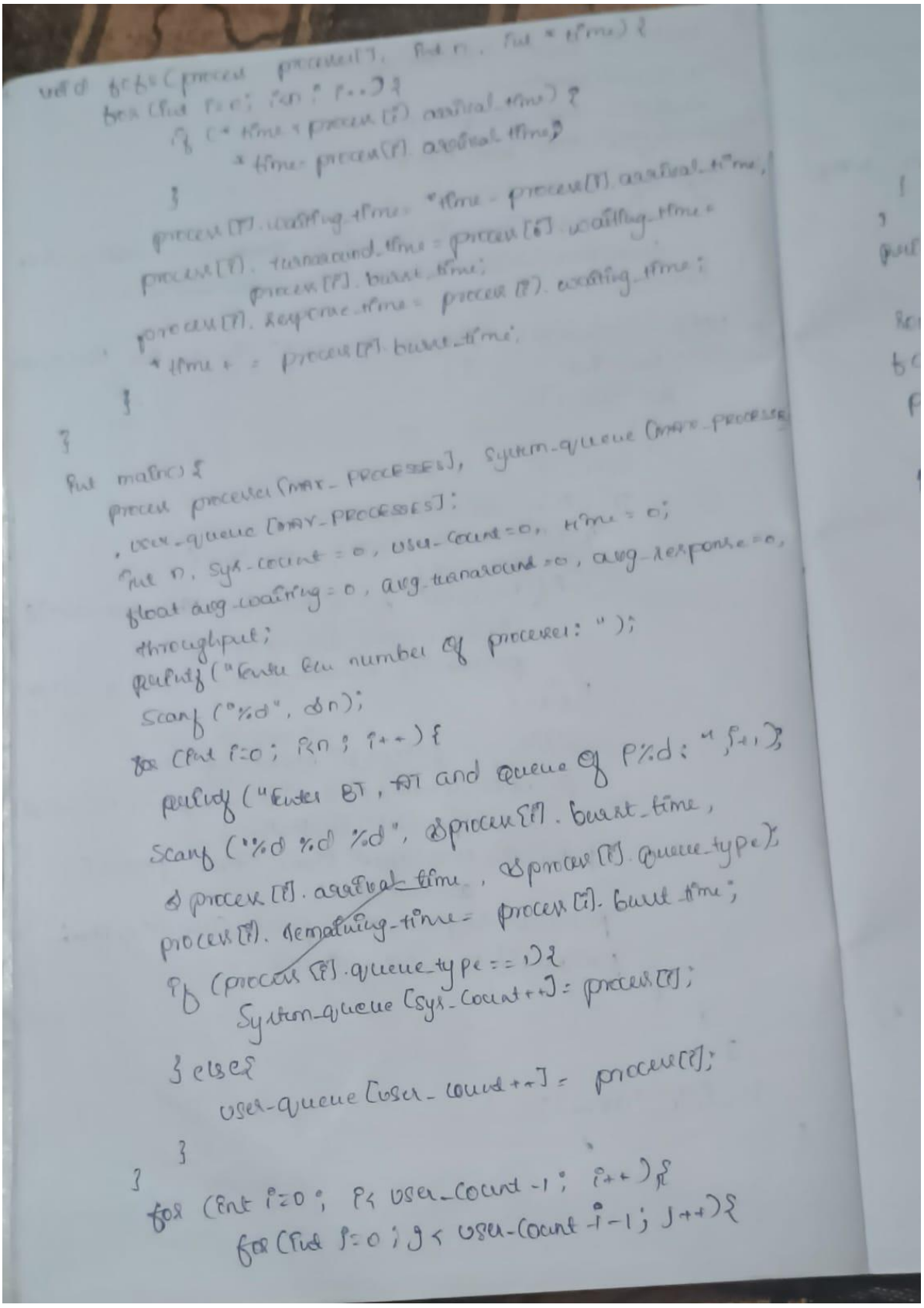
```
        scanf("%d %d %d", &processes[i].burst_time, &processes[i].arrival_time,
&processes[i].queue_type);
        processes[i].remaining_time = processes[i].burst_time;

        if (processes[i].queue_type == 1) {
            system_queue[sys_count++] = processes[i];
        } else {
            user_queue[user_count++] = processes[i];
        }
    }

    // Sort user processes by arrival time for FCFS
    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;
}
```


C:\Users\Admin\Desktop\Multilevel-queue-Scheduling.exe
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 : 41.000 s
Press any key to continue.

Multilevel Queue Scheduling

```
#include<stdio.h>
#define MAX_PROCESS 10
#define TIME_QUANTUM 2
typedef struct {
    int burst_time, arrival_time, queue_time, waiting_time,
    turnaround_time, response_time, remaining_time;
} Process;
void round_robin (Process processes[], int n, int time_quan
    -tum, 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 += process[i].remaining_time;
                    process[i].waiting_time = *time - process[i].arrival
                    -time - process[i].burst_time;
                    process[i].turnaround_time = *time - process[i].
                                arrival_time;
                    process[i].response_time = process[i].waiting_time;
                    process[i].remaining_time = 0;
                }
            }
        }
    } while(!done);
}
```



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

int main() {
    Process process[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 the number of processes: ");
    scanf("%d", &n);
    for (int i=0; i<n; i++) {
        printf("Enter BT, AT and queue of P%d: ", i+1);
        scanf("%d %d %d", &process[i].burst_time,
        &process[i].arrival_time, &process[i].queue_type);
        process[i].remaining_time = process[i].burst_time;
        if (process[i].queue_type == 1) {
            system_queue[sys_count++] = process[i];
        } else {
            user_queue[user_count++] = process[i];
        }
    }
    for (int i=0; i<user_count-1; i++) {
        for (int j=0; j<user_count-i-1; j++) {
```

```
printf("\n Average waiting time: %.2f", avg_waiting);
printf("\n Average turnaround_time : %.2f", avg_turnaround);
printf("\n Average response time : %.2f", Avg_response);
printf("\n Throughput : %.2f", throughput);
printf("\n process returned %d (0x%d) execution
 time : %.3f s\n", time, time, (float)time);
return 0;
}
```

Output:

Enter the number of processes : 4

Enter BT, AT and Queue of P1: 2 0 1
Enter BT, AT and Queue of P2: 1 0 2
Enter BT, AT and Queue of P3: 5 0 1
Enter BT, AT and Queue of P4: 3 0 2

Queue 1 → System process
Queue 2 → User process

process	waiting time	Turnaround 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

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>
#include <math.h>

typedef struct {
    int id, burst, period;
} Task;

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 findLCM(Task tasks[], int n) {
    int result = tasks[0].period;
    for (int i = 1; i < n; i++)
        result = lcm(result, tasks[i].period);
    return result;
}

void rateMonotonic(Task tasks[], int n) {
    float utilization = 0;
    printf("\nRate Monotonic Scheduling:\nPID\tBurst\tPeriod\n");
```

```
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t%d\n", tasks[i].id, tasks[i].burst, tasks[i].period);
        utilization += (float)tasks[i].burst / tasks[i].period;
    }

    float bound = n * (pow(2, (1.0 / n)) - 1);
    printf("\nUtilization: %.6f, Bound: %.6f\n", utilization, bound);
    if (utilization <= bound)
        printf("Tasks are Schedulable\n");
    else
        printf("Tasks are NOT Schedulable\n");
}

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

    Task tasks[n];
    printf("Enter the CPU burst times: ");
    for (int i = 0; i < n; i++)
        scanf("%d", &tasks[i].burst);

    printf("Enter the time periods: ");
    for (int i = 0; i < n; i++) {
        scanf("%d", &tasks[i].period);
        tasks[i].id = i + 1;
    }

    rateMonotonic(tasks, n);
```

```
    return 0;
}
```

Output

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

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

Utilization: 4.100000, Bound: 0.779763
Tasks are NOT Schedulable
```

Rate Monotonic

```
#include <stdio.h>
#include <math.h>
typedef struct {
    int id, burst, period;
} Task;

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 findLCM(Task tasks[], int n) {
    int result = tasks[0].period;
    for (int i = 1; i < n; i++)
        result = lcm(result, tasks[i].period);
    return result;
}

void rateMonotonic(Task tasks[], int n) {
    float utilization = 0;
    printf("\n Rate Monotonic Scheduling: \n PID \t Burst \t Period \n");
    for (int i = 0; i < n; i++) {
        printf("%d \t %d \t %d \n", tasks[i].id, tasks[i].burst,
               tasks[i].period);
        utilization += (float) tasks[i].burst / tasks[i].period;
    }
    float bound = n * (pow(2, (1.0/n)) - 1);
    printf("\n Utilization : %.6f, Bound: %.6f \n", utilization,
           bound);
    if (utilization <= bound)
        printf("Tasks are Schedulable\n");
    else
        printf("Tasks are not Schedulable \n");
}
```

```
int main() {
    int n;
    printf("Enter the number of process: ");
    scanf("%d", &n);
    Task task[n];
    printf("Enter the CPU burst times: ");
    for(int i=0; i<n; i++)
        scanf("%d", &task[i].burst);
    printf("Enter the time periods: ");
    for(int i=0; i<n; i++) {
        scanf("%d", &task[i].period);
        task[i].pid = i+1;
    }
    RateMonotonic(task, n);
    return 0;
}
```

Output

```
Enter the number of process: 3
Enter the CPU burst times: 3 6 8
Enter the time periods: 3 4 5
Rate monotonic scheduling:
```

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

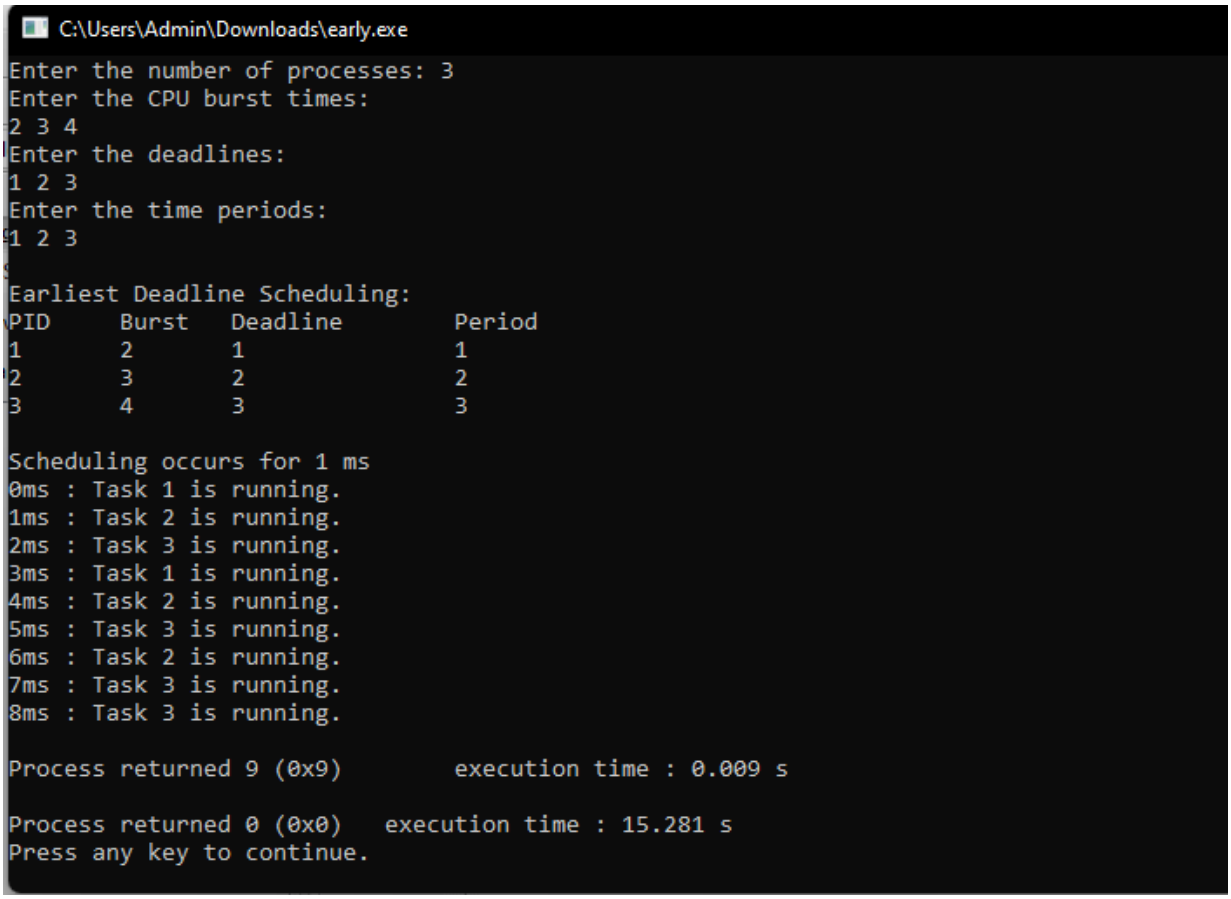
Utilization: 4.100000 , Bound: 0.779763
Tasks are not scheduleable.

→Earliast-Deadline First

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

typedef struct {
    int pid;
    int burst_time;
    int deadline;
    int period;
    int remaining_time;
} Process;

// Function to compare processes based on their deadlines
int compare_deadlines(const void *a, const void *b) {
    return ((Process *)a)->deadline - ((Process *)b)->deadline;
}

int main() {
    int num_processes;

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

    Process processes[num_processes];

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

```
    }

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

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

    // Sort processes based on deadlines
    qsort(processes, num_processes, sizeof(Process), compare_deadlines);

    printf("\nEarliest Deadline Scheduling:\n");
    printf("PID\tBurst\tDeadline\tPeriod\n");
    for (int i = 0; i < num_processes; i++) {
        printf("%d\t%d\t%d\t\t%d\n", processes[i].pid, processes[i].burst_time, processes[i].deadline,
processes[i].period);
    }

    int current_time = 0;
    int completed_processes = 0;

    printf("\nScheduling occurs for %d ms\n", processes[0].deadline); // Assuming the first process has
the earliest deadline

    while (completed_processes < num_processes) {
        for (int i = 0; i < num_processes; i++) {
```

```
            if (processes[i].remaining_time > 0) {
                printf("%dms : Task %d is running.\n", current_time, processes[i].pid);
                processes[i].remaining_time--;
                current_time++;

                if (processes[i].remaining_time == 0) {
                    completed_processes++;
                }
            }
        }
    }

    printf("\nProcess returned %d (0x%X)\texecution time : %.3f s\n", current_time, current_time,
(float)current_time / 1000.0);

    return 0;
}
```


C:\Users\Admin\Downloads\early.exe
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
Earliest Deadline Scheduling:
PID Burst Deadline Period
1 2 1 1
2 3 2 2
3 4 3 3
Scheduling occurs for 1 ms
0ms : Task 1 is running.
1ms : Task 2 is running.
2ms : Task 3 is running.
3ms : Task 1 is running.
4ms : Task 2 is running.
5ms : Task 3 is running.
6ms : Task 2 is running.
7ms : Task 3 is running.
8ms : Task 3 is running.
Process returned 9 (0x9) execution time : 0.009 s
Process returned 0 (0x0) execution time : 15.281 s
Press any key to continue.

Earliest Deadline first

```
#include <stdio.h>
#include <stdlib.h>
typedef struct {
    int Pid;
    int burst_time;
    int deadline;
    int period;
    int remaining_time;
} process;
int compare_deadline (const void *a, const void *b){
    return ((process*)a)->deadline - ((process*)b)->deadline;
}
int main(){
    int num_process;
    printf("Enter the number of process:");
    scanf("%d", &num_process);
    process process[num_process];
    printf("Enter the CPU burst time: \n");
    for(int i=0; i<num_process; i++){
        scanf("%d", &process[i].burst_time);
        process[i].pid = i+1;
        process[i].remaining_time = process[i].burst_time;
    }
    printf("Enter the deadline: \n");
    for(int i=0; i<num_process; i++){
        scanf("%d", &process[i].deadline);
    }
    printf("Enter the time period: \n");
    for(int i=0; i<num_process; i++){
        scanf("%d", &process[i].period);
    }
    qsort(process, num_process, sizeof(process), compare_dea
printf("\n Earliest Deadline scheduling: \n");
printf("\nPID \t Burst \t Deadline \t period \n");
```

```
for (int i=0; i<num_processes; i++){
    printf("%d\t%d\t%d\t%d\n", processes[i].pid,
    processes[i].burst_time, processes[i].deadline, processes[i].priority);
}
int current_time=0;
int completed_processes=0;
printf("\nScheduling occurs for %d ms\n\n", processes[0].deadline);
while (completed_processes<num_processes){
    for (int i=0; i<num_processes; i++){
        if (processes[i].remaining_time>0){
            printf("%d ms: Task %d is running.\n",
            current_time, processes[i].pid);
            processes[i].remaining_time--;
            current_time++;
            if (processes[i].remaining_time==0){
                completed_processes++;
            }
        }
    }
}
printf("\nProcess returned %d (0x%x)\t execution
    time: %.3f s\n", current_time, current_time,
    (float)current_time/1000.0);
return 0;
}
```

Output

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

Inter-Arrival time periods:

1 2 3

Earliest Deadline Scheduling:

PID	Burst	Deadline	period
1	2	1	1
2	3	2	2
3	4	3	3

scheduling occurs for 1ms

0ms: Task 1 is running.

1ms: Task 2 is running.

2ms: Task 3 is running

3ms: Task 1 is running

4ms: Task 2 is running

5ms: Task 3 is running

6ms: Task 2 is running

7ms: Task 3 is running

8ms: Task 3 is running

process returned 9 (0x9) execution time: 0.009 s

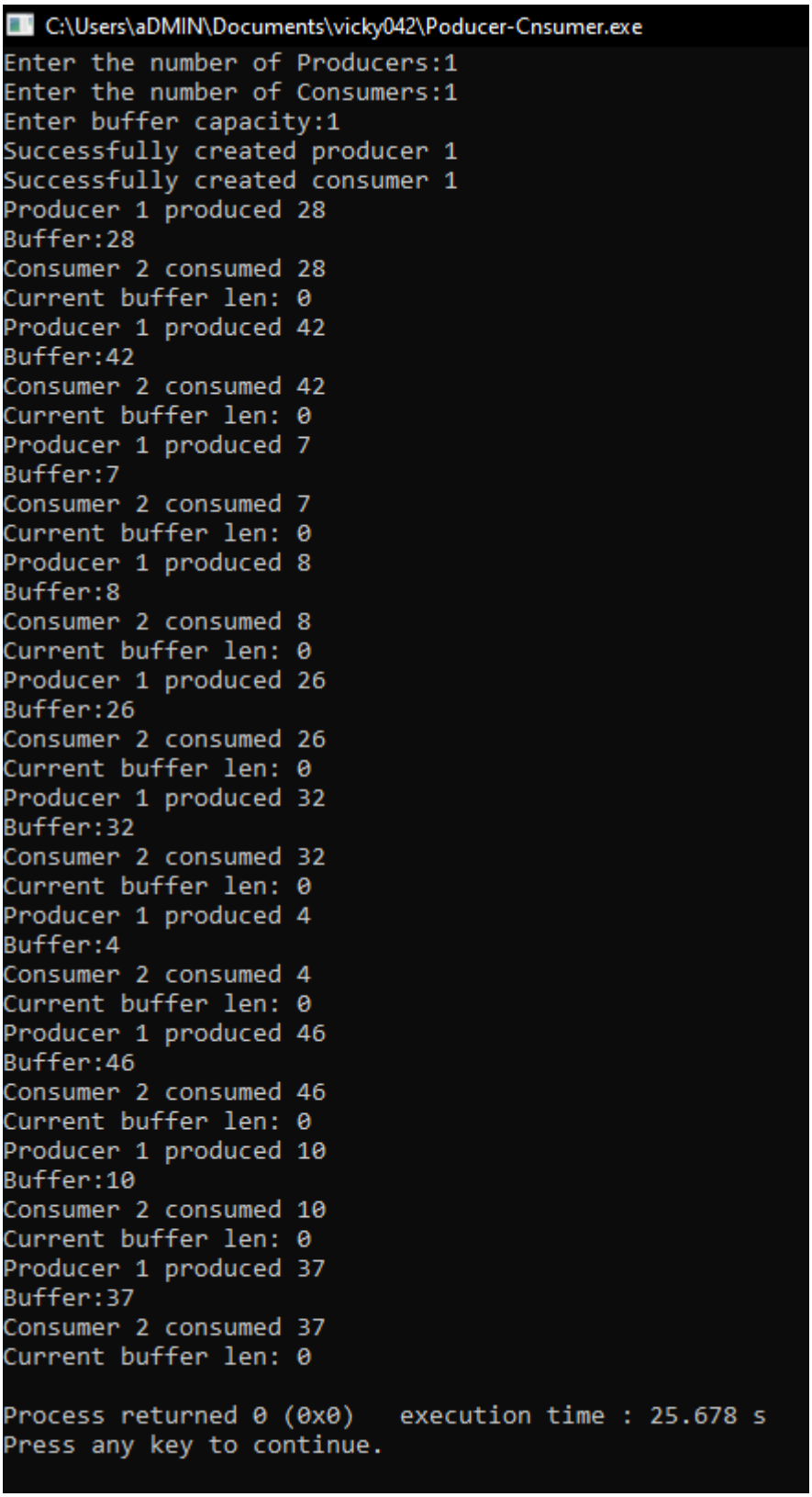
Program 5:

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

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

int mutex = 1, full = 0, empty, x = 0;
int *buffer, buffer_size;
int in = 0, out = 0;

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() % 50;
      buffer[in] = item;
      x++;
      printf("Producer %d produced %d\n", id, item);
      printf("Buffer:%d\n", item);
      in = (in + 1) % buffer_size;
```

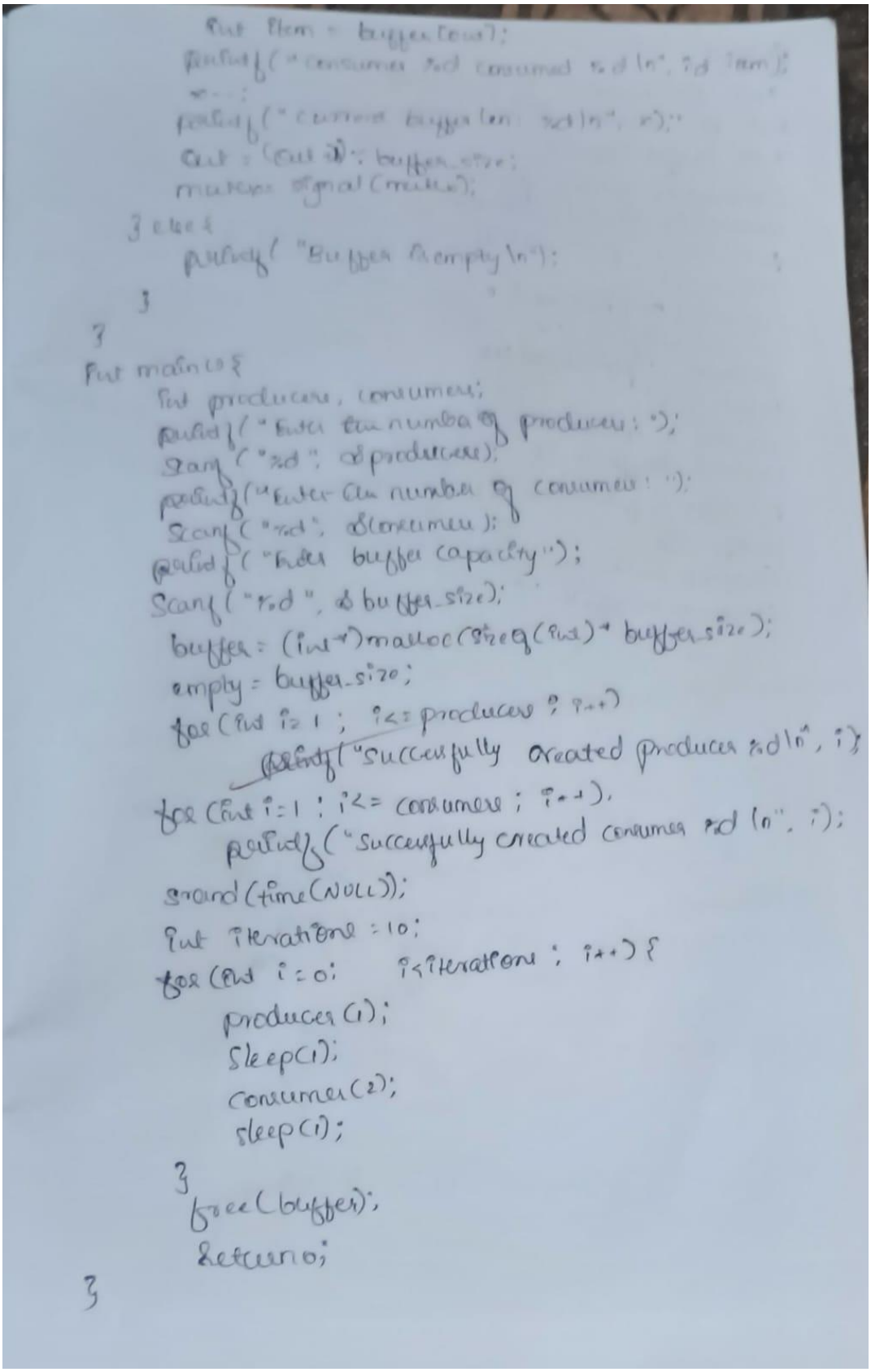
```
        mutex = signal(mutex);
    } else {
        printf("Buffer is full\n");
    }
}

void consumer(int id) {
    if ((mutex == 1) && (full != 0)) {
        mutex = wait(mutex);
        full = wait(full);
        empty = signal(empty);
        int item = buffer[out];
        printf("Consumer %d consumed %d\n", id, item);
        x--;
        printf("Current buffer len: %d\n", x);
        out = (out + 1) % buffer_size;
        mutex = signal(mutex);
    } else {
        printf("Buffer is empty\n");
    }
}

int main() {
    int producers, consumers;
    printf("Enter the number of Producers:");
    scanf("%d", &producers);
    printf("Enter the number of Consumers:");
    scanf("%d", &consumers);
    printf("Enter buffer capacity:");
    scanf("%d", &buffer_size);
```

```
    buffer = (int *)malloc(sizeof(int) * buffer_size);
    empty = buffer_size;

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

    srand(time(NULL));

    int iterations = 10;
    for (int i = 0; i < iterations; i++) {
        producer(1);
        sleep(1);
        consumer(2);
        sleep(1);
    }

    free(buffer);
    return 0;
}
```

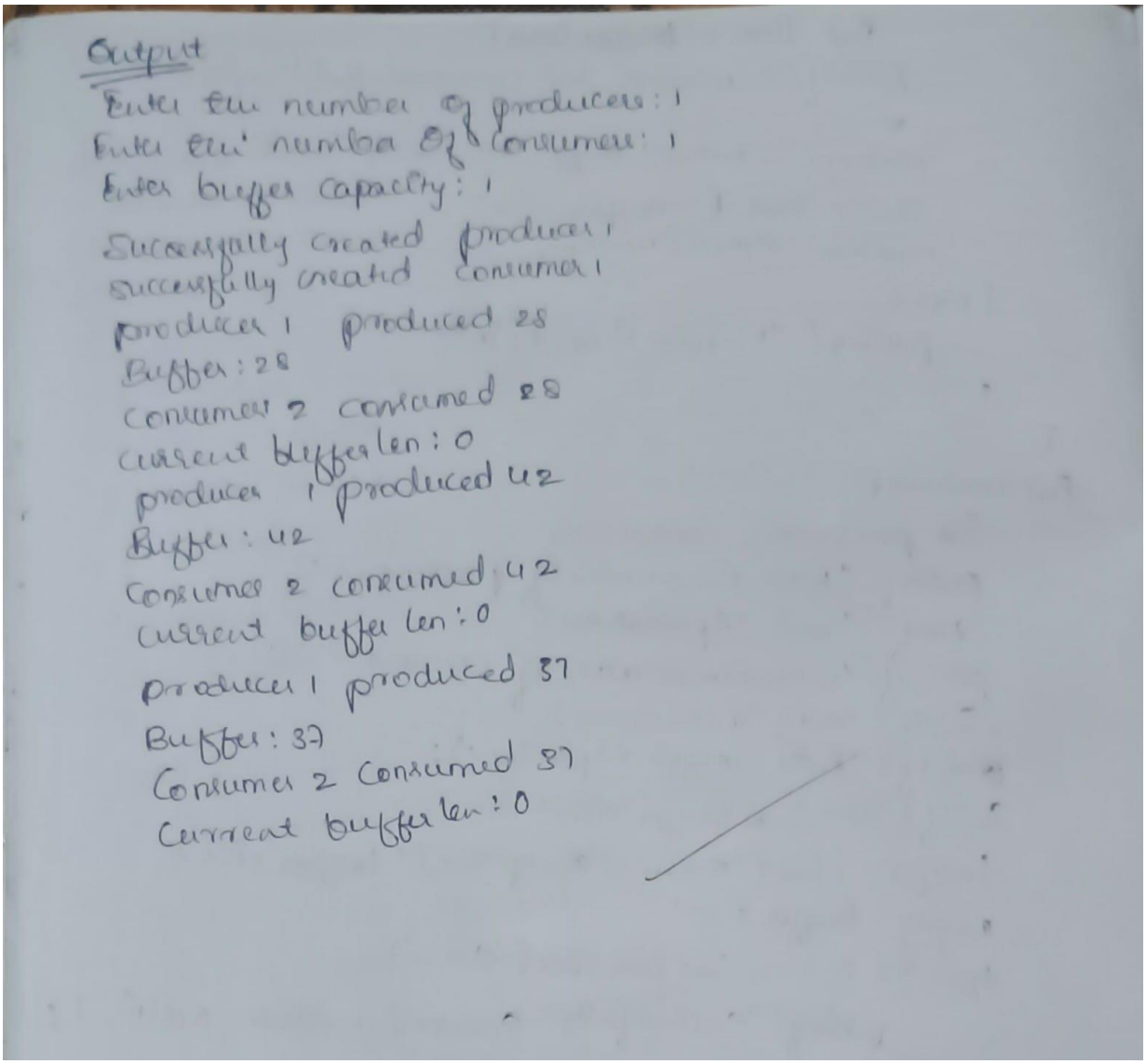

C:\Users\aDMIN\Documents\vicky042\Poducer-Cnsumer.exe
Enter the number of Producers:1
Enter the number of Consumers:1
Enter buffer capacity:1
Successfully created producer 1
Successfully created consumer 1
Producer 1 produced 28
Buffer:28
Consumer 2 consumed 28
Current buffer len: 0
Producer 1 produced 42
Buffer:42
Consumer 2 consumed 42
Current buffer len: 0
Producer 1 produced 7
Buffer:7
Consumer 2 consumed 7
Current buffer len: 0
Producer 1 produced 8
Buffer:8
Consumer 2 consumed 8
Current buffer len: 0
Producer 1 produced 26
Buffer:26
Consumer 2 consumed 26
Current buffer len: 0
Producer 1 produced 32
Buffer:32
Consumer 2 consumed 32
Current buffer len: 0
Producer 1 produced 4
Buffer:4
Consumer 2 consumed 4
Current buffer len: 0
Producer 1 produced 46
Buffer:46
Consumer 2 consumed 46
Current buffer len: 0
Producer 1 produced 10
Buffer:10
Consumer 2 consumed 10
Current buffer len: 0
Producer 1 produced 37
Buffer:37
Consumer 2 consumed 37
Current buffer len: 0
Process returned 0 (0x0) execution time : 25.678 s
Press any key to continue.

Producer- Consumer

```
#include <stdio.h>
#include <stdlib.h>
#include <unistd.h>
#include <time.h>
int mutex = 1, full = 0, empty, x = 0;
int * buffer, buffer_size;
int in = 0, out = 0;
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() % 50;
        buffer[in] = item;
        x++;
        printf("Producer %d produced %d \n", id, item);
        printf("Buffer : %d \n", item);
        in = (in + 1) % buffer_size;
        mutex = signal(mutex);
    } else {
        printf("Buffer is full \n");
    }
}
void consumer(int id) {
    if ((mutex == 1) && (full != 0)){
        mutex = wait(mutex);
        full = wait(full);
        empty = signal(empty);
```



```
        int item = buffer[out];
        printf("Consumer %d consumed %d\n", id, item);
        --in;
        printf("current buffer len: %d\n", in);
        out = (out+1) % buffer_size;
        mutex = signal(mutex);
    } else {
        printf("Buffer is empty\n");
    }
}
int main() {
    int producers, consumers;
    printf("Enter the number of producers: ");
    scanf("%d", &producers);
    printf("Enter the number of consumers: ");
    scanf("%d", &consumers);
    printf("Enter buffer capacity");
    scanf("%d", &buffer_size);
    buffer = (int*)malloc(sizeof(int) * buffer_size);
    empty = buffer_size;
    for(int i = 1; i <= producers; i++)
        printf("Succesfully created producer %d\n", i);
    for(int i = 1; i <= consumers; i++)
        printf("Succesfully created consumer %d\n", i);
    srand(time(NULL));
    int iterations = 10;
    for(int i = 0; i < iterations; i++) {
        producer(1);
        sleep(1);
        consumer(2);
        sleep(1);
    }
    free(buffer);
    return 0;
}
```



Program 6:

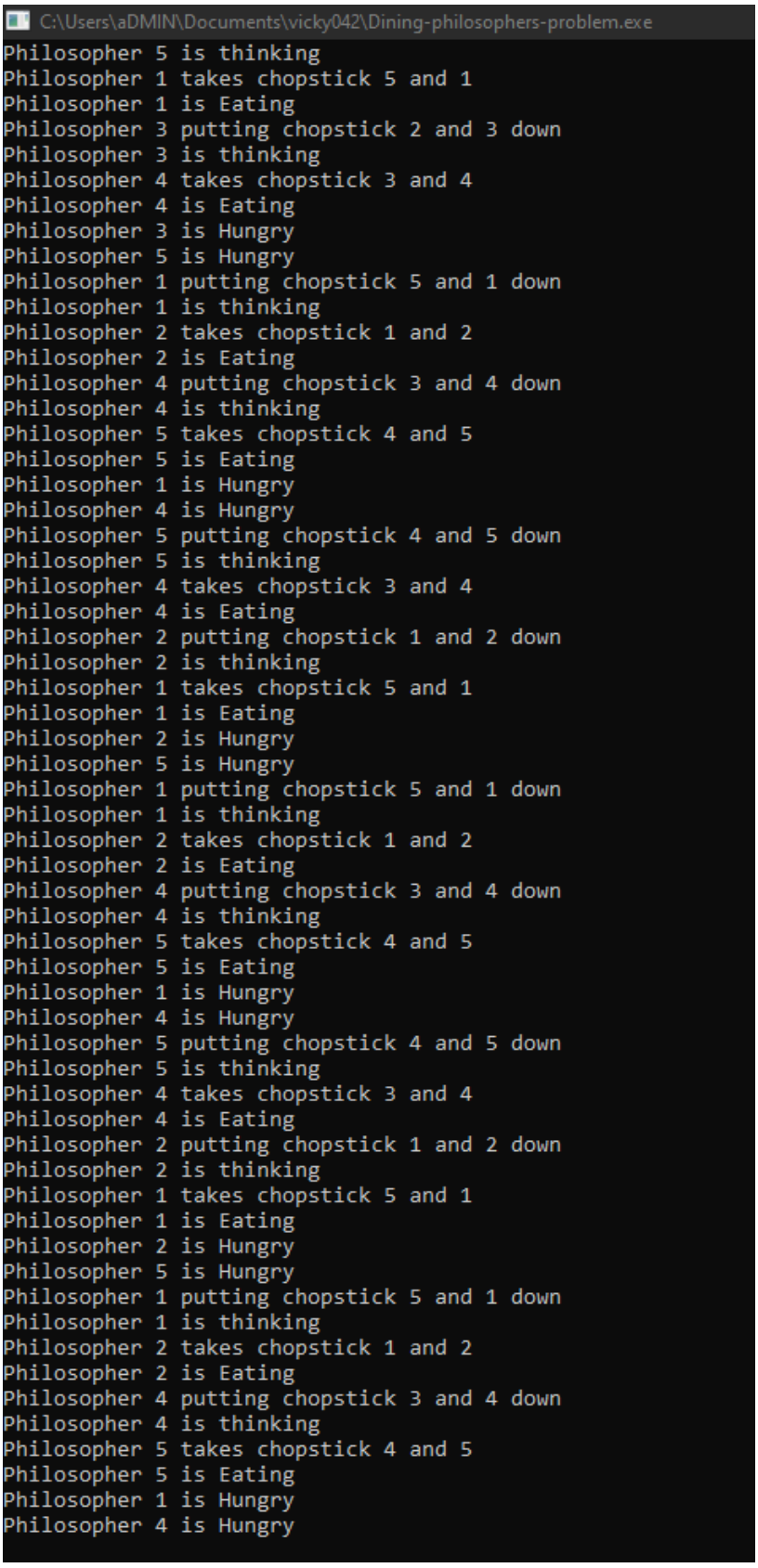
Write a C program to simulate the concept of Dining Philosophers problem.

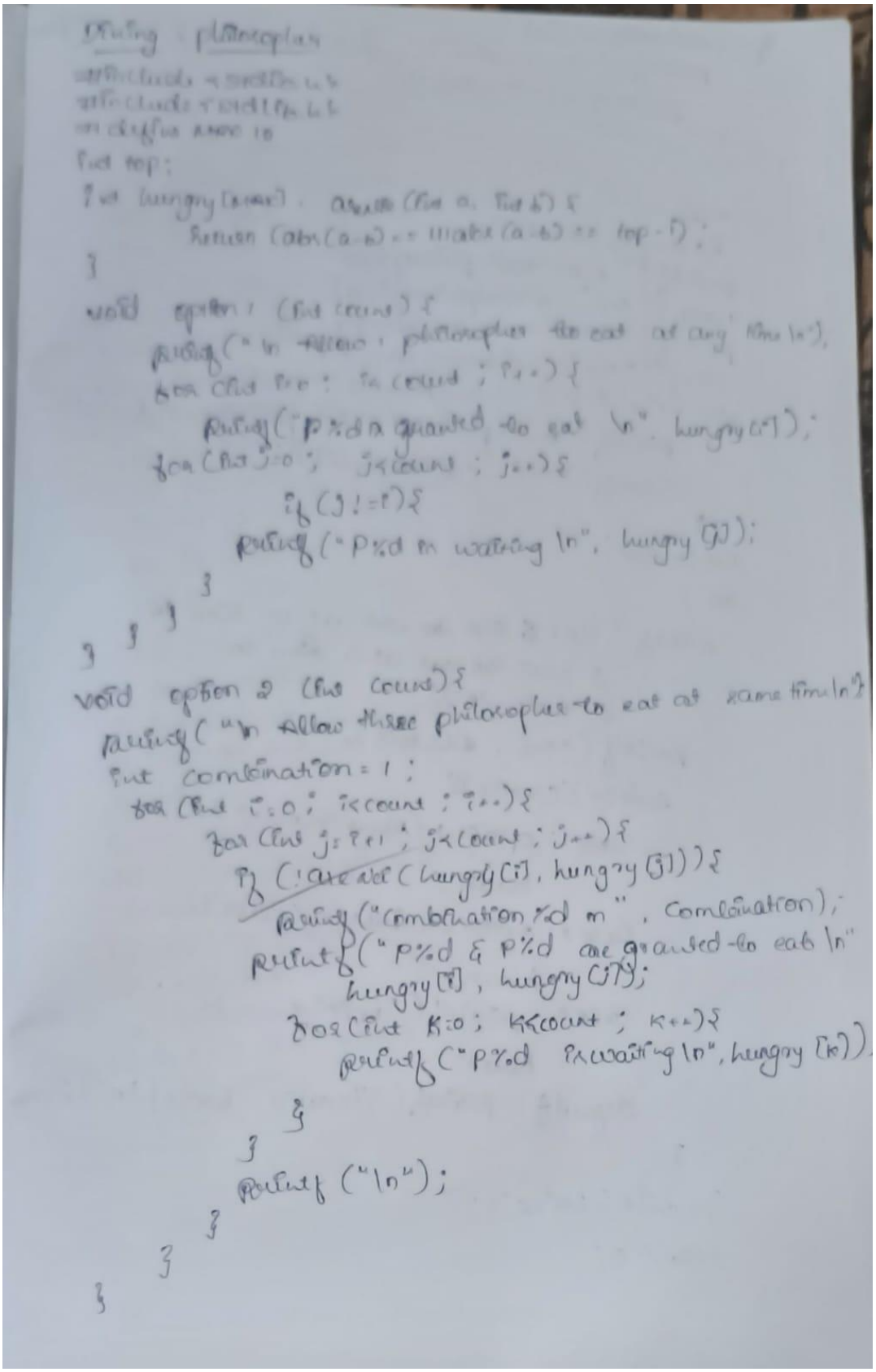
```
#include <pthread.h>
#include <semaphore.h>
#include <stdio.h>
#include <unistd.h>
```

```
#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;
sem_t S[N];

void test(int phnum)
{
   if (state[phnum] == HUNGRY &&
      state[LEFT] != EATING &&
      state[RIGHT] != EATING) {
      // Eating state
      state[phnum] = EATING;

      printf("Philosopher %d takes chopstick %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\n", phnum + 1);

    test(phnum);

    sem_post(&mutex);

    sem_wait(&S[phnum]);
    sleep(1);
}

void put_fork(int phnum)
{
    sem_wait(&mutex);

    state[phnum] = THINKING;
    printf("Philosopher %d putting chopstick %d and %d down\n", phnum + 1, LEFT + 1, phnum + 1);
    printf("Philosopher %d is thinking\n", phnum + 1);

    test(LEFT);
    test(RIGHT);

    sem_post(&mutex);
}

void* philosopher(void* num)
{
    while (1) {
```

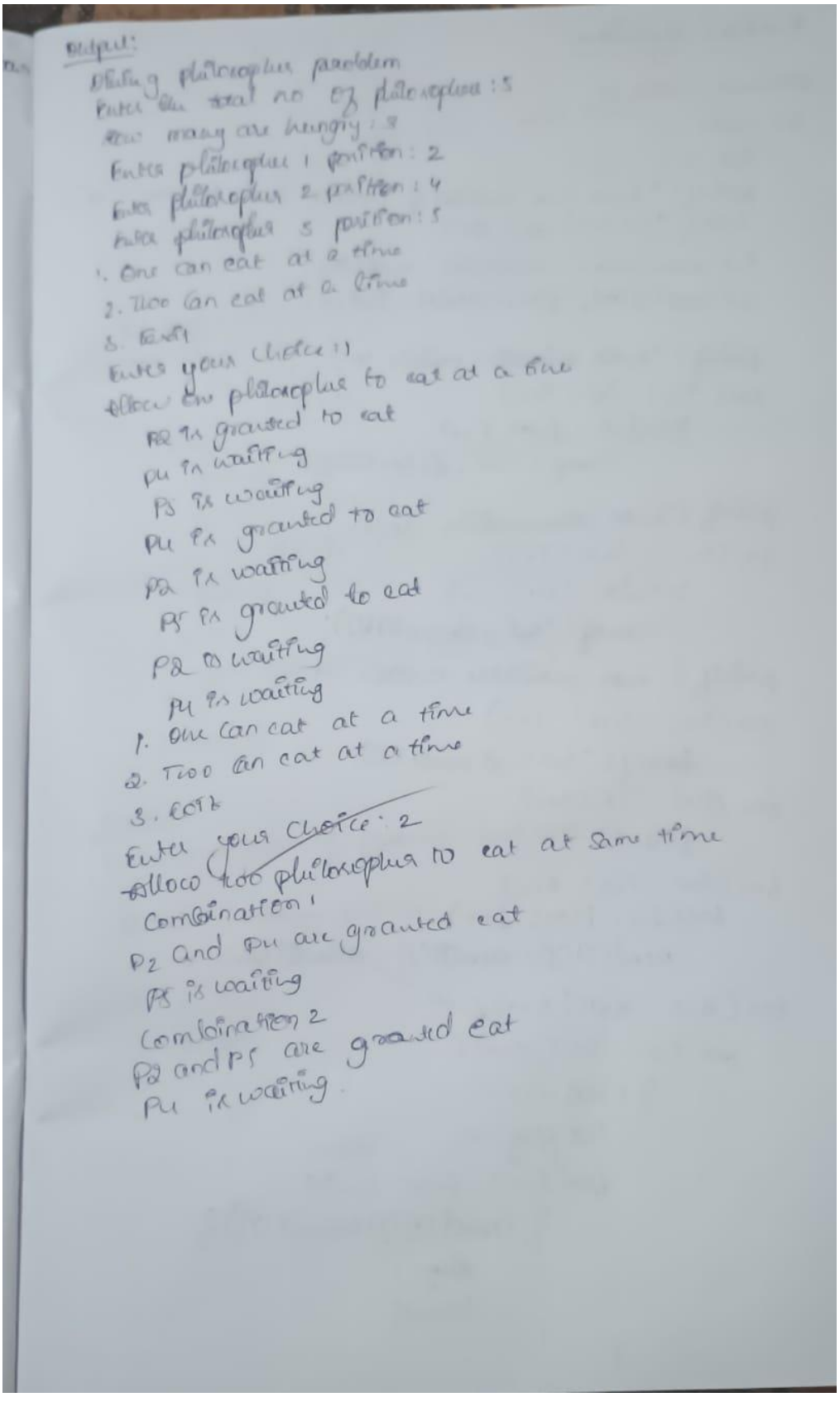
```
        int* i = num;

        sleep(1);
        take_fork(*i);
        sleep(1);
        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;
}
```


C:\Users\aDMIN\Documents\vicky042\Dining-philosophers-problem.exe
Philosopher 5 is thinking
Philosopher 1 takes chopstick 5 and 1
Philosopher 1 is Eating
Philosopher 3 putting chopstick 2 and 3 down
Philosopher 3 is thinking
Philosopher 4 takes chopstick 3 and 4
Philosopher 4 is Eating
Philosopher 3 is Hungry
Philosopher 5 is Hungry
Philosopher 1 putting chopstick 5 and 1 down
Philosopher 1 is thinking
Philosopher 2 takes chopstick 1 and 2
Philosopher 2 is Eating
Philosopher 4 putting chopstick 3 and 4 down
Philosopher 4 is thinking
Philosopher 5 takes chopstick 4 and 5
Philosopher 5 is Eating
Philosopher 1 is Hungry
Philosopher 4 is Hungry
Philosopher 5 putting chopstick 4 and 5 down
Philosopher 5 is thinking
Philosopher 4 takes chopstick 3 and 4
Philosopher 4 is Eating
Philosopher 2 putting chopstick 1 and 2 down
Philosopher 2 is thinking
Philosopher 1 takes chopstick 5 and 1
Philosopher 1 is Eating
Philosopher 2 is Hungry
Philosopher 5 is Hungry
Philosopher 1 putting chopstick 5 and 1 down
Philosopher 1 is thinking
Philosopher 2 takes chopstick 1 and 2
Philosopher 2 is Eating
Philosopher 4 putting chopstick 3 and 4 down
Philosopher 4 is thinking
Philosopher 5 takes chopstick 4 and 5
Philosopher 5 is Eating
Philosopher 1 is Hungry
Philosopher 4 is Hungry
Philosopher 5 putting chopstick 4 and 5 down
Philosopher 5 is thinking
Philosopher 4 takes chopstick 3 and 4
Philosopher 4 is Eating
Philosopher 2 putting chopstick 1 and 2 down
Philosopher 2 is thinking
Philosopher 1 takes chopstick 5 and 1
Philosopher 1 is Eating
Philosopher 2 is Hungry
Philosopher 5 is Hungry
Philosopher 1 putting chopstick 5 and 1 down
Philosopher 1 is thinking
Philosopher 2 takes chopstick 1 and 2
Philosopher 2 is Eating
Philosopher 4 putting chopstick 3 and 4 down
Philosopher 4 is thinking
Philosopher 5 takes chopstick 4 and 5
Philosopher 5 is Eating
Philosopher 1 is Hungry
Philosopher 4 is Hungry



```
Dining philosophers
#include <stdio.h>
#include <stdlib.h>
int top;
int hungry[count];
int check(int a, int b) {
    return (abs(a-b) == 1 || abs(a-b) == top-1);
}
void option1(int count) {
    printf("\n Allow philosophers 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("\n Allow three 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(!check(hungry[i], hungry[j])) {
                printf("combination %d \n", combination);
                printf("P%d & P%d are granted to eat\n",
                    hungry[i], hungry[j]);
                for(int k=0; k<count; k++) {
                    printf("P%d is waiting\n", hungry[k]);
                }
            }
        }
        printf("\n");
    }
}
```

```
if (combination == 1) {
    printf("No combination found where 2 non-neighbour
    philosophers can eat \n");
}
}

int main() {
    int hungry_count;
    printf("Enter total philosophers: ");
    scanf("%d", &totalphilosophers);
    printf("How many are hungry: ");
    scanf("%d", &hungry_count);
    for (int i=0; i< hungry_count; i++) {
        printf("Enter philosopher %d position: ", i+1);
        scanf("%d", &hungry[i]);
    }
    int choice;
    do {
        printf("\n1. One can eat at a time \n
                2. Two can eat at a time \n
                3. exit \n");
        printf("%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 philosophers 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 a time
P2 is granted to eat
P4 is waiting
P5 is waiting
P1 is granted to eat
P2 is waiting
P5 is granted to eat
P2 is waiting
P4 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
P2 and P4 are granted eat
P5 is waiting
Combination 2
P2 and P5 are granted eat
P4 is waiting

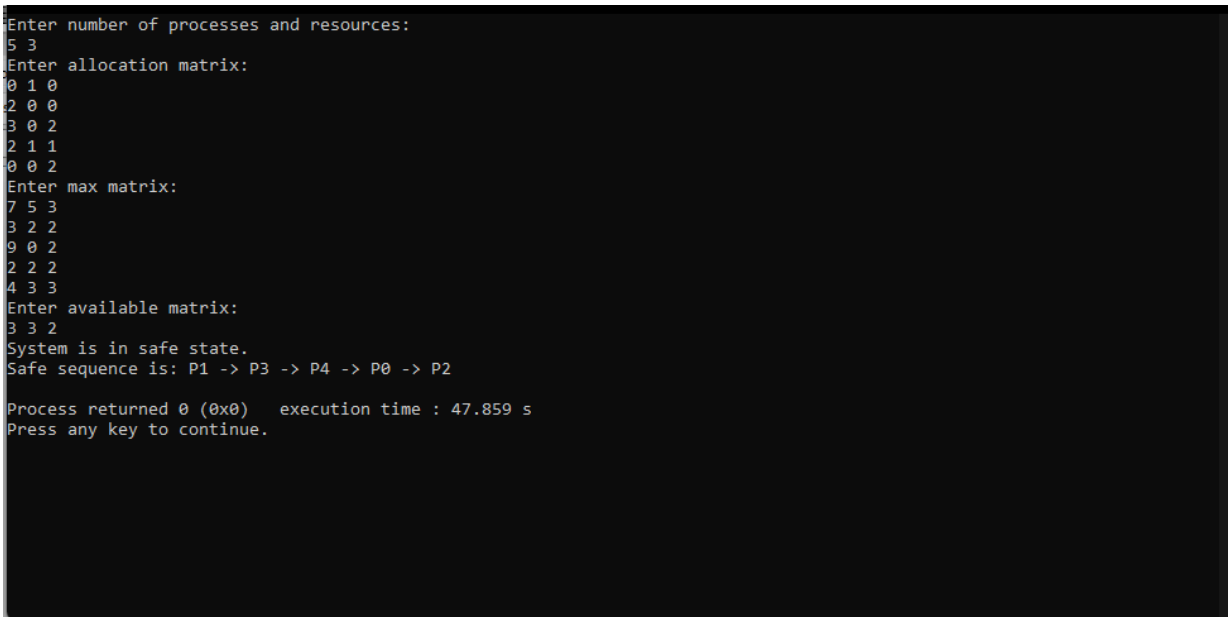
Program 7:

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 number of processes and resources:\n");
    scanf("%d %d", &n, &m);

    int alloc[n][m], max[n][m], avail[m];
    int need[n][m], f[n], ans[n], ind = 0;

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

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

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

    for (i = 0; i < n; i++)
        f[i] = 0;
```

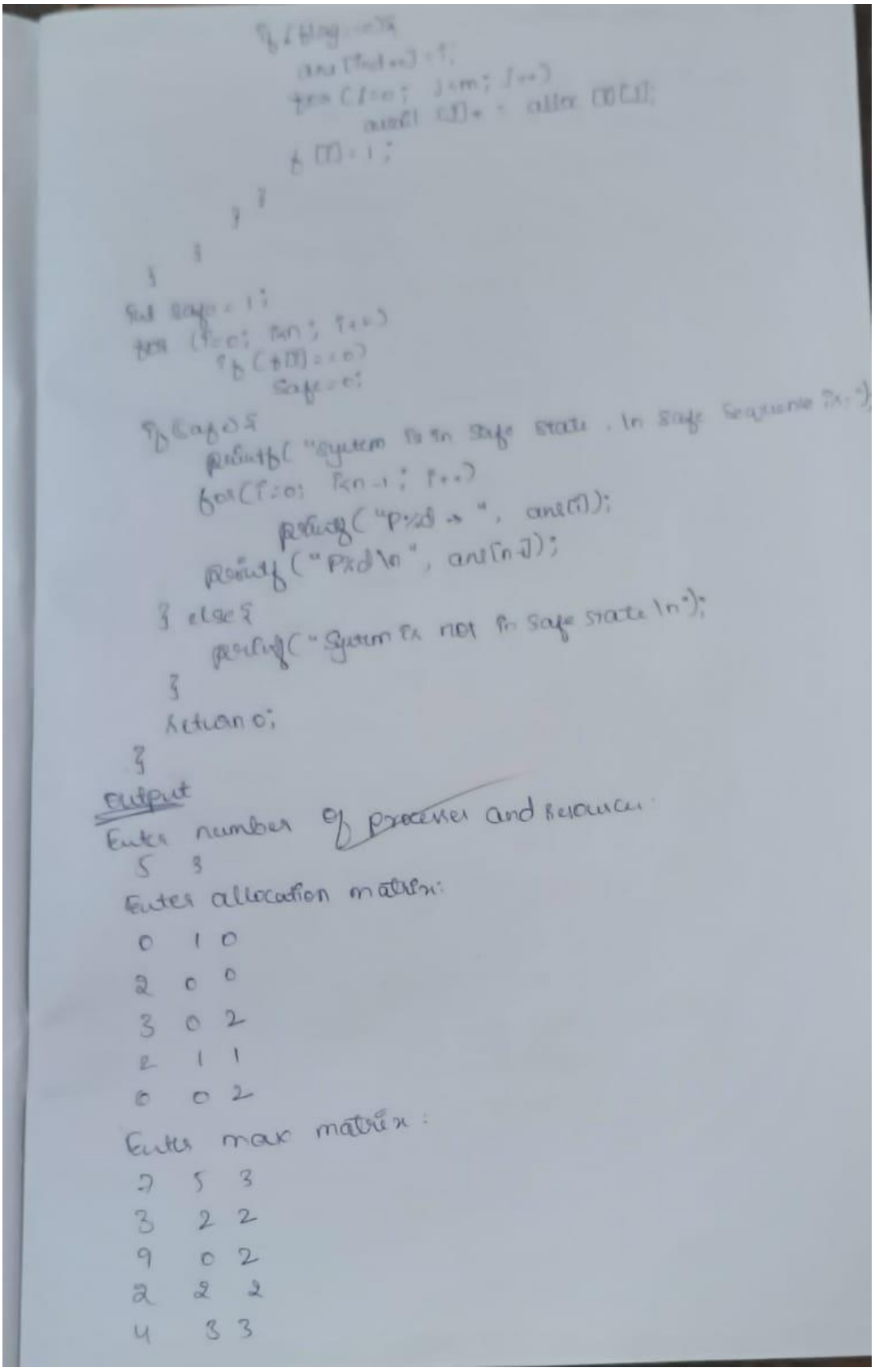
```
for (i = 0; i < n; i++)
    for (j = 0; j < m; j++)
        need[i][j] = max[i][j] - alloc[i][j];

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

int safe = 1;
for (i = 0; i < n; i++)
    if (f[i] == 0)
        safe = 0;

if (safe) {
```

```
        printf("System is in safe state.\nSafe sequence is: ");
        for (i = 0; i < n - 1; i++)
            printf("P%d -> ", ans[i]);
        printf("P%d\n", ans[n - 1]);
    } else {
        printf("System is not in safe state\n");
    }

    return 0;
}
```


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 : 47.859 s
Press any key to continue.

Banker's Algorithm

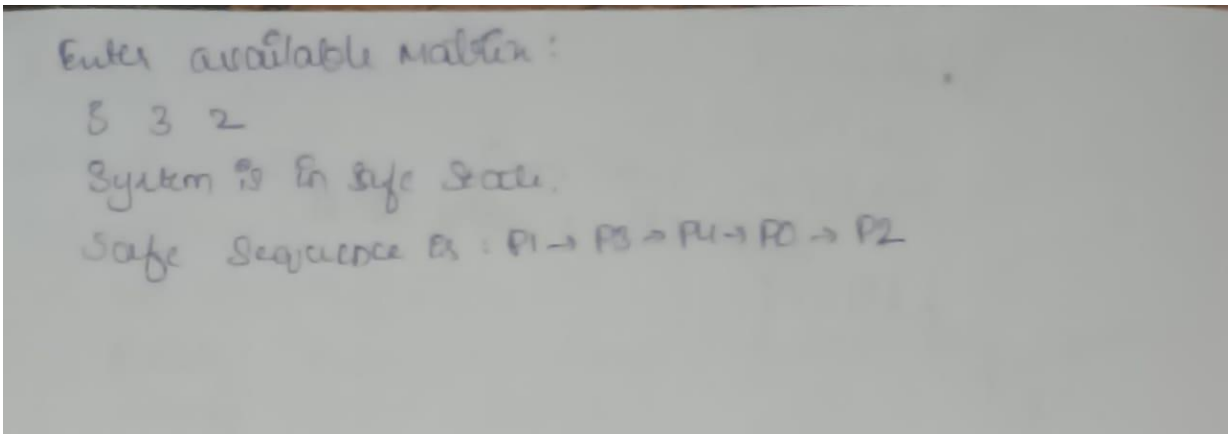
```
#include <stdio.h>
int main() {
    int n, m, i, j, k;
    printf("Enter the number of processes and resources: \n");
    scanf("%d %d", &n, &m);
    int alloc[n][m], max[n][m], avail[m];
    int need[n][m], f[n], ans[n], ind=0;

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

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

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

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



```
        if(flag==0){
            ans[ind++]=i;
            for(j=0; j<m; j++)
                avail[j]+= alloc[i][j];
            f[i]=1;
        }
    }
}
int safe=1;
for(i=0; i<n; i++)
    if(f[i]==0)
        safe=0;
if(safe){
    printf("System is in safe state. In safe sequence is:");
    for(i=0; i<n-1; i++)
        printf("P%d -> ", ans[i]);
    printf("P%d\n", ans[n-1]);
} else {
    printf("System is not in safe state\n");
}
return 0;
}
```

Output

Enter number of processes and resources:
5 3
Enter allocation matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter max matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3



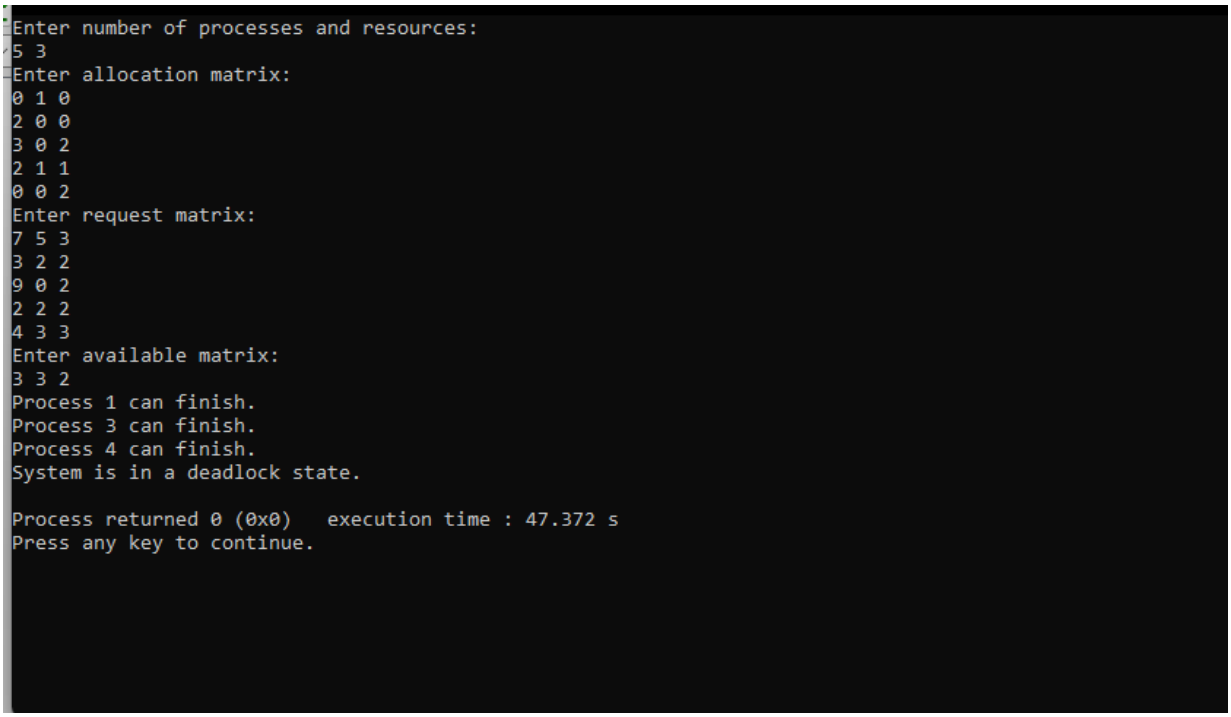
Program 8:

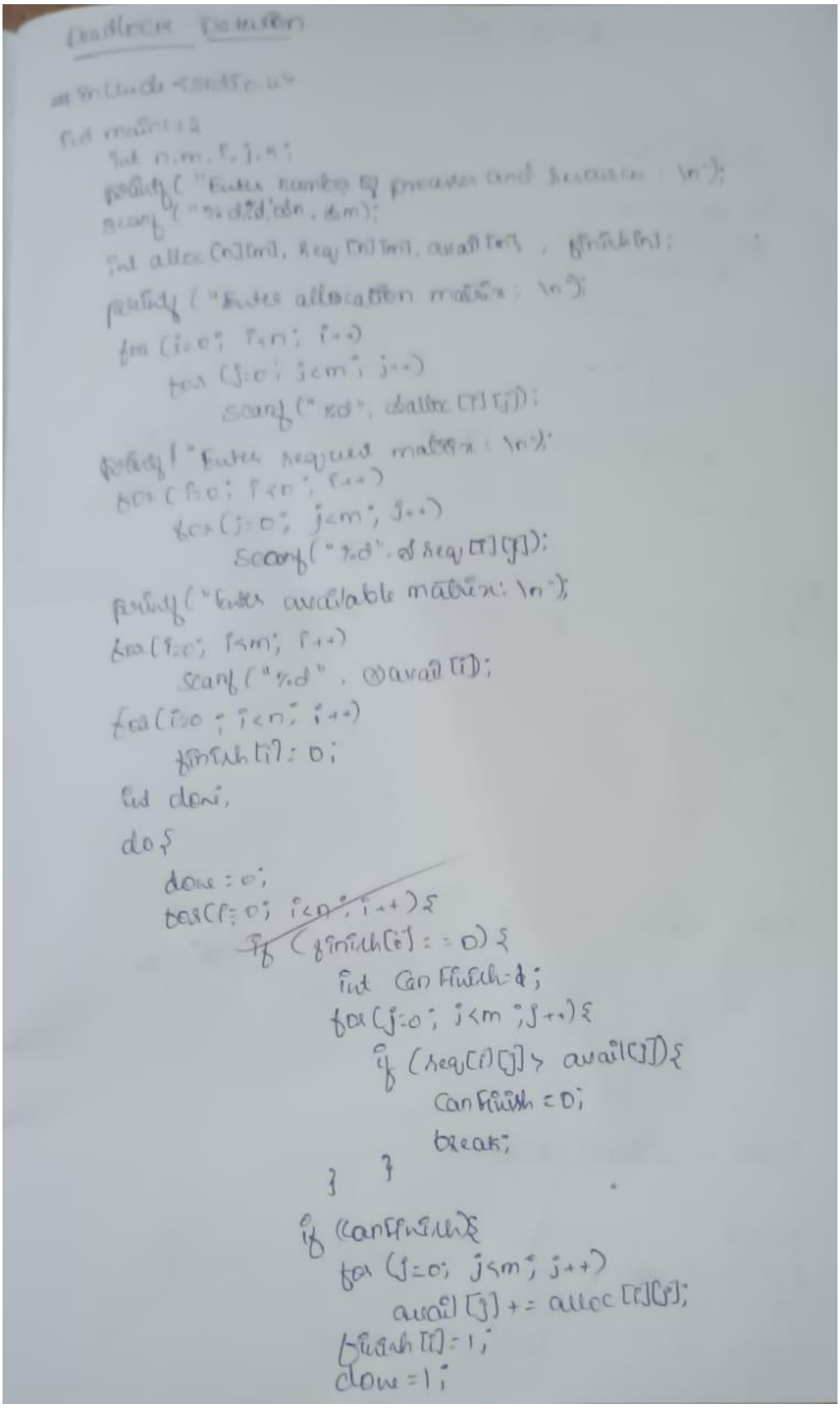
Write a C program to simulate deadlock detection

```
#include <stdio.h>

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

    int alloc[n][m], req[n][m], avail[m], finish[n];

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

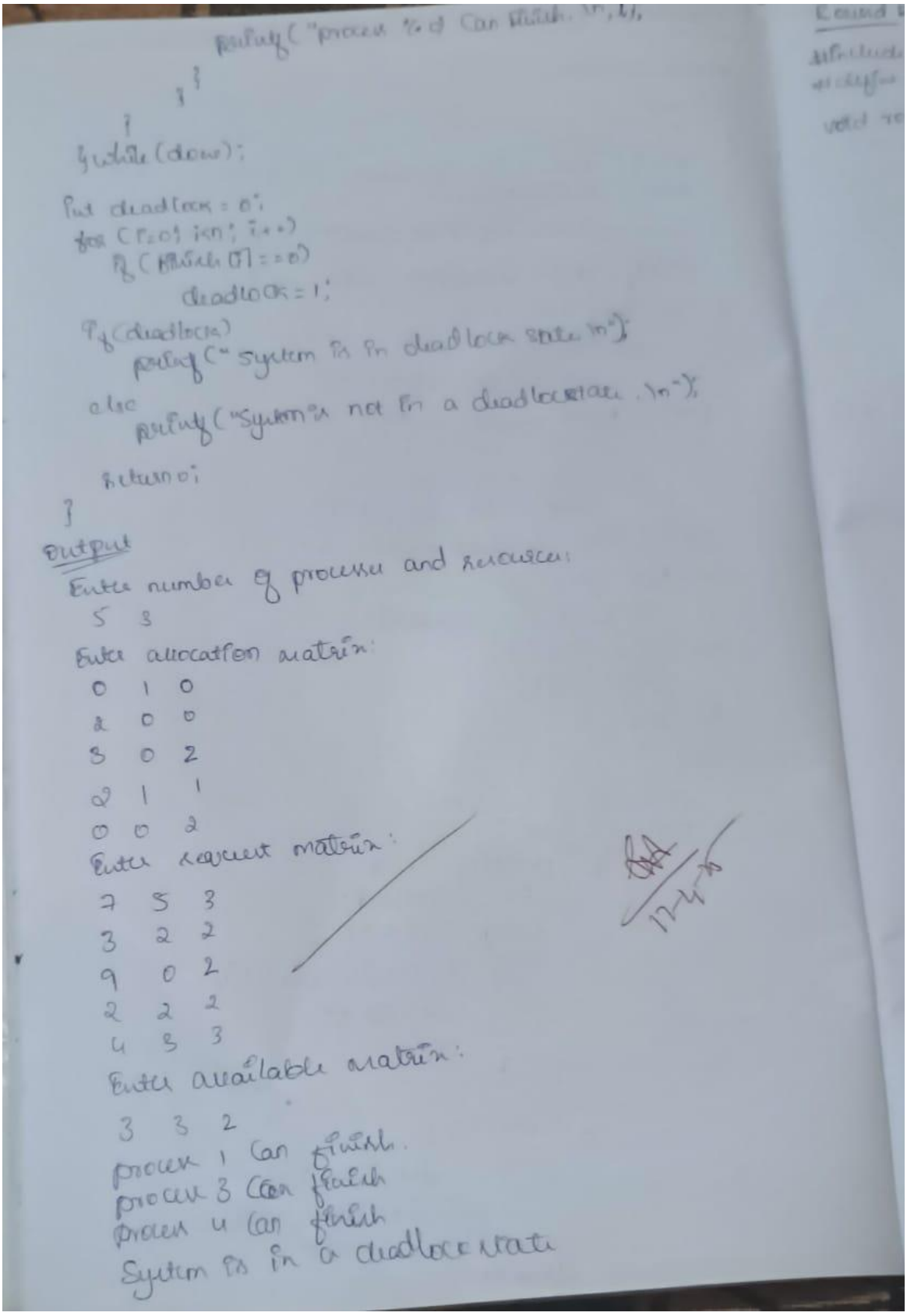
```
printf("Enter available matrix:\n");
for (i = 0; i < m; i++)
   scanf("%d", &avail[i]);

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

int done;
do {
   done = 0;
   for (i = 0; i < n; i++) {
      if (finish[i] == 0) {
         int canFinish = 1;
         for (j = 0; j < m; j++) {
            if (req[i][j] > avail[j]) {
               canFinish = 0;
               break;
            }
         }
         if (canFinish) {
            for (j = 0; j < m; j++)
               avail[j] += alloc[i][j];
            finish[i] = 1;
            done = 1;
            printf("Process %d can finish.\n", i);
         }
      }
   }
} while (done);
```

```
    int deadlock = 0;
    for (i = 0; i < n; i++)
        if (finish[i] == 0)
            deadlock = 1;

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

    return 0;
}
```


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 : 47.372 s
Press any key to continue.



```
Deadlock Detection

#include<stdio.h>
int main(){
    int n,m,i,j,k;
    printf("Enter number of process and resources: \n");
    scanf("%d%d",&n,&m);
    int alloc[n][m], req[n][m], avail[m], finish[n];
    printf("Enter allocation matrix: \n");
    for(i=0; i<n; i++)
        for(j=0; j<m; j++)
            scanf("%d", &alloc[i][j]);
    printf("Enter required matrix: \n");
    for(i=0; i<n; i++)
        for(j=0; j<m; j++)
            scanf("%d", &req[i][j]);
    printf("Enter available matrix: \n");
    for(i=0; i<m; i++)
        scanf("%d", &avail[i]);
    for(i=0; i<n; i++)
        finish[i]=0;
    int done;
    do{
        done=0;
        for(i=0; i<n; i++){
            if(finish[i]==0){
                int canFinish=1;
                for(j=0; j<m; j++){
                    if(req[i][j]>avail[j]){
                        canFinish=0;
                        break;
                    }
                }
                if(canFinish){
                    for(j=0; j<m; j++)
                        avail[j]+=alloc[i][j];
                    finish[i]=1;
                    done=1;
```



```
            printf("process %d can finish.\n", i);
        }
    }
    while(done);

int deadlock = 0;
for(i=0; i<n; i++)
    if(finish[i] == 0)
        deadlock = 1;
if(deadlock)
    printf("System is in deadlock state.\n");
else
    printf("System is not in a deadlock state.\n");

return 0;
}
```

Output

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

Program 9:

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

a) **Worst Fit**
b) **Best Fit**
c) **First Fit**

→Worst Fit

```
#include <stdio.h>

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

struct File {
   int file_no;
   int file_size;
};

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

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

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

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

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

int main() {
    int n_blocks, n_files;

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

    struct Block blocks[n_blocks];

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

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

    struct File files[n_files];

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

    worstFit(blocks, n_blocks, files, n_files);

    return 0;
}
```

```
Enter the number of blocks: 5
Enter the size of block 1: 100
Enter the size of block 2: 500
Enter the size of block 3: 200
Enter the size of block 4: 300
Enter the size of block 5: 600
Enter the number of files: 4
Enter the size of file 1: 212
Enter the size of file 2: 417
Enter the size of file 3: 112
Enter the size of file 4: 426

Memory Management Scheme - Worst Fit
File_no File_size       Block_no        Block_size      Fragment
1       212             5               600             388
2       417             2               500             83
3       112             4               300             188
4       426             Not Allocated
```

→Best Fit

```
#include <stdio.h>

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

struct File {
    int file_no;
    int file_size;
};

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

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

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

```
            }
        }

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

int main() {
    int n_blocks, n_files;

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

    struct Block blocks[n_blocks];

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

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

    struct File files[n_files];

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

    bestFit(blocks, n_blocks, files, n_files);

    return 0;
}
```

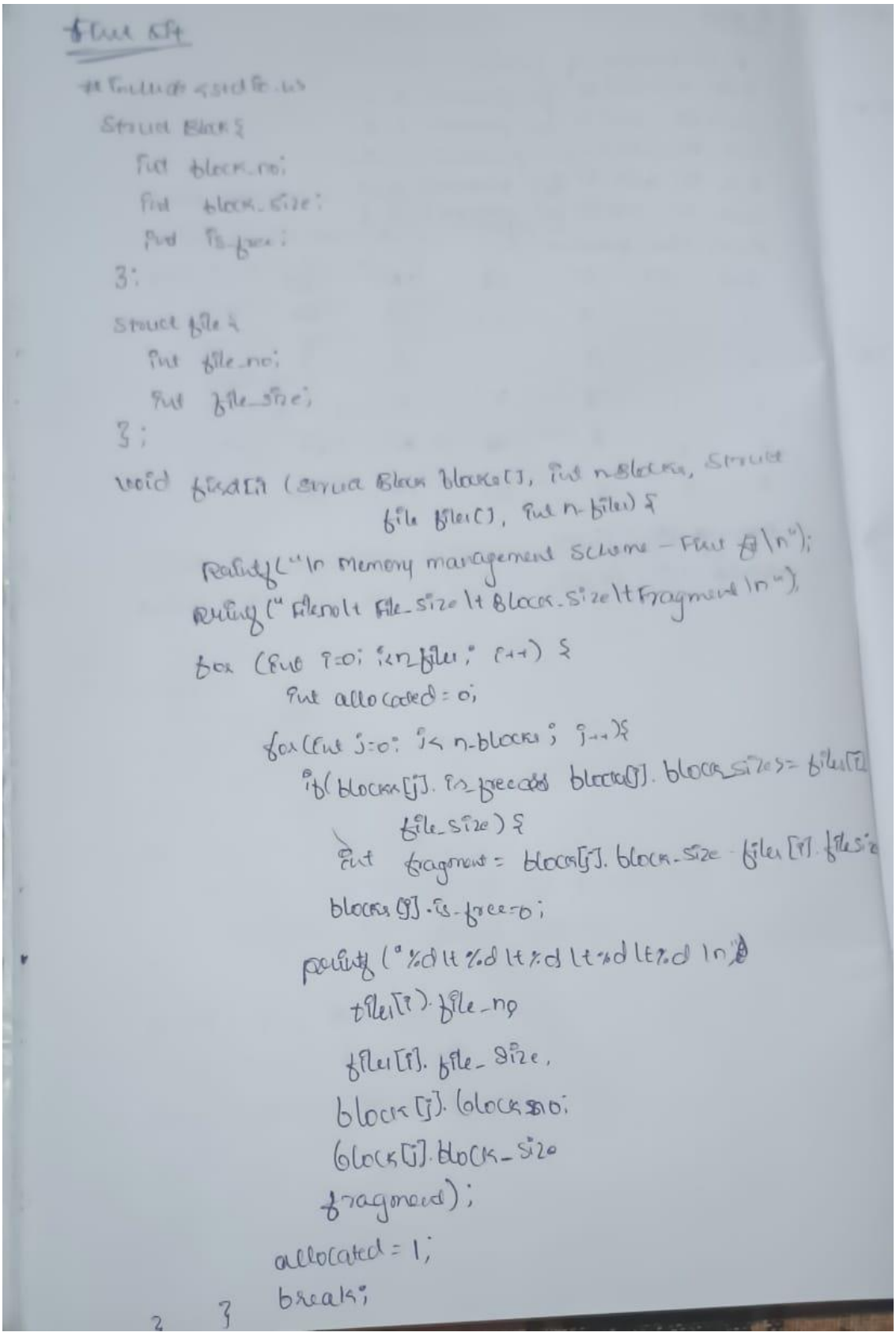
```
Enter the number of blocks: 5
Enter the size of block 1: 100
Enter the size of block 2: 500
Enter the size of block 3: 200
Enter the size of block 4: 300
Enter the size of block 5: 600
Enter the number of files: 4
Enter the size of file 1: 212
Enter the size of file 2: 417
Enter the size of file 3: 113
Enter the size of file 4: 426

Memory Management Scheme - Best Fit
File_no File_size       Block_no        Block_size      Fragment
1       212             4               300             88
2       417             2               500             83
3       113             3               200             87
4       426             5               600             174
```

→First Fit

```
#include <stdio.h>

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

struct File {
    int file_no;
    int file_size;
};

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

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

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

                printf("%d\t%d\t\t%d\t\t%d\t\t%d\n",
                       files[i].file_no,
```

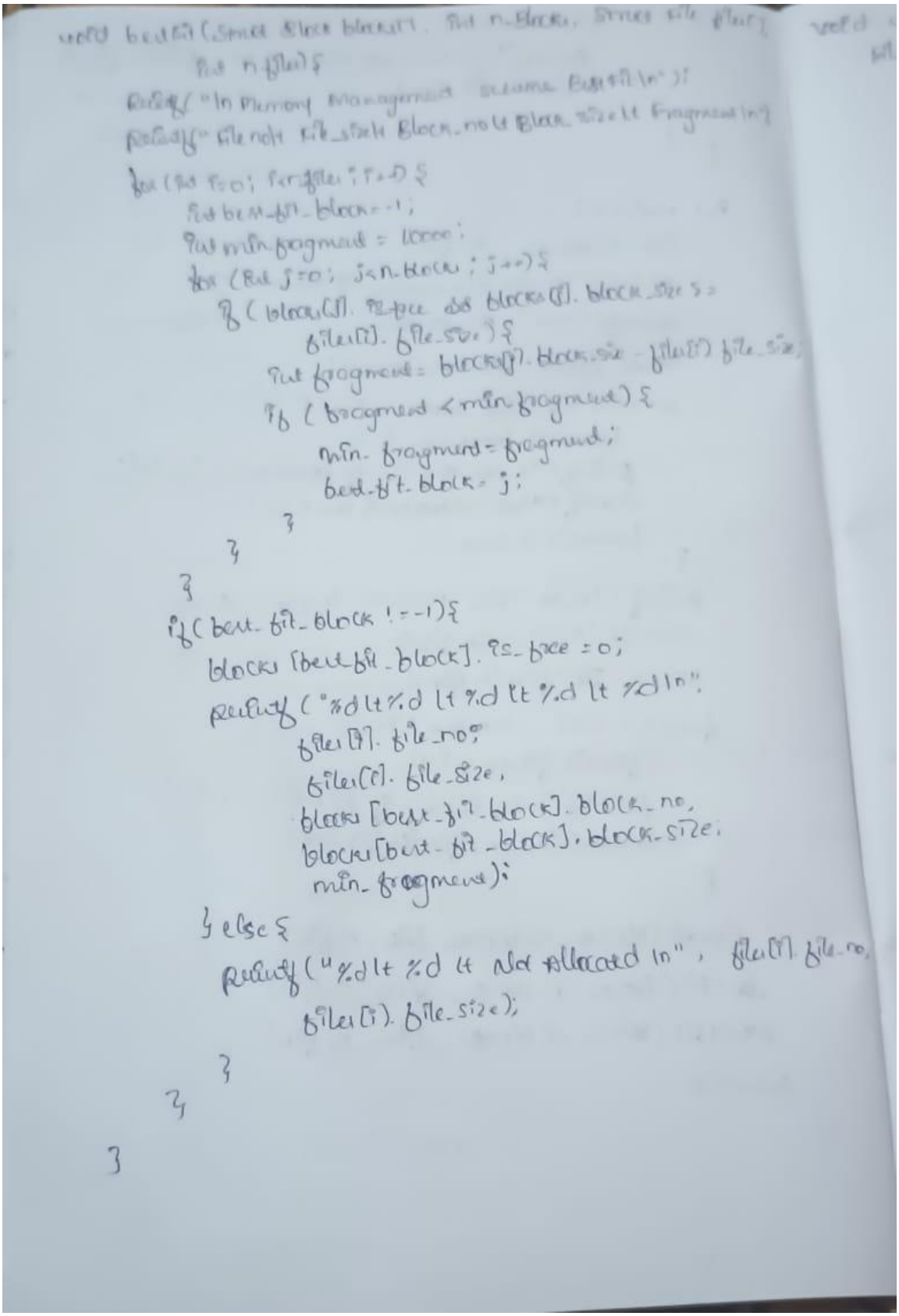
```
                files[i].file_size,
                blocks[j].block_no,
                blocks[j].block_size,
                fragment);

            allocated = 1;
            break;
        }
    }

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

int main() {
  int n_blocks, n_files;

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

  struct Block blocks[n_blocks];

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

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

  struct File files[n_files];

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

  firstFit(blocks, n_blocks, files, n_files);

  return 0;
}
```

```
Enter the number of blocks: 5
Enter the size of block 1: 100
Enter the size of block 2: 500
Enter the size of block 3: 200
Enter the size of block 4: 300
Enter the size of block 5: 600
Enter the number of files: 4
Enter the size of file 1: 212
Enter the size of file 2: 417
Enter the size of file 3: 112
Enter the size of file 4: 426

Memory Management Scheme - First Fit
File_no File_size       Block_no        Block_size      Fragment
1       212             2               500             288
2       417             5               600             183
3       112             3               200             88
4       426             Not Allocated
```

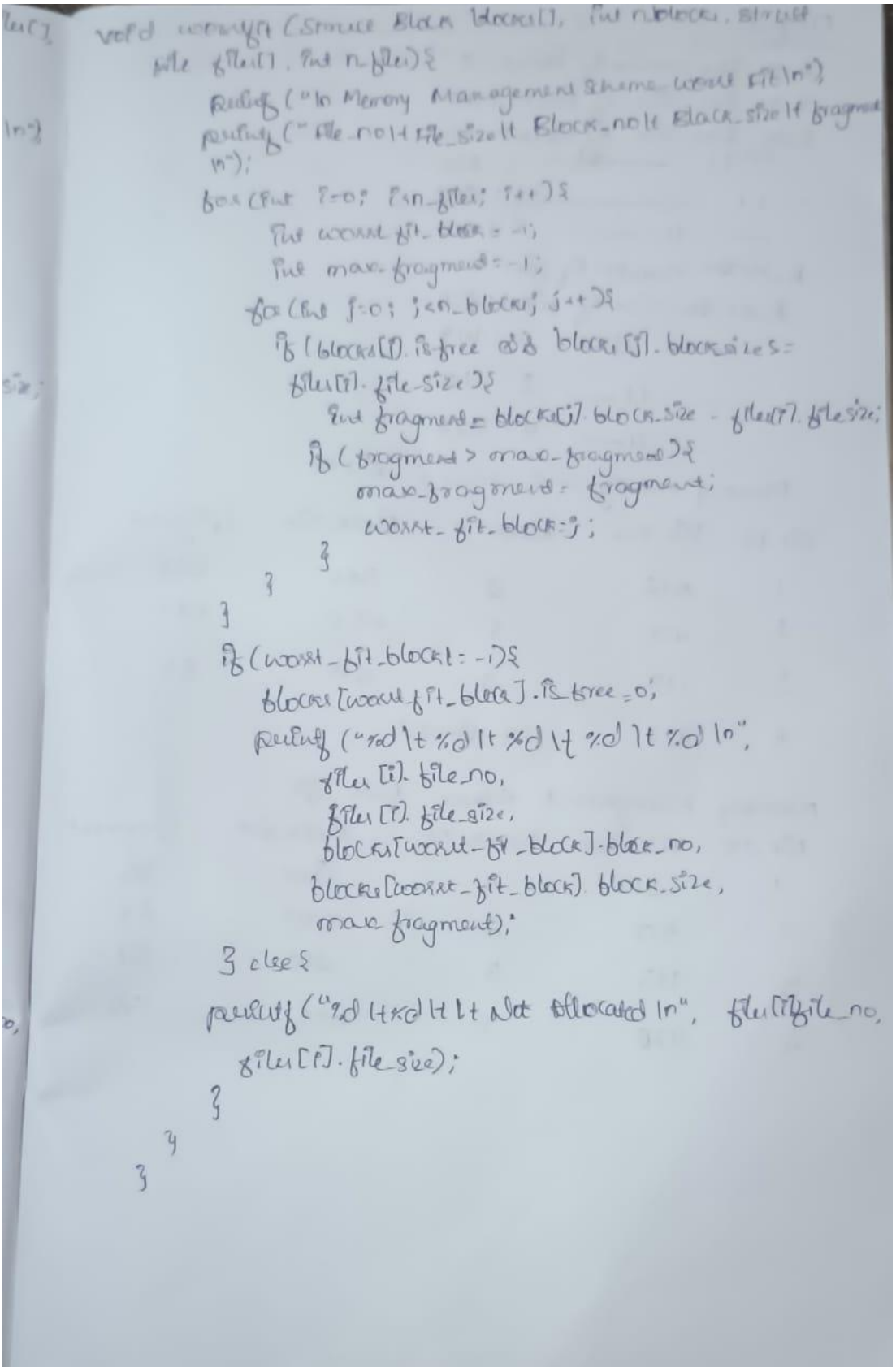


```
First fit

#include<stdio.h>
struct Block {
    int block_no;
    int block_size;
    int is_free;
};
struct file {
    int file_no;
    int file_size;
};
void firstfit(struct Block blocks[], int n_blocks, struct
                file files[], int n_files) {
    printf("\n Memory management scheme - First fit\n");
    printf("File no\t File_size\t Block_size\t Fragment\n");
    for (int i=0; i<n_files; i++) {
        int allocated = 0;
        for(int j=0; j< n_blocks; j++){
            if(blocks[j].is_free && blocks[j].block_size >= files[i].
                file_size) {
                int fragment = blocks[j].block_size - files[i].filesize
                blocks[j].is_free=0;
                printf("%d\t %d\t %d\t %d\t %d\n",
                    files[i].file_no,
                    files[i].file_size,
                    blocks[j].block_no,
                    blocks[j].block_size
                    fragment);
                allocated = 1;
                break;
            }
        }
```

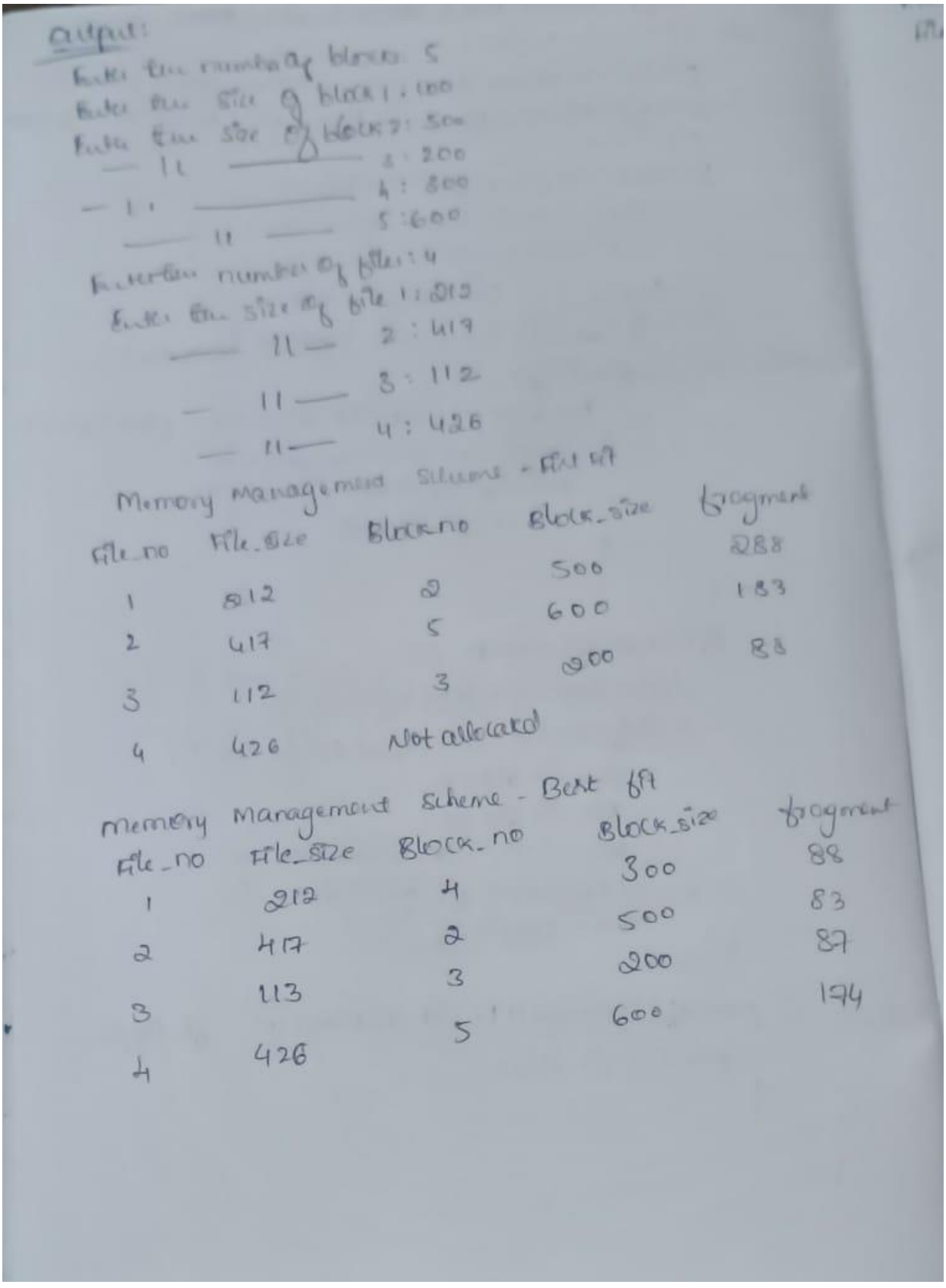
```
        if(!allocated){
            printf("%d\t\t%d\t Not allocated\n", files[i].file_no,
              files[i].file_size);
        }
    }
}

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



```
void bestFit(struct Block blocks[], int n_blocks, struct File files[],
             int n_files) {
    printf("\n Memory Management Scheme - Best Fit\n");
    printf("File no\t File size\t Block no\t Block size\t Fragment\n");

    for (int i=0; i<n_files; i++) {
        int best_fit_block = -1;
        int min_fragment = 10000;
        for (int j=0; j<n_blocks; j++) {
            if (blocks[j].is_free && blocks[j].block_size >=
                files[i].file_size) {
                int fragment = blocks[j].block_size - files[i].file_size;
                if (fragment < min_fragment) {
                    min_fragment = fragment;
                    best_fit_block = j;
                }
            }
        }
        if (best_fit_block != -1) {
            blocks[best_fit_block].is_free = 0;
            printf("%d\t%d\t%d\t%d\t%d\n",
                files[i].file_no,
                files[i].file_size,
                blocks[best_fit_block].block_no,
                blocks[best_fit_block].block_size,
                min_fragment);
        } else {
            printf("%d\t%d\t Not allocated\n", files[i].file_no,
                files[i].file_size);
        }
    }
}
```



```
void worstFit(struct Block blocks[], int n_blocks, struct
    File files[], int n_files){
        printf("\n Memory Management Scheme - Worst Fit\n");
        printf("File_no\tFile_size\tBlock_no\tBlock_size\tFragment
        \n");
        for(int i=0; i<n_files; i++){
            int worst_fit_block = -1;
            int max_fragment = -1;
            for(int j=0; j<n_blocks; j++){
                if (blocks[j].is_free && blocks[j].block_size >=
                files[i].file_size){
                    int fragment = blocks[j].block_size - files[i].file_size;
                    if (fragment > max_fragment){
                        max_fragment = fragment;
                        worst_fit_block = j;
                    }
                }
            }
            if(worst_fit_block != -1){
                blocks[worst_fit_block].is_free = 0;
                printf("%d\t%d\t%d\t%d\t%d\n",
                    files[i].file_no,
                    files[i].file_size,
                    blocks[worst_fit_block].block_no,
                    blocks[worst_fit_block].block_size,
                    max_fragment);
            } else {
            printf("%d\t%d\tNot allocated\n", files[i].file_no,
              files[i].file_size);
            }
        }
    }
```



Output:

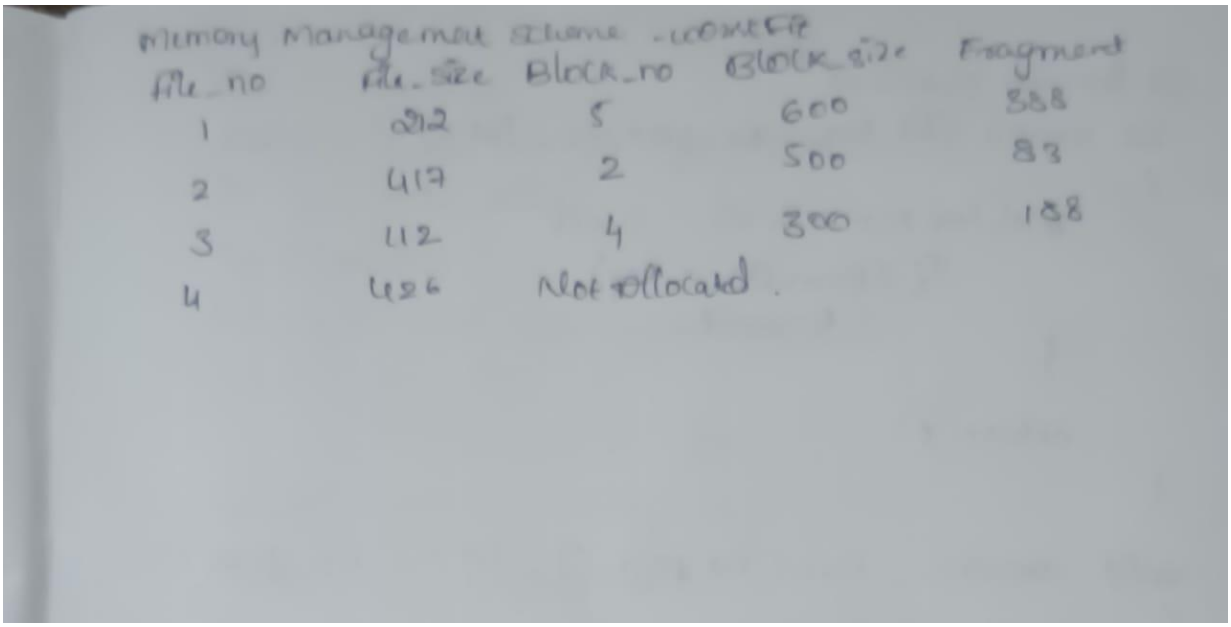
Enter the number of blocks: 5
Enter the size of block 1: 100
Enter the size of block 2: 500
— " — 3: 200
— " — 4: 800
— " — 5: 600
Enter the number of files: 4
Enter the size of file 1: 212
— " — 2: 417
— " — 3: 112
— " — 4: 426

Memory Management Scheme - First fit

File_no	File_Size	Block no	Block_size	fragment
1	212	2	500	288
2	417	5	600	183
3	112	3	200	88
4	426	Not allocated		

Memory Management Scheme - Best fit

File_no	File_Size	Block_no	Block_size	fragment
1	212	4	300	88
2	417	2	500	83
3	112	3	200	87
4	426	5	600	174



Program 10:
Write a C program to simulate page replacement algorithms

a) **FIFO**
b) **LRU**
c) **Optimal**

→FIFO

```
#include <stdio.h>

int main() {
   int n, frames, i, j, k, found, index = 0, page_faults = 0, hits = 0;
   char pages[100];

   printf("Enter the size of the pages:\n");
   scanf("%d", &n);
   printf("Enter the page strings:\n");
   scanf("%s", pages);
   printf("Enter the no of page frames:\n");
   scanf("%d", &frames);

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

   for (i = 0; i < n; i++) {
      found = 0;
      for (j = 0; j < frames; j++) {
         if (mem[j] == pages[i] - '0') {
            hits++;
            found = 1;
```

```
            break;
        }
    }
    if (!found) {
        mem[index] = pages[i] - '0';
        index = (index + 1) % frames;
        page_faults++;
    }
}

printf("FIFO Page Faults: %d, Page Hits: %d\n", page_faults, hits);
return 0;
}
```

```
Enter the size of the pages:
7
Enter the page strings:
103563
Enter the no of page frames:
3
FIFO Page Faults: 6, Page Hits: 1
```

→LRU

```
#include <stdio.h>

int main() {
    int n, frames, i, j, k, page_faults = 0, hits = 0;
    char pages[100];
    int mem[10], used[10];

    printf("Enter the size of the pages:\n");
    scanf("%d", &n);
    printf("Enter the page strings:\n");
    scanf("%s", pages);
    printf("Enter the no of page frames:\n");
    scanf("%d", &frames);

    for (i = 0; i < frames; i++) {
        mem[i] = -1;
        used[i] = -1;
    }

    for (i = 0; i < n; i++) {
        int page = pages[i] - '0';
        int found = 0;

        for (j = 0; j < frames; j++) {
```

```
            if (mem[j] == page) {
                hits++;
                used[j] = i;
                found = 1;
                break;
            }
        }

        if (!found) {
            int lru = 0;
            for (j = 1; j < frames; j++) {
                if (used[j] < used[lru]) lru = j;
            }
            mem[lru] = page;
            used[lru] = i;
            page_faults++;
        }
    }

    printf("LU Page Faults: %d, Page Hits: %d\n", page_faults, hits);
    return 0;
}
```

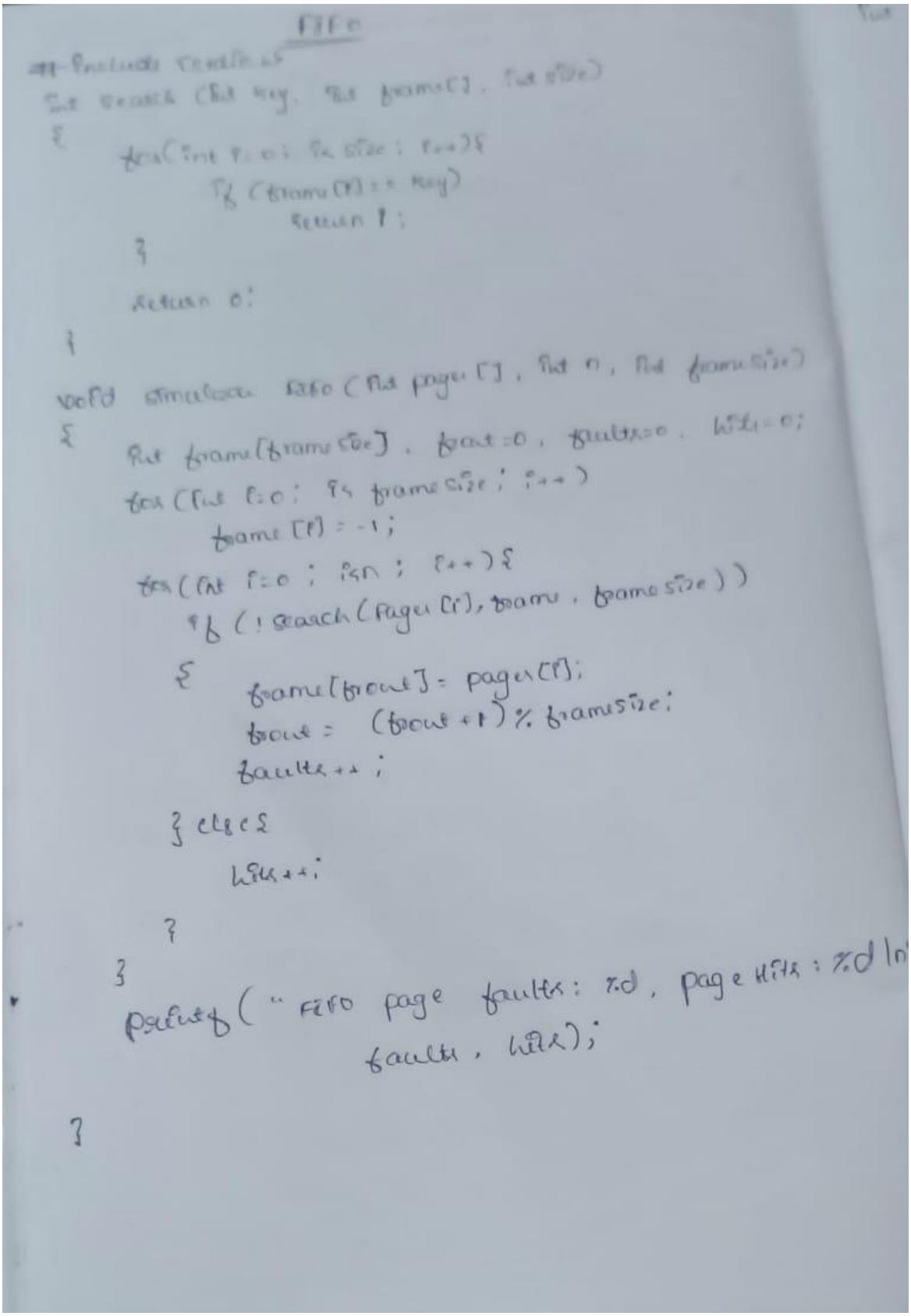
```
Enter the size of the pages:
7
Enter the page strings:
1303563
Enter the no of page frames:
3
LU Page Faults: 5, Page Hits: 2
```

→Optimal

```
#include <stdio.h>

int main() {
    int n, frames, i, j, k, page_faults = 0, hits = 0;

    printf("Enter the size of the pages:\n");
    scanf("%d", &n);

    char pages[n + 1];
    printf("Enter the page strings:\n");
    scanf("%s", pages);

    printf("Enter the no of page frames:\n");
    scanf("%d", &frames);

    int mem[frames], next_use[frames];
```

```
    for (i = 0; i < frames; i++) {
        mem[i] = -1;
    }

    for (i = 0; i < n; i++) {
        int page = pages[i] - '0';
        int found = 0;

        for (j = 0; j < frames; j++) {
            if (mem[j] == page) {
                hits++;
                found = 1;
                break;
            }
        }

        if (!found) {
            if (page_faults < frames) {
                mem[page_faults++] = page;
            } else {
                for (j = 0; j < frames; j++) {
                    next_use[j] = -1;
                    for (k = i + 1; k < n; k++) {
                        if (mem[j] == pages[k] - '0') {
                            next_use[j] = k;
                            break;
                        }
                    }
                }

                int farthest = 0;
                for (j = 1; j < frames; j++) {
                    if (next_use[j] > next_use[farthest]) {
                        farthest = j;
                    }
                }

                mem[farthest] = page;
                page_faults++;
            }
        }
    }

    printf("Optimal Page Faults: %d, Page Hits: %d\n", page_faults, hits);
    return 0;
}
```

```
Enter the size of the pages:
7
Enter the page strings:
13035631
Enter the no of page frames:
3
Optimal Page Faults: 6, Page Hits: 1
```



FIFO

```
#include <stdio.h>
int search(int key, int frame[], int size)
{
    for(int i=0; i<size; i++){
        if (frame[i] == key)
            return 1;
    }
    return 0;
}
void simulateFIFO(int pages[], int n, int frameSize)
{
    int frame[frameSize], front=0, faults=0, hits=0;
    for(int i=0; i<frameSize; i++)
        frame[i] = -1;
    for(int i=0; i<n; i++){
        if (!search(pages[i], frame, frameSize))
        {
            frame[front] = pages[i];
            front = (front+1) % frameSize;
            faults++;
        }else{
            hits++;
        }
    }
    printf("FIFO page faults: %d, page hits: %d\n",
            faults, hits);
}
```

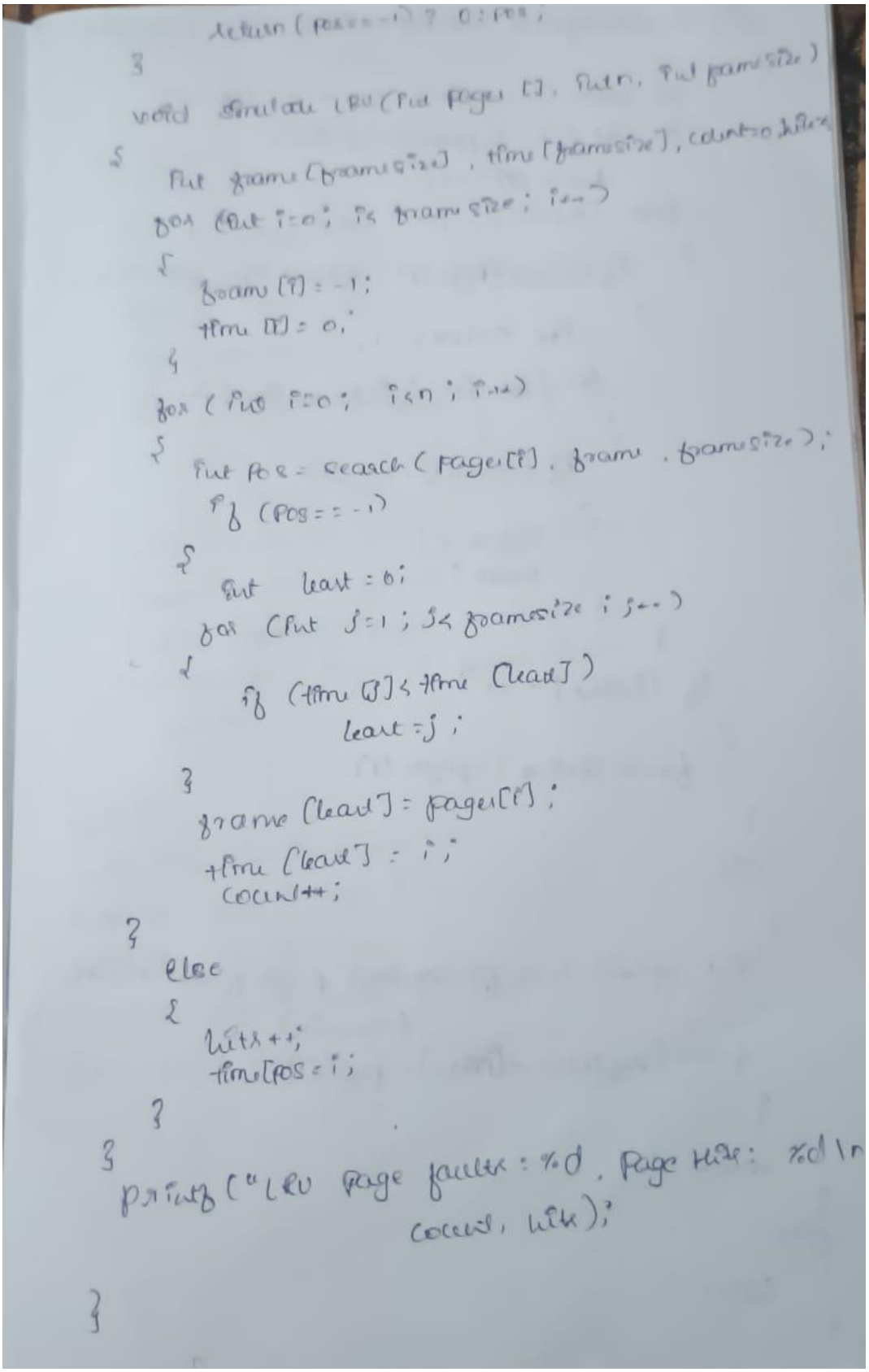
```
int main() {
    int n, framesize;
    printf("Enter the size of the pages: ");
    scanf("%d", &n);
    int pages[n];
    printf("Enter the page strings: ");
    for(int i=0; i<n; i++)
        scanf("%d", &pages[i]);
    printf("Enter the no of page frames: ");
    scanf("%d", &framesize);
    simulateFIFO(pages, n, framesize);
    return 0;
}
```

Output

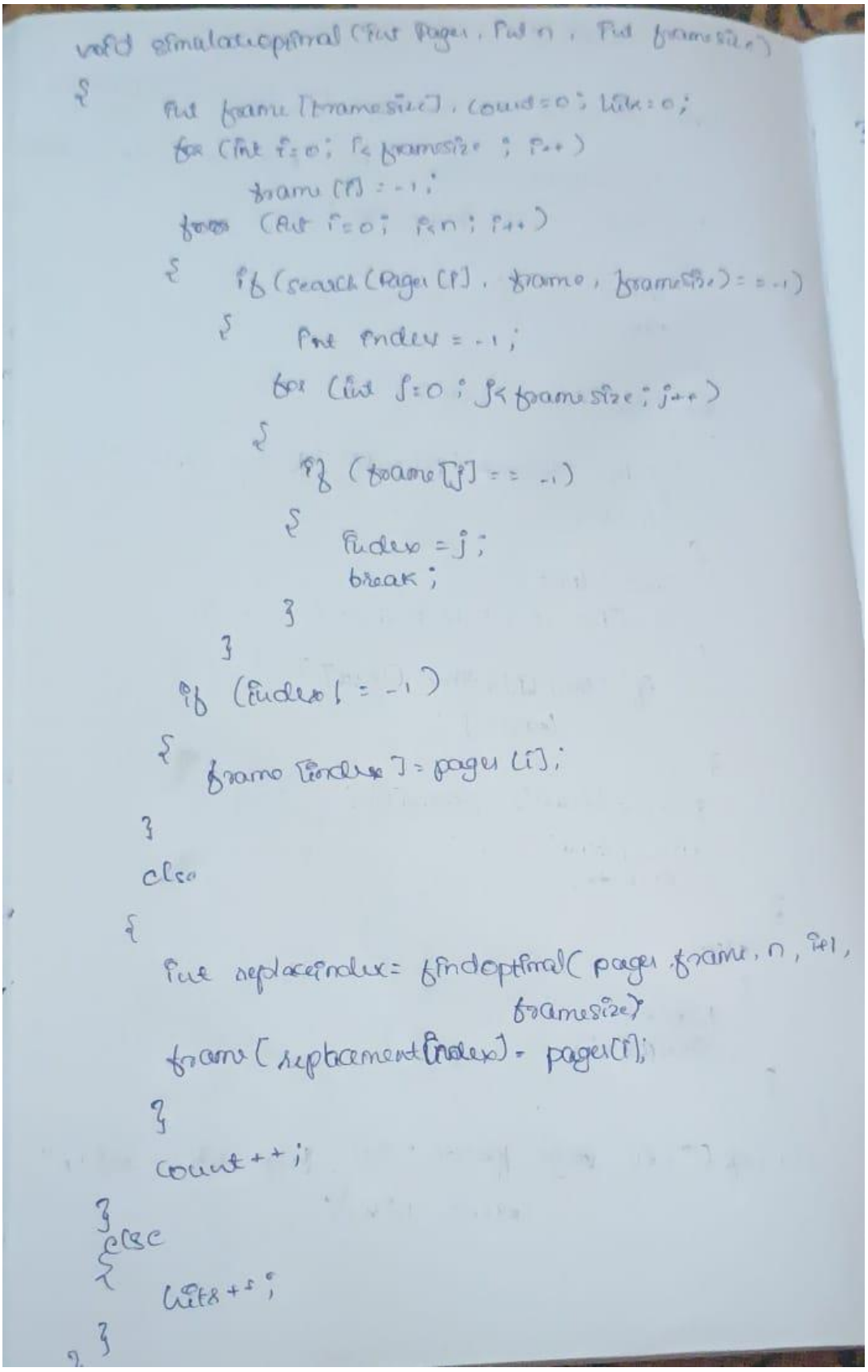
```
Enter the size of pages: 7
Enter the page strings: 1 3 0 3 5 6 3
FIFO page faults: 6
Page Hits: 1
```

LRU and optimal

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

int search (int key, int frame[], int frame_size)
{
    int i;
    for(i=0; i< frame_size; i++)
    {
        if (frame[i] == key)
            return i;
    }
    return -1;
}
int findoptimal (int page[], int frame[], int n,
    int index, int frame_size)
{
    int farthest = index, pos = -1;
    for (int i=0; i< frame_size; i++)
    {
        int j;
        for (j= index; j<n; j++)
        {
            if (frame[i] == page[j])
            {
                if (j > farthest)
                {
                    farthest = j;
                    pos = i;
                }
                break;
            }
        }
        if (j == n)
            return i;
    }
```



```
    return (pos==-1) ? 0:pos;
}
void simulateLRU(int pages[], int n, int framesize)
{
    int frame[framesize], time[framesize], count=0, hits=0;
    for(int i=0; i<framesize; i++)
    {
        frame[i] = -1;
        time[i] = 0;
    }
    for(int i=0; i<n; i++)
    {
        int pos = search(pages[i], frame, framesize);
        if(pos==-1)
        {
            int least=0;
            for(int j=1; j<framesize; j++)
            {
                if(time[j]<time[least])
                    least=j;
            }
            frame[least] = pages[i];
            time[least] = i;
            count++;
        }
        else
        {
            hits++;
            time[pos]=i;
        }
    }
    printf("LRU page faults: %d, Page Hits: %d\n",
                count, hits);
}
```



```
void simulateoptimal (int pages, int n, int framesize)
{
    int frame[framesize], count=0; hits=0;
    for (int i=0; i<framesize ; i++)
        frame[i] = -1;
    for (int i=0; i<n ; i++)
    {
        if (search(pages[i], frame, framesize) == -1)
        {
            int index = -1;
            for (int j=0; j<framesize; j++)
            {
                if (frame[j] == -1)
                {
                    index = j;
                    break;
                }
            }
        if (index != -1)
        {
            frame[index] = pages[i];
        }
        else
        {
            int replaceindex= findoptimal( pages, frame, n, i+1,
                                framesize)
            frame[replacement[index]= pages[i];
        }
        count++;
    }
    else
    {
        hits++;
    }
}
```

```
    printf("optimal page faults: %d, Page hits: %d\n",
                    faults, hits);
}

int main()
{
    int n, framesize;
    printf("Enter the size of the pages: ");
    scanf("%d", &n);
    int pages[n];
    printf("Enter the page strings: \n");
    for (int i=0; i<n; i++)
        scanf("%d", &pages[i]);
    printf("Enter the no of page frames: ");
    scanf("%d", &framesize);
    simulateoptimal(pages, n, framesize);
    simulateLRU(Pages, n, framesize);
    return 0;
}
```

Output

```
Enter the size of pages: 12
Enter the page strings: 7 0 1 2 0 3 0 4 2 3 0 3
Enter the no of frames: 3
Optimal page Faults: 7, Page hits: 5
LRU page faults: 9, Page Hits: 3.
```