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LAB REPORT

on

OPERATING SYSTEMS

Submitted by

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(1BM22CS190)

in partial fulfillment for the award of the degree of

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in

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CERTIFICATE

This is to certify that the Lab work entitled "OPERATING SYSTEMS – 23CS4PCOPS" carried out by Parth Rawat (1BM22CS190), 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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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

Question:

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

→FCFS

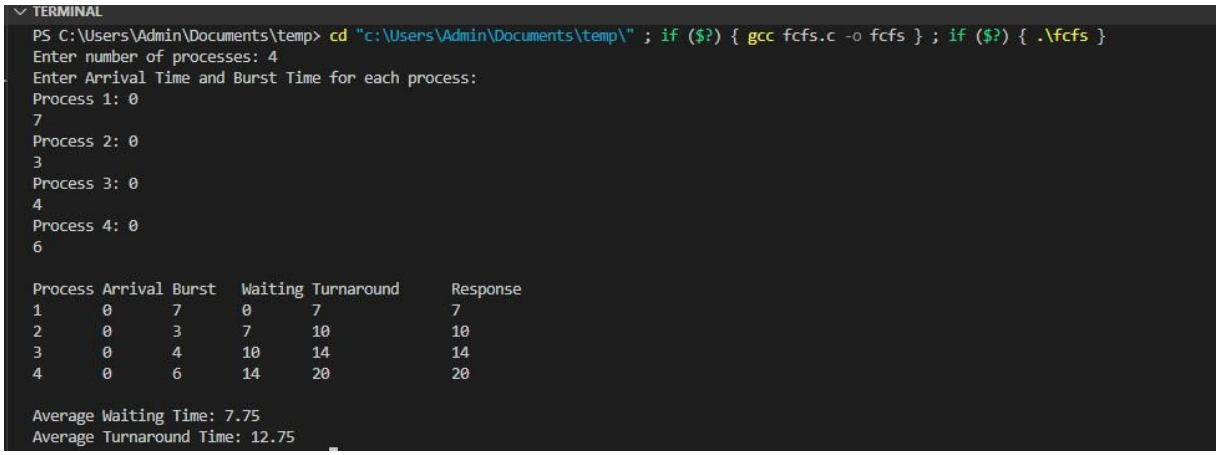
→ SJF (pre-emptive & Non-preemptive)

Code:

```
#include <stdio.h>
void main() {
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    int arrival[n], burst[n], waiting[n], turnaround[n],
completion[n], response[n];
    printf("Enter Arrival Time and Burst Time for each
process:\n");
    for (int i = 0; i < n; i++) {
        printf("Process %d: ", i + 1);
        scanf("%d %d", &arrival[i], &burst[i]);
    }
    int currentTime = 0;
    float totalWaiting = 0, totalTurnaround = 0;

printf("\nProcess\tArrival\tBurst\tWaiting\tTurnaround\tResponse\n"
);
    for (int i = 0; i < n; i++) {
         if (currentTime < arrival[i])
            currentTime = arrival[i];
        completion[i] = currentTime + burst[i];
        turnaround[i] = completion[i] - arrival[i];
        waiting[i] = turnaround[i] - burst[i];
        response[i] = completion[i] - arrival[i];
        totalWaiting += waiting[i];
        totalTurnaround += turnaround[i];
        printf("%d\t%d\t%d\t%d\t%d\t\t%d\n", i + 1, arrival[i],
burst[i], waiting[i], turnaround[i], response[i]);
        currentTime = completion[i];
    }
    printf("\nAverage Waiting Time: %.2f", totalWaiting / n);
```

```
    printf("\nAverage Turnaround Time: %.2f\n", totalTurnaround / n);
}
```

Result:



Write a C program to implement first come first serve algorithm (FCFS).

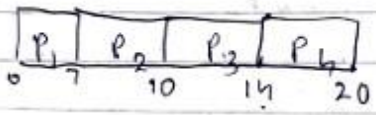
```
#include <stdio.h>
void main()
{
  int n;
  printf("Enter number of processes: ");
  scanf("%d", &n);
  int arrival[n], burst[n], waiting[n], turnaround[n], completion[n];
  printf("Enter arrival time and burst time for each process:\n");
  for (int i = 0; i<n; i++) {
      printf("Process %d: ", i+1);
      scanf("%d %d", &arrival[i], &burst[i]); }
  int currentTime = 0;
  float totalWaiting = 0, totalTurnaround = 0;
  printf("\n Process \t Arrival \t Waiting \t Turnaround \n");
  for(int i = 0; i<n; i++) {
      if (currentTime < arrival[i])
          currentTime = arrival[i];
      completion[i] = currentTime + burst[i];
      turnaround[i] = completion[i] - arrival[i];
      waiting[i] = turnaround[i] - burst[i];
      response[i] = completion[i] - arrival[i]
      totalTurnaround += turnaround[i];
      totalWaiting += waiting[i];
  printf("%d \t %d \t %d \t %d \t %d \n", i+1,
      arrival[i], burst[i], waiting[i], turnaround[i]
      currentTime = completion[i];
      }
```

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

Output

```
Enter number of processes: 4
Enter arrival time and burst time for each process:
Process 1: 0 7
Process 2: 0 3
Process 3: 0 4
Process 4: 0 6
```

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



Average Waiting Time: 7.75
Average Turnaround Time: 12.75

6/9/25

=>SJF(Non-preemptive):

Code:

```
#include <stdio.h>
void nonPreemptiveSJF(int n, int at[], int bt[], int ct[], int
tat[], int wt[], int rt[])
{
    int completed = 0, time = 0, min_bt, shortest, finish_time;
    int remaining_bt[n];
    for (int i = 0; i < n; i++)
    {
        remaining_bt[i] = bt[i];
    }

    while (completed < n)
    {
        min_bt = 9999;
        shortest = -1;
        for (int i = 0; i < n; i++)
        {
            if (at[i] <= time && remaining_bt[i] > 0 && bt[i] <
min_bt)
            {
                min_bt = bt[i];
                shortest = i;
            }
        }
        if (shortest == -1)
        {
            time++;
            continue;
        }
        time += bt[shortest];
        remaining_bt[shortest] = 0;
```

```
            completed++;
            ct[shortest] = time;
            tat[shortest] = ct[shortest] - at[shortest];
            wt[shortest] = tat[shortest] - bt[shortest];
            rt[shortest] = wt[shortest];
        }
    }

void displayTable(int n, int at[], int bt[], int ct[], int tat[],
int wt[], int rt[])
{
    printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++)
    {
        printf("%d\t%d\t%d\t%d\t%d\t%d\t%d\n", i + 1, at[i], bt[i],
ct[i], tat[i], wt[i], rt[i]);
    }
}

int main()
{
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    int at[n], bt[n], ct[n], tat[n], wt[n], rt[n];
    printf("Enter Arrival Time and Burst Time for each
process:\n");
    for (int i = 0; i < n; i++)
    {
        printf("Process %d - Arrival Time: ", i + 1);
        scanf("%d", &at[i]);
        printf("Process %d - Burst Time: ", i + 1);
        scanf("%d", &bt[i]);
    }
```

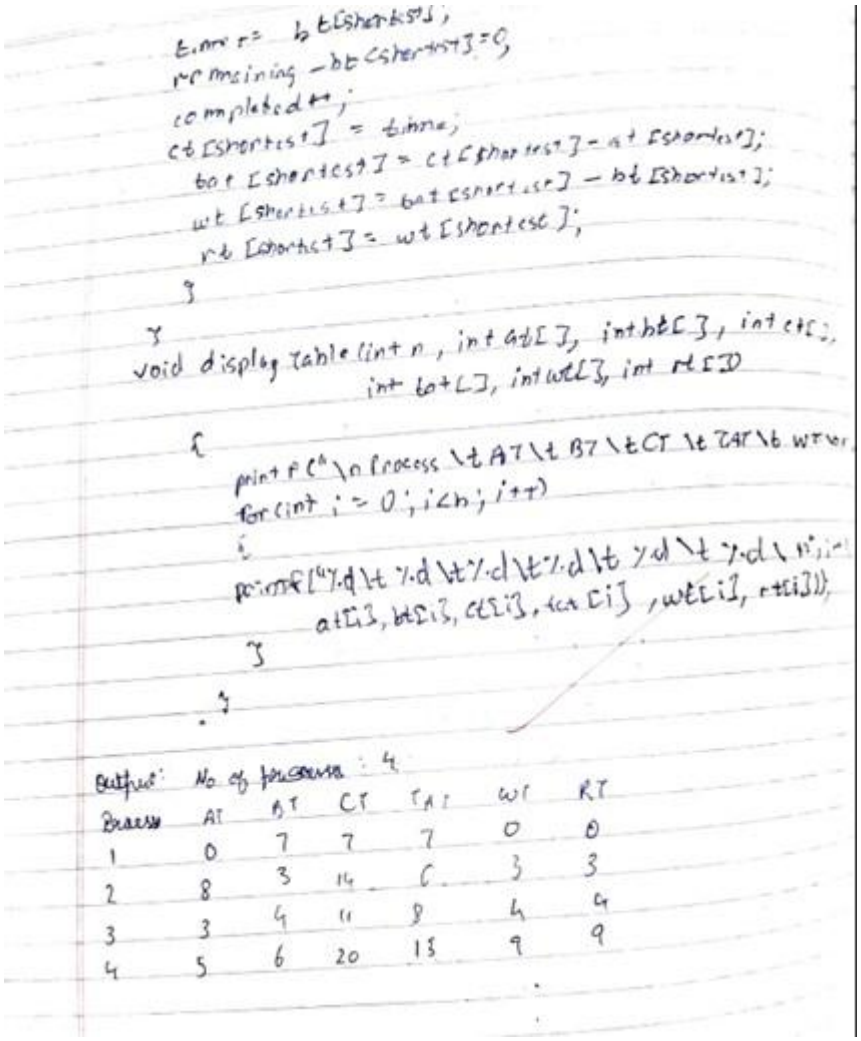
```
    nonPreemptiveSJF(n, at, bt, ct, tat, wt, rt);
    displayTable(n, at, bt, ct, tat, wt, rt);
    return 0;
}
```

Output:

```
Enter number of processes: 4
Enter Arrival Time and Burst Time for each process:
Process 1 - Arrival Time: 0
Process 1 - Burst Time: 7
Process 2 - Arrival Time: 8
Process 2 - Burst Time: 3
Process 3 - Arrival Time: 3
Process 3 - Burst Time: 4
Process 4 - Arrival Time: 5
Process 4 - Burst Time: 6

Process AT      BT      CT      TAT     WT      RT
1       0       7       7       7       0       0
2       8       3       14      6       3       3
3       3       4       11      8       4       4
4       5       6       20      15      9       9
```

8 Write a C program to implement Shortest Job First (SJF) scheduling (Non-preemptive)

```
#include<stdio.h>
void nonPreemptiveSJF(int n, int at[], int bt[], int ct[],
                      int tat[], int wt[], int rt[])
{
    int completed = 0, time = 0, min_bt, shortest, finish_time;
    int remaining_bt[n];
    for(int i = 0; i<n; i++)
    {
        remaining_bt[i] = bt[i];
    }
    while (completed < n)
    {
        min_bt = 9999;
        shortest = -1;
        for(int i = 0; i<n; i++)
        {
            if(at[i] <= time && remaining_bt[i] > 0
            && bt[i] < min_bt)
            {
                min_bt[shortest] > 0
                completed++;
                ct[shortest] = time;
                tat[shortest] = ct
                shortest = i;
            }
        }
        if(shortest == -1)
        {
            time++; continue; }
```



Output: No of process : 4

Process	AT	BT	CT	TAT	WT	RT
1	0	7	7	7	0	0
2	8	3	14	6	3	3
3	3	4	11	8	4	4
4	5	6	20	15	9	9

=> SJF (Preemptive):

Code

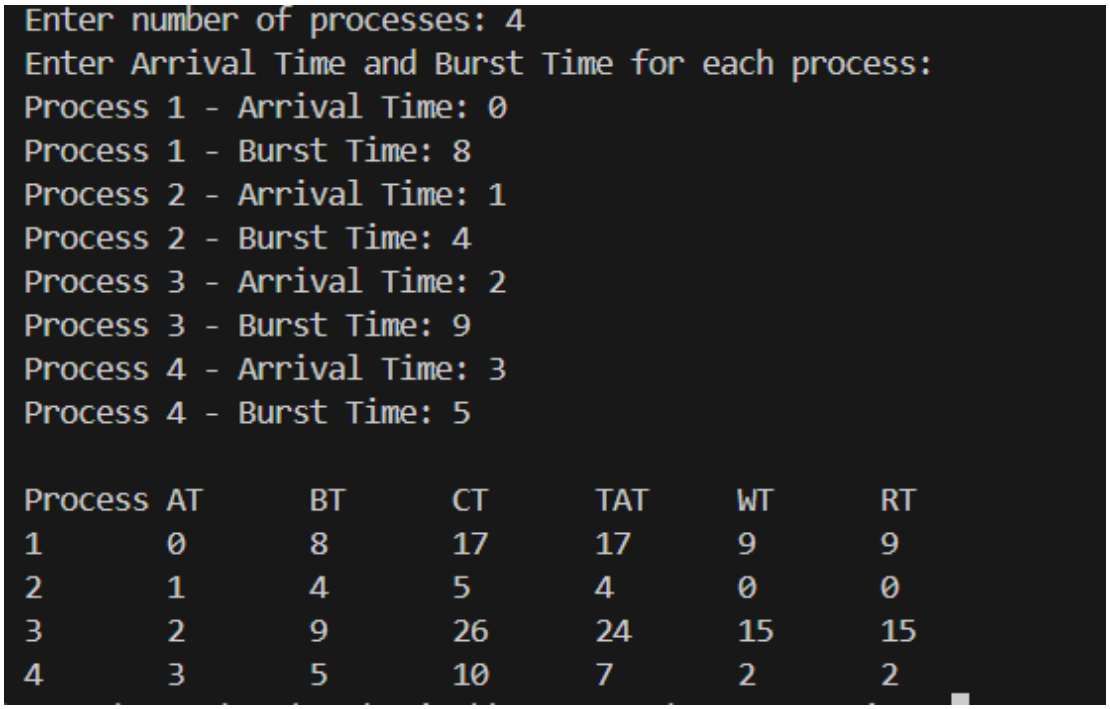
```
#include <stdio.h>

void preemptiveSJF(int n, int at[], int bt[], int ct[], int tat[],
int wt[], int rt[])

{

    int remaining_bt[n];

    int completed = 0, time = 0, min_bt, shortest;

    int flag[n];

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

    {
```

```
        remaining_bt[i] = bt[i];
        flag[i] = 0;
    }

    while (completed < n)
    {
        min_bt = 9999;
        shortest = -1;
        for (int i = 0; i < n; i++)
        {
            if (at[i] <= time && remaining_bt[i] > 0 &&
remaining_bt[i] < min_bt && flag[i] == 0)
            {
                min_bt = remaining_bt[i];
                shortest = i;
            }
        }
        if (shortest == -1)
        {
            time++;
            continue;
        }
        remaining_bt[shortest]--;
        if (remaining_bt[shortest] == 0)
        {
            completed++;
            flag[shortest] = 1;
            ct[shortest] = time + 1;
            tat[shortest] = ct[shortest] - at[shortest];
            wt[shortest] = tat[shortest] - bt[shortest];
            rt[shortest] = wt[shortest];
        }
        time++;
```

```
    }
}

void displayTable(int n, int at[], int bt[], int ct[], int tat[],
int wt[], int rt[])
{
    printf("\nProcess\tAT\tBT\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++)
    {
        printf("%d\t%d\t%d\t%d\t%d\t%d\t%d\n", i + 1, at[i], bt[i],
ct[i], tat[i], wt[i], rt[i]);
    }
}

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

    int at[n], bt[n], ct[n], tat[n], wt[n], rt[n];
    printf("Enter Arrival Time and Burst Time for each
process:\n");
    for (int i = 0; i < n; i++)
    {
        printf("Process %d - Arrival Time: ", i + 1);
        scanf("%d", &at[i]);
        printf("Process %d - Burst Time: ", i + 1);
        scanf("%d", &bt[i]);
    }
    preemptiveSJF(n, at, bt, ct, tat, wt, rt);
    displayTable(n, at, bt, ct, tat, wt, rt);

    return 0;
```

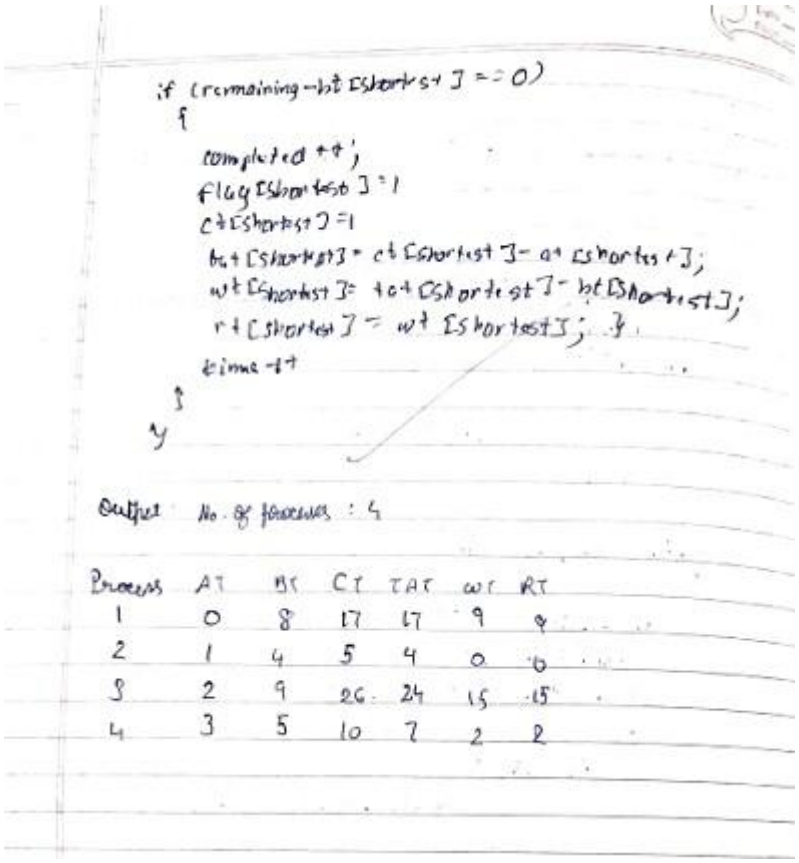
```
}
```

Output:


Enter number of processes: 4
Enter Arrival Time and Burst Time for each process:
Process 1 - Arrival Time: 0
Process 1 - Burst Time: 8
Process 2 - Arrival Time: 1
Process 2 - Burst Time: 4
Process 3 - Arrival Time: 2
Process 3 - Burst Time: 9
Process 4 - Arrival Time: 3
Process 4 - Burst Time: 5
Process AT BT CT TAT WT RT
1 0 8 17 17 9 9
2 1 4 5 4 0 0
3 2 9 26 24 15 15
4 3 5 10 7 2 2

8. Preemptive SJF

```
void preemptiveSJF(int n, int at[], int bt[], int ct[], int tat[],
                   int wt[], int rt[])
{
    int remaining_bt[n];
    int completed = 0, time = 0, min_bt, shortest;
    int flag[n];
    for(int i = 0; i<n; i++)
    {
        remaining_bt[i] = bt[i];
        flag[i] = 0;
    }
    while(completed < n)
    {
        min_bt = 9999;
        shortest = -1;
        for(int i=0; i<n; i++)
        {
            if(at[i] <= time && remaining_bt[i] > 0 &&
                remaining_bt[i] < min_bt && flag[i] == 0)
            {
                min_bt = remaining_bt[i];
                shortest = i;
            }
        }
        if(shortest == -1)
        {
            time++;
            continue;
        }
        remaining_bt[shortest]--;
```



Program 2

Question

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 Scheduling (Non-preemptive):

Code

```
#include <stdio.h>
//non-preemptive
void priorityScheduling(int n, int at[], int bt[], int pr[], int
ct[], int tat[], int wt[], int rt[]) {
    int completed = 0, time = 0, min_priority, highest_priority;
    int flag[n];
    for (int i = 0; i < n; i++) {
        flag[i] = 0;
    }
    while (completed < n) {
        min_priority = 9999;
        highest_priority = -1;
```

```
        for (int i = 0; i < n; i++) {
            if (at[i] <= time && flag[i] == 0 && pr[i] <
min_priority) {
                min_priority = pr[i];
                highest_priority = i;
            }
        }
        if (highest_priority == -1) {
            time++;
            continue;
        }
        time += bt[highest_priority];
        flag[highest_priority] = 1;
        ct[highest_priority] = time;
        tat[highest_priority] = ct[highest_priority] -
at[highest_priority];
        wt[highest_priority] = tat[highest_priority] -
bt[highest_priority];
        rt[highest_priority] = wt[highest_priority];
        completed++;
    }
}

void displayTable(int n, int at[], int bt[], int pr[], int ct[],
int tat[], int wt[], int rt[]) {
    printf("\nProcess\tAT\tBT\tPriority\tCT\tTAT\tWT\tRT\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t%d\t%d\t\t%d\t%d\t%d\t%d\n", i + 1, at[i],
bt[i], pr[i], ct[i], tat[i], wt[i], rt[i]);
    }
}

int main() {
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    int at[n], bt[n], pr[n], ct[n], tat[n], wt[n], rt[n];
    printf("Enter Arrival Time, Burst Time, and Priority for each
process:\n");
    for (int i = 0; i < n; i++) {
        printf("Process %d - Arrival Time: ", i + 1);
        scanf("%d", &at[i]);
        printf("Process %d - Burst Time: ", i + 1);
        scanf("%d", &bt[i]);
        printf("Process %d - Priority: ", i + 1);
        scanf("%d", &pr[i]);
```

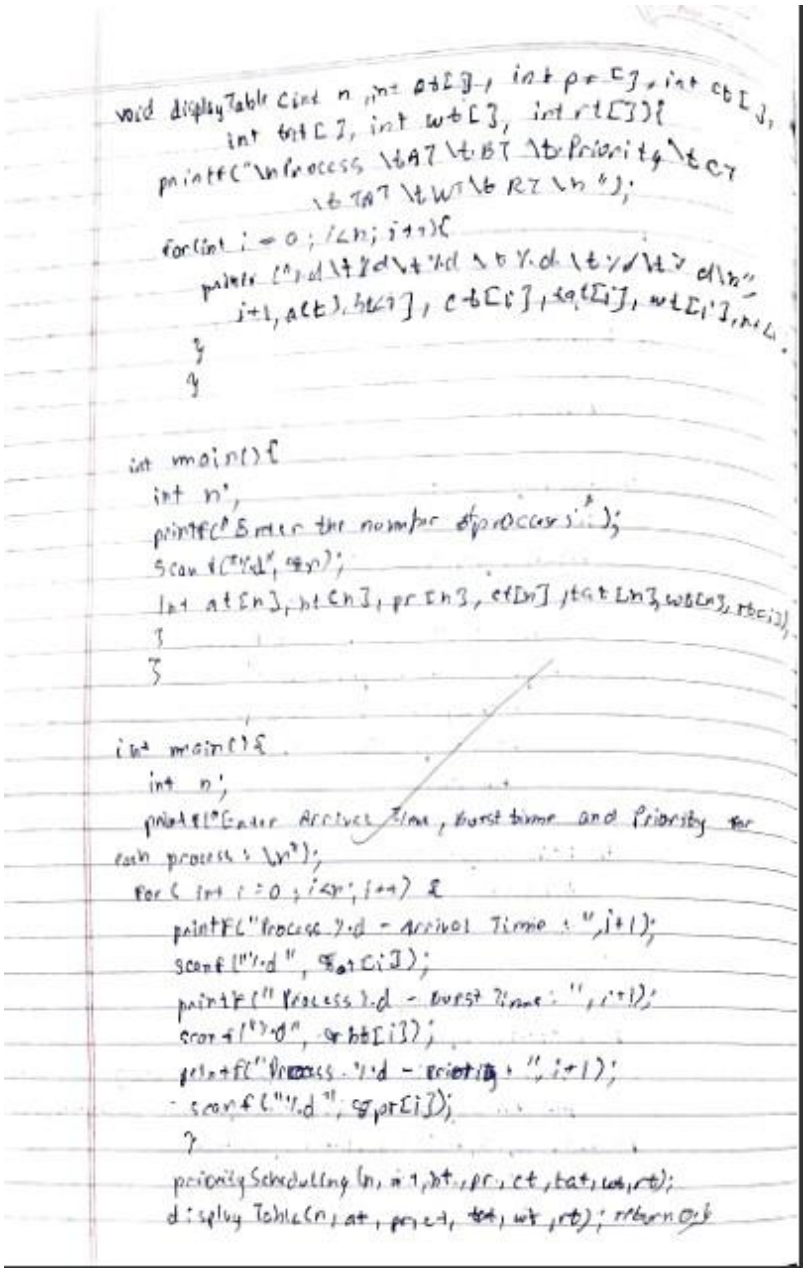
```
    }
    priorityScheduling(n, at, bt, pr, ct, tat, wt, rt);
    displayTable(n, at, bt, pr, ct, tat, wt, rt);
    return 0;
}
```

Output:

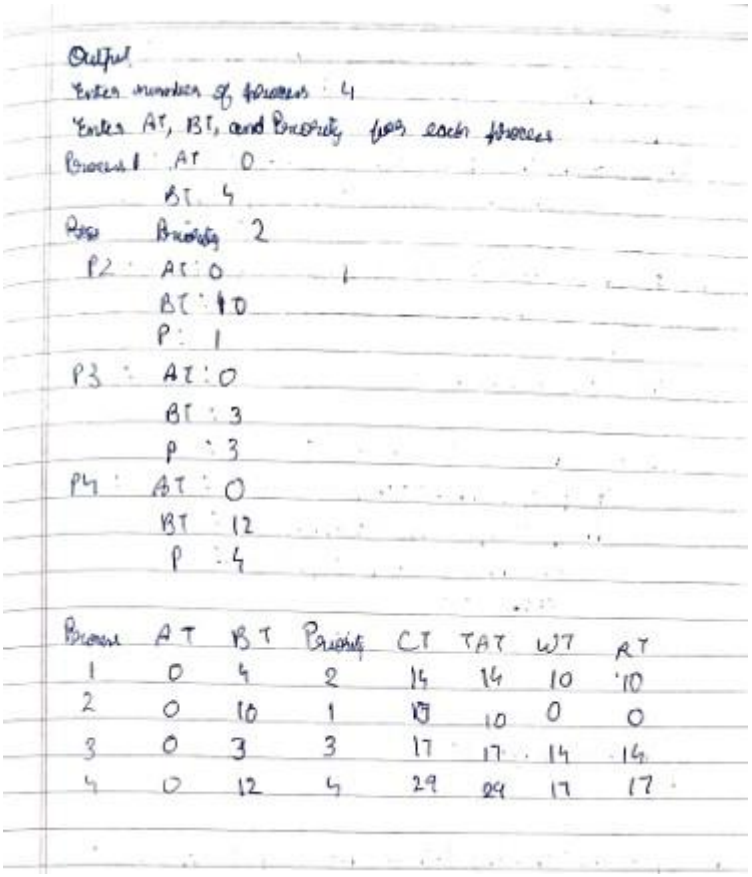
```
Enter number of processes: 4
Enter Arrival Time, Burst Time, and Priority for each process:
Process 1 - Arrival Time: 0
Process 1 - Burst Time: 4
Process 1 - Priority: 2
Process 2 - Arrival Time: 0
Process 2 - Burst Time: 10
Process 2 - Priority: 1
Process 3 - Arrival Time: 0
Process 3 - Burst Time: 3
Process 3 - Priority: 3
Process 4 - Arrival Time: 0
Process 4 - Burst Time: 12
Process 4 - Priority: 4

Process AT      BT      Priority        CT      TAT     WT      RT
1       0       4       2               14      14      10      10
2       0       10      1               10      10      0       0
3       0       3       3               17      17      14      14
4       0       12      4               29      29      17      17
```

Q) Priority Scheduling algorithm

```
#include <stdio.h>

void priorityScheduling(int n, int at[], int bt[], int pr[],
int ct[], int tat[], int wt[], int vt[]) {
  int completed = 0, time = 0, min_priority, highest_priority;
  int flag[n];
  for(int i = 0; i < n; i++) {
    flag[i] = 0;
  }
  while(completed < n) {
    min_priority = 9999;
    highest_priority = -1;
    for(int i = 0; i < n; i++) {
      if(at[i] <= time && flag[i] == 0
      && pr[i] < min_priority) {
        min_priority = pr[i];
        highest_priority = i;
      }
    }
    if(highest_priority == -1) {
      time++;
      continue;
    }
    time += bt[highest_priority];
    flag[highest_priority] = 1;
    ct[highest_priority] = ct[highest_priority] + at[highest_priority]
    wt[highest_priority] = tat[highest_priority] - bt[highest_priority];
    vt[highest_priority] = wt[highest_priority];
    completed++;
  }
}
```



```
void displayTable(int n, int at[], int p[], int ct[],
        int tat[], int wt[], int rt[]){
    printf("\nProcess \tAT \tBT \tPriority \tCT
        \tTAT \tWT \tRT \n");
    for(int i = 0; i<n; i++){
        printf("%d \t%d \t%d \t%d \t%d \t%d \t%d\n",
        i+1, at[i], bt[i], ct[i], tat[i], wt[i], rt[i]);
    }
}

int main(){
    int n;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    int at[n], bt[n], pr[n], ct[n], tat[n], wt[n], rt[i];
}
}

int main(){
    int n;
    printf("Enter Arrival Time, Burst time and Priority for
each process: \n");
    for(int i=0; i<n; i++){
        printf("Process %d - Arrival Time: ", i+1);
        scanf("%d", &at[i]);
        printf("Process %d - Burst Time: ", i+1);
        scanf("%d", &bt[i]);
        printf("Process %d - Priority: ", i+1);
        scanf("%d", &pr[i]);
    }
    priorityScheduling(n, at, bt, pr, ct, tat, wt, rt);
    displayTable(n, at, pr, ct, tat, wt, rt); return 0;
```


Output

Enter number of processes : 4

Enter AT, BT, and Priority for each process

Process 1 AT 0

BT 4

Priority 2

P2 AT: 0

BT: 10

P: 1

P3 AT: 0

BT: 3

P: 3

P4 AT: 0

BT: 12

P: 4

Process	AT	BT	Priority	CT	TAT	WT	RT
1	0	4	2	14	14	10	10
2	0	10	1	10	10	0	0
3	0	3	3	17	17	14	14
4	0	12	4	29	29	17	17

=> Priority Scheduling (Preemptive):

Code

```
#include <stdio.h>

struct Process {
    int id, arrivalTime, burstTime, remainingTime, priority;
    int waitingTime, turnaroundTime, completionTime;
};
int findHighestPriority(struct Process p[], int n, int currentTime)
{
    int highest = -1;
    int highestPriority = 1e9;

    for (int i = 0; i < n; i++) {
        if (p[i].arrivalTime <= currentTime && p[i].remainingTime >
0) {
            if (p[i].priority < highestPriority) {
                highestPriority = p[i].priority;
                highest = i;
            }
        }
```

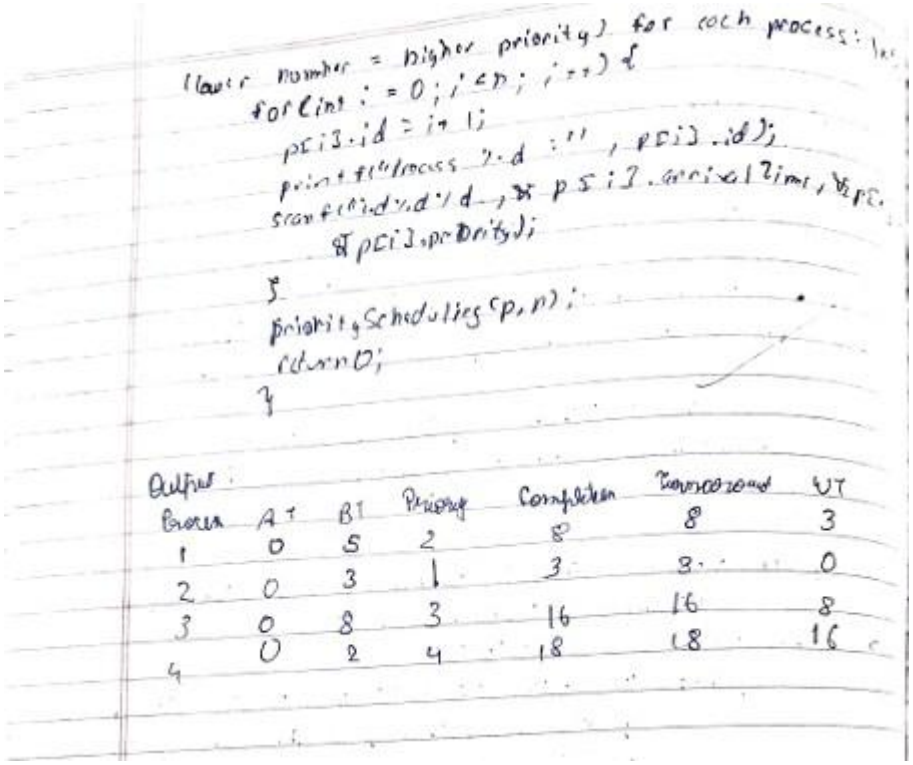
```
    }
    return highest;
}

void priorityScheduling(struct Process p[], int n) {
    int currentTime = 0, completed = 0;
    float totalWaitingTime = 0, totalTurnaroundTime = 0;
    for (int i = 0; i < n; i++) {
        p[i].remainingTime = p[i].burstTime;
    }
    while (completed < n) {
        int idx = findHighestPriority(p, n, currentTime);

        if (idx == -1) {
            currentTime++;
            continue;
        }

        p[idx].remainingTime--;
        currentTime++;
        if (p[idx].remainingTime == 0) {
            completed++;
            p[idx].completionTime = currentTime;
            p[idx].turnaroundTime = p[idx].completionTime -
p[idx].arrivalTime;
            p[idx].waitingTime = p[idx].turnaroundTime -
p[idx].burstTime;

            totalWaitingTime += p[idx].waitingTime;
            totalTurnaroundTime += p[idx].turnaroundTime;
        }
    }

printf("\nProcess\tArrival\tBurst\tPriority\tCompletion\tTurnaround
\tWaiting\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t%d\t%d\t\t%d\t\t%d\t\t%d\n", p[i].id,
p[i].arrivalTime, p[i].burstTime,
               p[i].priority, p[i].completionTime,
p[i].turnaroundTime, p[i].waitingTime);
    }

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

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

    printf("Enter Arrival Time, Burst Time, and Priority (lower
number = higher priority) for each process:\n");
    for (int i = 0; i < n; i++) {
        p[i].id = i + 1;
        printf("Process %d: ", p[i].id);
        scanf("%d %d %d", &p[i].arrivalTime, &p[i].burstTime,
&p[i].priority);
    }
    priorityScheduling(p, n);
    return 0;
}
```

Output:

```
Enter number of processes: 4
Enter Arrival Time, Burst Time, and Priority (lower number = higher priority) for each process:
Process 1: 0
5
2
Process 2: 0
3
1
Process 3: 0
8
3
Process 4: 0
2
4

Process Arrival Burst   Priority        Completion      Turnaround      Waiting
1       0       5       2               8               8               3
2       0       3       1               3               3               0
3       0       8       3               16              16              8
4       0       2       4               18              18              16

Average Waiting Time: 6.75
Average Turnaround Time: 11.25
```

```
        continue;
    }
    p[idx].remainingTime--;
    currentTime++;
    p[idx].completionTime = currentTime;
    p[idx].turnaroundTime = p[idx].completionTime -
                            p[idx].arrivalTime;
    p[idx].waitingTime = p[idx].turnaroundTime - p[idx]
                                                .burstTime;
    totalWaitingTime += p[idx].waitingTime;
    totalTurnaroundTime += p[idx].turnaroundTime;
  }
}
printf("\nProcess\tArrival\tBurst\tPriority\tCompletion
        \tTurnaround\tWaiting\n");
for(int i = 0; i<n; i++) {
    printf("%d\t%d\t%d\t\t%d\t\t%d\t\t%d\n", p[i].id,
           p[i].arrivalTime, p[i].burstTime, p[i].priority,
           p[i].completionTime, p[i].turnaroundTime, p[i].
                                    waitingTime);
}
printf("\nAverage waiting time: %.2f", totalTurnaroundTime
                                        /n);
printf("\nAverage Turnaround time: %.2f\n");
}
int main() {
    int n;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    struct Process p[n];
    printf("Enter Arrival Time, Burst Time and Priority
```



=> Round Robin:

Code

```
#include <stdio.h>

void findWaitingTime(int processes[], int n, int bt[], int wt[],
int quantum) {
    int rem_bt[n];
    for (int i = 0; i < n; i++) {
        rem_bt[i] = bt[i];
        wt[i] = 0;
        wt++;
    }
    int t = 0;
    while (1) {
        int done = 1;

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

```
            if (rem_bt[i] > 0) {
                done = 0;
                if (rem_bt[i] > quantum) {
                    rem_bt[i] -= quantum;
                    //++quantum;
                    t += quantum;
                } else {
                    t += rem_bt[i];
                    wt[i] = t - bt[i];
                    rem_bt[i] = 0;
                }
            }
        }
        if (done) break;
    }
}

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

void findAvgTime(int processes[], int n, int bt[], int quantum) {
    int wt[n], tat[n];
    findWaitingTime(processes, n, bt, wt, quantum);
    findTurnAroundTime(processes, n, bt, wt, tat);

    int total_wt = 0, total_tat = 0;
    printf("\nProcess\tBurst Time\tWaiting Time\tTurnaround
Time\n");
    for (int i = 0; i < n; i++) {
        total_wt += wt[i];
```

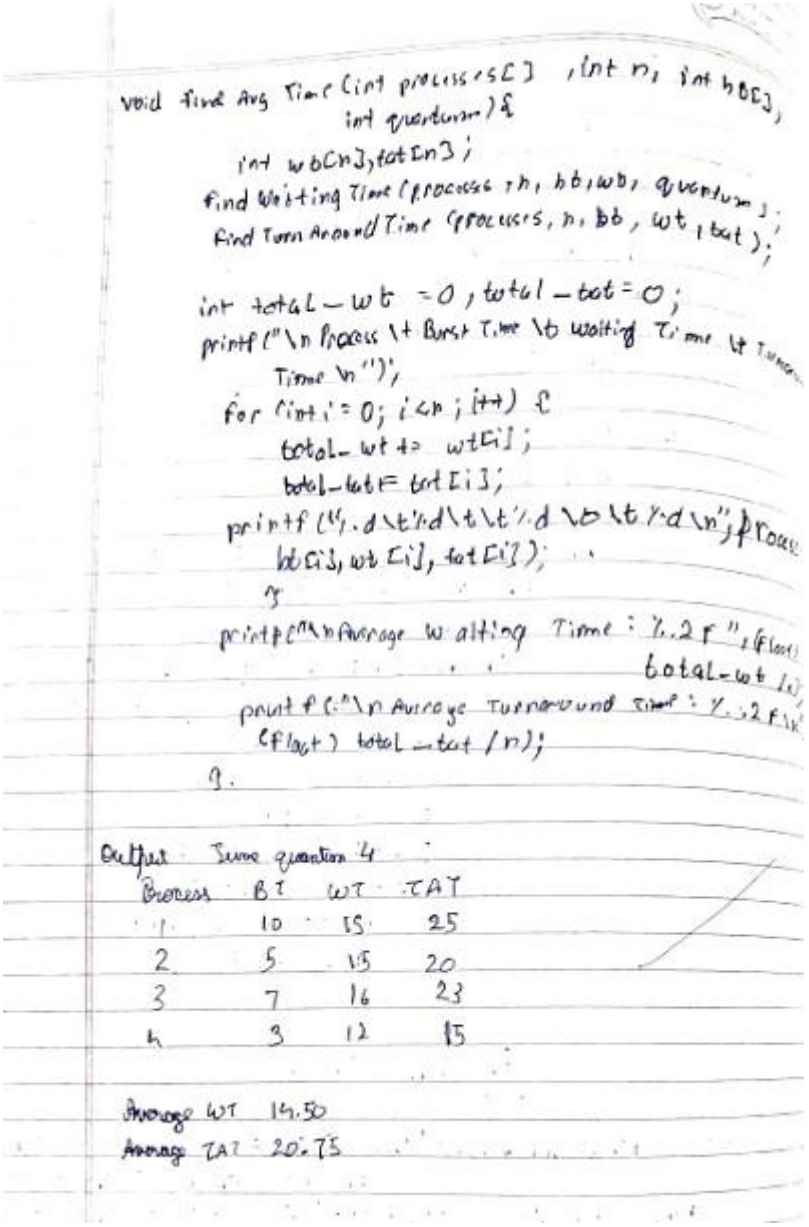
```
        total_tat += tat[i];
        printf("%d\t%d\t\t%d\t\t%d\n", processes[i], bt[i], wt[i],
tat[i]);
    }
    printf("\nAverage Waiting Time: %.2f", (float)total_wt / n);
    printf("\nAverage Turnaround Time: %.2f\n", (float)total_tat /
n);
}

int main() {
    int n, quantum;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    int processes[n];
    int burst_time[n];
    for (int i = 0; i < n; i++) {
        processes[i] = i + 1;
        printf("Enter burst time for process %d: ", i + 1);
        scanf("%d", &burst_time[i]);
    }
    printf("Enter time quantum: ");
    scanf("%d", &quantum);
    findAvgTime(processes, n, burst_time, quantum);
    return 0;
}
```

Output:

```
Enter number of processes: 4
Enter burst time for process 1: 10
Enter burst time for process 2: 5
Enter burst time for process 3: 7
Enter burst time for process 4: 3
Enter time quantum: 4

Process Burst Time      Waiting Time    Turnaround Time
1       10              15              25
2       5               15              20
3       7               16              23
4       3               12              15

Average Waiting Time: 14.50
Average Turnaround Time: 20.75
```

Round Robin.

```
#include <stdio.h>
void findWaitingTime(int processes[], int n, int bt[],
                     int wt[], int quantum) {
    int rem_bt[n];
    for (int i = 0; i < n; i++) {
        rem_bt[i] = bt[i];
        wt[i] = 0;
    }
    int t = 0;
    while(1) {
        int done = 1;
        for (int i = 0; i < n; i++) {
            if (rem_bt[i] > 0) {
                done = 0;
                if (rem_bt[i] > quantum) {
                    rem_bt[i] -= quantum;
                    t += quantum;
                } else {
                    t += rem_bt[i];
                    wt[i] = t - bt[i];
                    rem_bt[i] = 0;
                }
            }
        }
        if (done) break;
    }
}
void findTurnAroundTime(int processes[], int n,
                        int bt[], int wt[], int tat[]) {
    for (int i = 0; i < n; i++) tat[i] = bt[i] + wt[i];
}
```



```
void findAvgTime(int processes[], int n, int bt[],
                 int quantum){
    int wt[n], tat[n];
    findWaitingTime(processes, n, bt, wt, quantum);
    findTurnAroundTime(processes, n, bt, wt, tat);

    int total_wt = 0, total_tat = 0;
    printf("\n Process \t Burst Time \t Waiting Time \t Turnaround
        Time \n");
    for(int i = 0; i<n; i++){
        total_wt += wt[i];
        total_tat += tat[i];
    printf("%d \t\t %d \t\t %d \t\t %d \n", proc
        bt[i], wt[i], tat[i]);
    }
    printf("\n Average Waiting Time : %.2f ", (float)
                                    total_wt /n);
    printf("\n Average Turnaround time : %.2f\n"
      (float) total_tat /n);
}
```

Output Time quantum 4

Process	BT	WT	TAT
1	10	15	25
2	5	15	20
3	7	16	23
4	3	12	15

Average WT 14.50
Average TAT 20.75

Program 3

Question

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

=> Multilevel queue Scheduling

Code

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

```
            *time = p[i].arrival_time;
        p[i].waiting_time = *time - p[i].arrival_time;
        p[i].turnaround_time = p[i].waiting_time + p[i].burst_time;
        p[i].response_time = p[i].waiting_time;
        *time += p[i].burst_time;
    }
}
int main() {
    int n, i, time = 0;
    printf("Enter number of processes: ");
    scanf("%d", &n);

    Process p[n], system_processes[n], user_processes[n];
    int sys_count = 0, user_count = 0;

    for (i = 0; i < n; i++) {
        printf("Enter Burst Time, Arrival Time and Queue of P%d: ",
i + 1);
        p[i].pid = i + 1;
        scanf("%d %d %d", &p[i].burst_time, &p[i].arrival_time,
&p[i].queue);
        p[i].remaining_time = p[i].burst_time;

        if (p[i].queue == 0)
            system_processes[sys_count++] = p[i];
        else
            user_processes[user_count++] = p[i];
    }
    sort_by_arrival(system_processes, sys_count);
    sort_by_arrival(user_processes, user_count);
    printf("\nQueue 1 is System Process\nQueue 2 is User
Process\n");
    round_robin(system_processes, sys_count, &time);
    fcfs(user_processes, user_count, &time);
    Process final_list[n];
    int index = 0;
    for (i = 0; i < sys_count; i++)
        final_list[index++] = system_processes[i];
    for (i = 0; i < user_count; i++)
        final_list[index++] = user_processes[i];

    printf("\nProcess\tWaiting Time\tTurn Around Time\tResponse
Time\n");
    float avg_wt = 0, avg_tat = 0, avg_rt = 0;

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

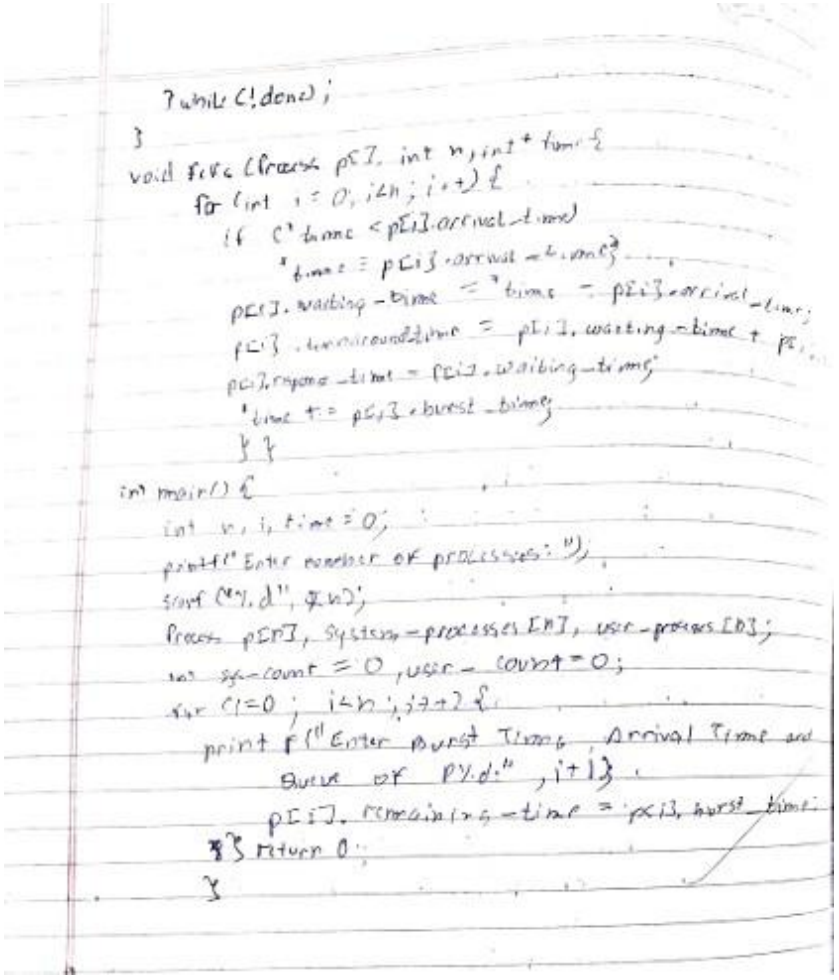
```
        printf("%d\t%d\t\t%d\t\t\t%d\n", final_list[i].pid,
final_list[i].waiting_time, final_list[i].turnaround_time,
final_list[i].response_time);
        avg_wt += final_list[i].waiting_time;
        avg_tat += final_list[i].turnaround_time;
        avg_rt += final_list[i].response_time;
    }
    avg_wt /= n;
    avg_tat /= n;
    avg_rt /= n;
    float throughput = (float)n / time;
    printf("\nAverage Waiting Time: %.2f", avg_wt);
    printf("\nAverage Turn Around Time: %.2f", avg_tat);
    printf("\nAverage Response Time: %.2f", avg_rt);
    printf("\nThroughput: %.2f", throughput);
    return 0;
}
```

Output:

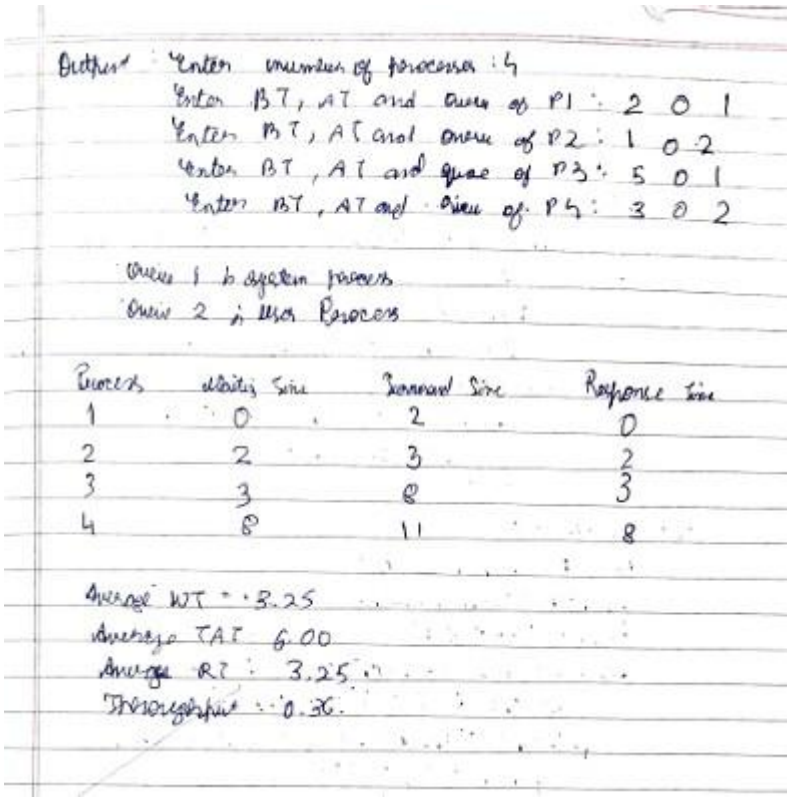
```
Enter number of processes: 4
Enter Burst Time, Arrival Time and Queue of P1: 2
0
1
Enter Burst Time, Arrival Time and Queue of P2: 1
0
2
Enter Burst Time, Arrival Time and Queue of P3: 5
0

1
Enter Burst Time, Arrival Time and Queue of P4: 3
0

2

Queue 1 is System Process
Queue 2 is User Process

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

Average Waiting Time: 3.25
Average Turn Around Time: 6.00
Average Response Time: 3.25
Throughput: 0.36
```

6 Multilevel queue scheduling

```
#include<stdio.h>
#define TIME_QUANTUM 2
typedef struct {
    int pid, burst_time, arrival_time, queue;
    int waiting_time, turnaround_time, response_time,
    remaining_time;
} process;
void sort_by_arrival(process p[], int n) {
    process temp;
    for(int i=0; i<n; i++) {
        for(j=i+1; j<n; j++) {
            if(p[i].arrival_time > p[j].arrival_time) {
                temp = p[i];
                p[i] = p[j];
                p[j] = temp; } } }
void round_robin(process p[], int n, int *time) {
    int done, i;
    do {
        done=1;
        for(i=0; i<n; i++) {
            if(p[i].remaining_time >0 ) {
            done=0;
            if(p[i].remaining_time>TIME_QUANTUM) {
            *time+= TIME_QUANTUM;
            p[i].waiting_time = *time - p[i].arrival_time;
            p[i].turnaround_time
            p[i].remaining_time = 0;
            }
        } }
```



```
} while (!done);
}
void fcfs (Process p[], int n, int * time) {
    for (int i = 0; i<n; i++) {
        if (* time < p[i].arrival_time)
            * time = p[i].arrival_time;
        p[i].waiting_time = * time - p[i].arrival_time;
        p[i].turnaroundtime = p[i].waiting_time + p[i].
        p[i].response_time = p[i].waiting_time;
        * time += p[i].burst_time;
    }
}
int main() {
    int n, i, time = 0;
    printf("Enter number of processes: ");
    scanf("%d", &n);
    Process p[n], system_processes[n], user_processes[n];
    int sys_count = 0, user_count = 0;
    for (i=0; i<n; i++) {
        printf("Enter Burst Time, Arrival Time and
            Queue of P%d: ", i+1);
        p[i].remaining_time = p[i].burst_time;
    } return 0;
}
```



Program 4

Question

Write a C program to simulate Real-Time CPU Scheduling algorithms:
-> Rate- Monotonic
-> Earliest-deadline First
-> Proportional scheduling

=> Rate Monotonic Scheduling

Code

```
#include <stdio.h>
#include <stdlib.h>
typedef struct {
    int id;
    int period;
    int execution_time;
    int next_deadline;
    int executed;
} Task;

int compare_tasks(const void *a, const void *b) {
```

```
    return ((Task *)a)->period - ((Task *)b)->period;
}

void rate_monotonic_scheduling(Task tasks[], int num_tasks, int
total_time) {
    qsort(tasks, num_tasks, sizeof(Task), compare_tasks);

    /*
    for(int i = 0; i < num_tasks; i++)
        printf("Task %d: %d %d\n", tasks[i].id,
tasks[i].execution_time,  tasks[i].period);
    */

    for (int i = 0; i < num_tasks; i++)
        tasks[i].next_deadline = tasks[i].period;
    printf("Time\t");
    for (int i = 0; i < num_tasks; i++)
        printf("Task %d\t", tasks[i].id);
    printf("\n");
    for (int current_time = 0; current_time < total_time;
current_time++)
    {
        printf("%d\t", current_time);
        int executed_task = -1;

        for (int i = 0; i < num_tasks; i++)
        {
            if (current_time % tasks[i].period == 0)
            {
                tasks[i].next_deadline = current_time +
tasks[i].period;
                tasks[i].executed = 0;
            }
            if (current_time < tasks[i].next_deadline)
            {
                if(tasks[i].executed < tasks[i].execution_time)
                {
                    executed_task = i;
                    tasks[i].executed++;
                    break;
                }
            }
        }
        if (executed_task != -1)
        {
            for (int i = 0; i < num_tasks; i++)
```

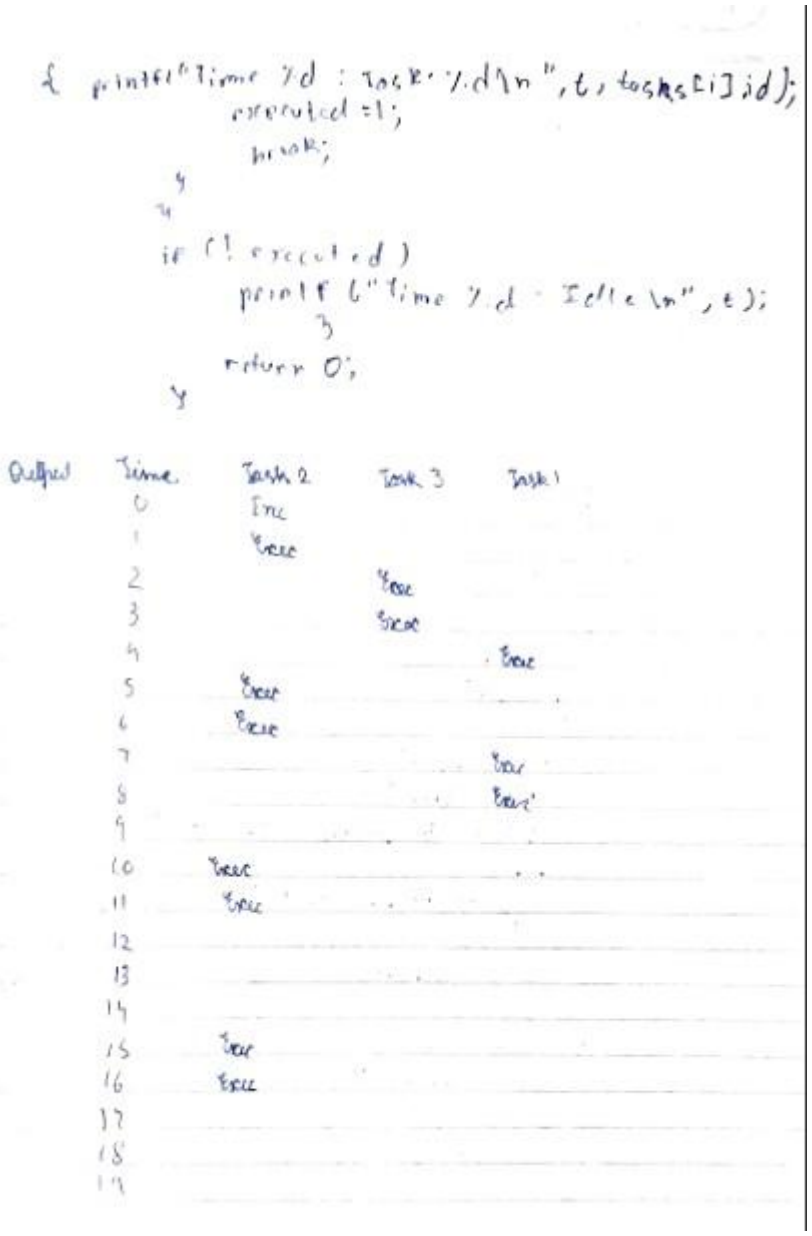
```
            {
                if (i == executed_task) {
                    printf("Exec\t");
                } else {
                    printf("\t");
                }
            }
        } else {
             for (int i = 0; i < num_tasks; i++) {
                printf("\t");
            }
        }
        printf("\n");
    }
}

int main() {
    Task tasks[] = {
        {1, 20, 3},
        {2, 5, 2},
        {3, 10, 2}
    };

    int num_tasks = sizeof(tasks) / sizeof(tasks[0]);
    int total_time = 20;

    rate_monotonic_scheduling(tasks, num_tasks, total_time);
    return 0;
}
```

Output:

```
Time    Task 2  Task 3  Task 1
0       Exec
1       Exec
2               Exec
3               Exec
4                       Exec
5       Exec
6       Exec
7                       Exec
8                       Exec
9
10      Exec
11      Exec
12
13
14
15      Exec
16      Exec
17
18
19
```

Rate monotonic scheduling

```
#include <stdio.h>
struct Task {
    int id, executionTime, period;
};
void sortTasks(struct Task tasks[], int n);
    for (int i = 0; i < n-1; i++)
        for (j = 0; j < n-1-1; j++)
        if (tasks[j].period > tasks[j+1].period)
    struct Task temp = tasks[j];
        tasks[j] = tasks[j+1];
        tasks[j+1] = temp;
    }
}
int main() {
    int n, time = 20;
    printf("Enter number of tasks: ");
    scanf("%d", &n);
    struct Task tasks[n];
    for (int i=0; i<n; i++){
    printf("Task %d execution time and
        period: ", i+1);
    scanf("%d %d", &tasks[i].executionTime,
                    &tasks[i].period);
                tasks[i].id = i+1;
    }
    sortTasks(tasks, n);
    printf("RMS \n");
    for(int t = 0; t < time; t++){
        int executed = 0;
        for(int i = 0; i<n; i++){
            if(t % tasks[i].period < tasks[i].
```



=> Earliest Deadline First

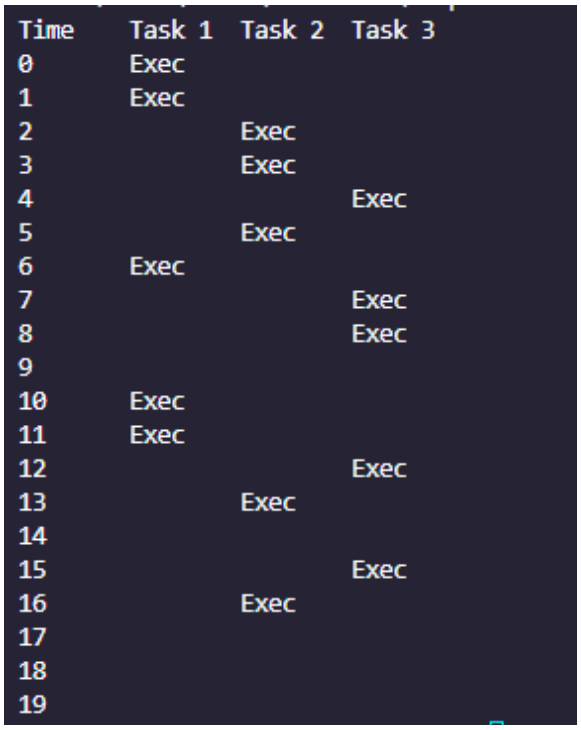
Code

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

typedef struct {
    int id;
    int period;
    int execution_time;
    int deadline;
```

```
    int executed;
} Task;

int compare_tasks(const void *a, const void *b) {
    return ((Task *)a)->deadline - ((Task *)b)->deadline;
}

void earliest_deadline_first_scheduling(Task tasks[], int
num_tasks, int total_time) {
    printf("Time\t");
    for (int i = 0; i < num_tasks; i++)
        printf("Task %d\t", tasks[i].id);
    printf("\n");
    for (int current_time = 0; current_time < total_time;
current_time++) {
        printf("%d\t", current_time);
        int executed_task = -1;

        for (int i = 0; i < num_tasks; i++) {
            if (current_time % tasks[i].period == 0) {
                tasks[i].deadline = current_time + tasks[i].period;
                tasks[i].executed = 0;
            }
        }
        qsort(tasks, num_tasks, sizeof(Task), compare_tasks);

        for (int i = 0; i < num_tasks; i++) {
            if (current_time < tasks[i].deadline &&
tasks[i].executed < tasks[i].execution_time) {
                executed_task = i;
                tasks[i].executed++;
                break;
            }
        }
        if (executed_task != -1) {
            for (int i = 0; i < num_tasks; i++) {
                if (i == executed_task) {
                    printf("Exec\t");
                } else {
                    printf("\t");
                }
            }
        } else {
            for (int i = 0; i < num_tasks; i++) {
                printf("\t");
            }
```

```
            }
            printf("\n");
        }
    }

    int main() {
        Task tasks[] = {
            {1, 20, 3, 20, 0},
            {2, 5, 2, 5, 0},
            {3, 10, 2, 10, 0}
    //task
        };

        int num_tasks = sizeof(tasks) / sizeof(tasks[0]);
        int total_time = 20;

        earliest_deadline_first_scheduling(tasks, num_tasks,
    total_time);
        return 0;
    }
```

Output:



Program 5

Question

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

=> Producer Consumer

Code

```
#include <stdio.h>

int x = 1, mutex = 1, full = 0, empty = 3;
void wait(int *S)
{
    (*S)--;
}

void signal(int *S)
{
    (*S)++;
}
void producer()
{
    wait(&mutex);
    if (empty > 0)
    {
        wait(&empty);
        signal(&full);
        printf("Item produced: %d\n", x++);
    } else {
        printf("Buffer is Full\n");
    }
    signal(&mutex);
}
void consumer() {
    wait(&mutex);
    if (full > 0) {
        wait(&full);
        signal(&empty);
        printf("Item Consumed: %d\n", --x);
    } else {
        printf("Buffer is Empty\n");
    }
    signal(&mutex);
}

int main() {
```

```
    int ch;
    printf("1. Produce\n2. Consume\n3. Exit\n");
    while (1) {
        printf("Enter Choice: ");
        scanf("%d", &ch);
        switch (ch) {
            case 1: producer(); break;
            case 2: consumer(); break;
            default: return 0;
    }
}
}
```

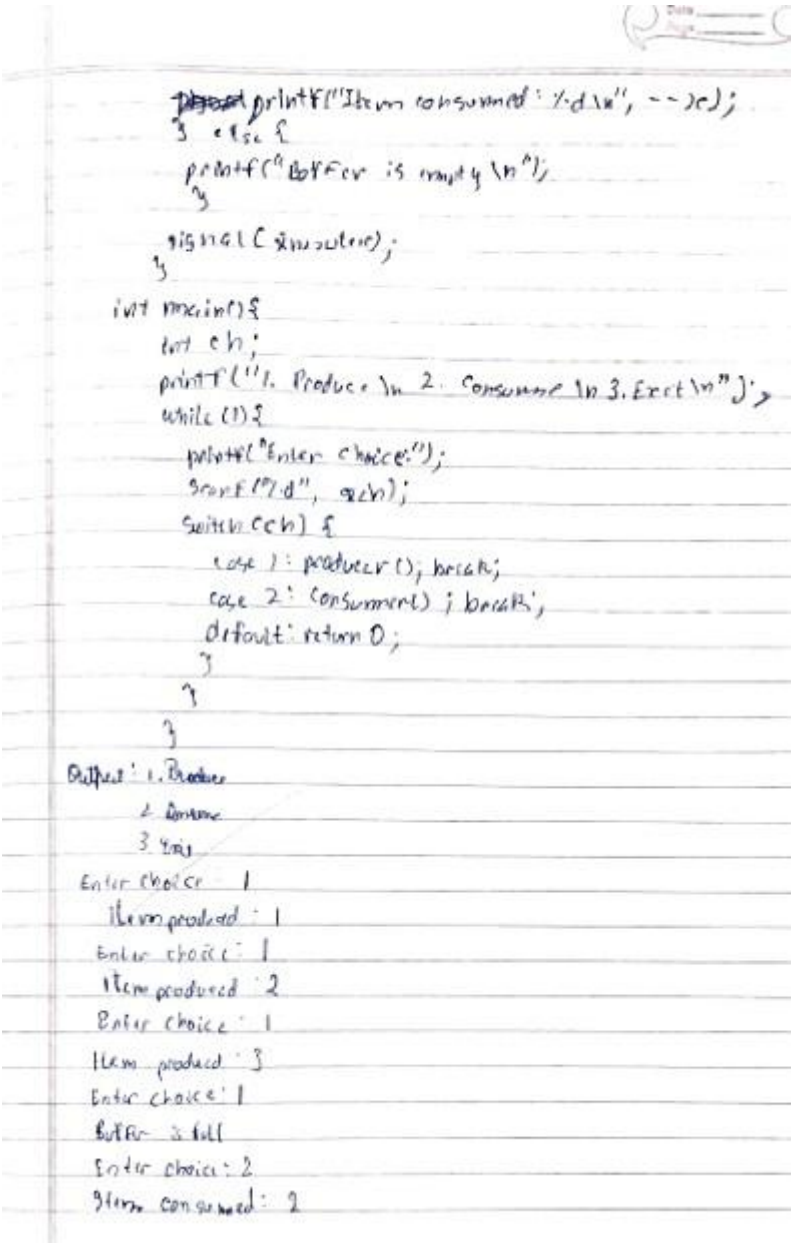
Output:

```
1. Produce
2. Consume
3. Exit
Enter Choice: 2
Buffer is Empty
Enter Choice: 2
Buffer is Empty
Enter Choice: 2
Buffer is Empty
Enter Choice: 2
Buffer is Empty
Enter Choice: 2
Buffer is Empty
Enter Choice: 2
Buffer is Empty
Enter Choice: 1
Item produced: 1
Enter Choice: 1
Item produced: 2
Enter Choice: 1
Item produced: 3
Enter Choice: 1
Buffer is Full
Enter Choice: 1
Buffer is Full
Enter Choice: 2
Item Consumed: 3
Enter Choice: 2
Item Consumed: 2
Enter Choice: 2
Item Consumed: 1
Enter Choice: 2
Buffer is Empty
Enter Choice:

2
Buffer is Empty
Enter Choice: 2
Buffer is Empty
Enter Choice: 3
```

Dining Philosophers & Producer-Consumer

Producer-Consumer

```
#include <stdio.h>
int x = 1, mutex = 1, full = 0, empty = 3;
void wait(int *S)
 {
   (*S)--;
 }
void signal (int *S)
 {
   (*S)++; }
void producer() {
   wait(&mutex);
    if (empty > 0)
    {
     wait(&empty);
     signal (&full);
     printf("Item produced : %d\n", x++);
    } else {
      printf("Buffer is full\n");
    }
    signal(&mutex);
   }
void consumer() {
    wait(&mutex);
    if (full > 0) {
      wait(&full);
      signal(&empty);
```



```
        printf("Item consumed: %d\n", --x);
    } else {
        printf("Buffer is empty\n");
    }
    signal(&mutex);
}
int main(){
    int ch;
    printf("1. Produce\n 2. Consume\n 3. Exit\n");
    while (1){
        printf("Enter choice:");
        scanf("%d", &ch);
        switch(ch) {
            case 1: producer(); break;
            case 2: consumer(); break;
            default: return 0;
        }
    }
}
```

Output: 1. Produce
2. Consume
3. Exit

```
Enter choice 1
Item produced : 1
Enter choice: 1
Item produced 2
Enter choice 1
Item produced 3
Enter choice: 1
Buffer is full
Enter choice: 2
Item consumed: 2
```

Program 6

Question

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

=> Dining Philosophers

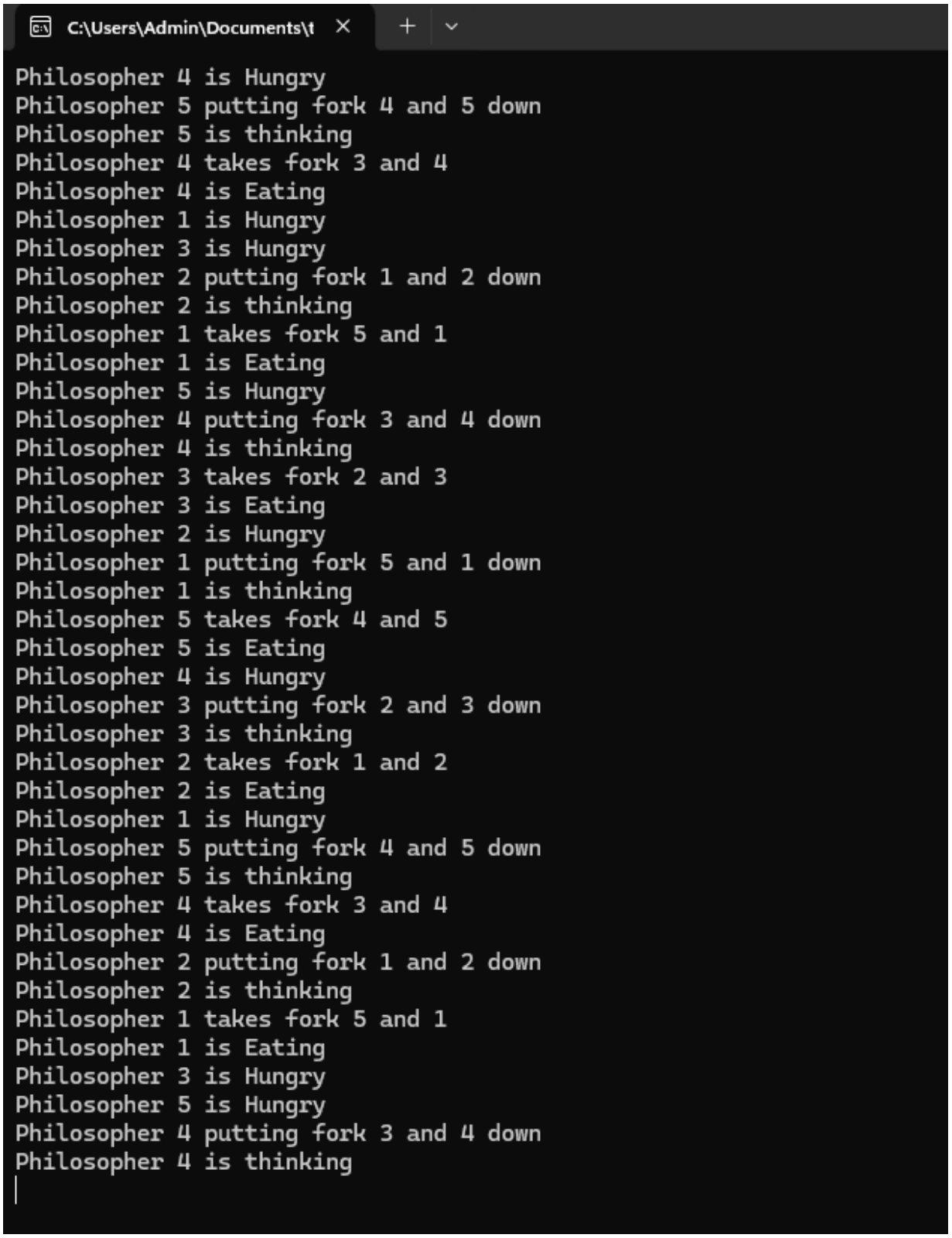
Code

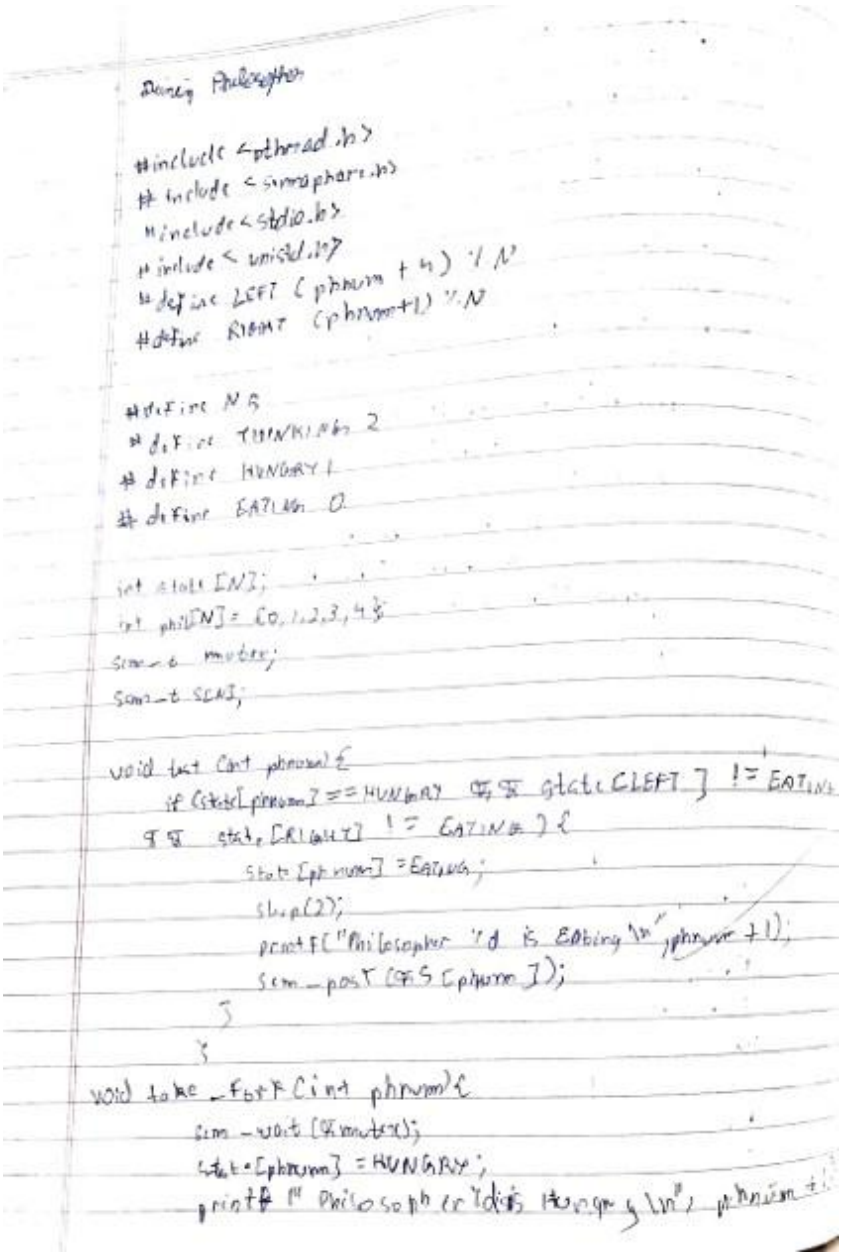
```
//PTHRED AND SEMAPHORE LIBRARY ONLY WORK IN CODEBLOCKS, NOT VSC

#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) {
        state[phnum] = EATING;
        sleep(2);
         printf("Philosopher %d takes fork %d and %d\n", phnum + 1,
LEFT + 1, phnum + 1);
        printf("Philosopher %d is Eating\n", phnum + 1);
        sem_post(&S[phnum]);
    }
}
void take_fork(int phnum) {
    sem_wait(&mutex);
    state[phnum] = HUNGRY;
    printf("Philosopher %d is Hungry\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 fork %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 = (int*)num;
        sleep(1);
        take_fork(*i);
        sleep(0);
        put_fork(*i);
    }
}

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

    return 0;
}
```

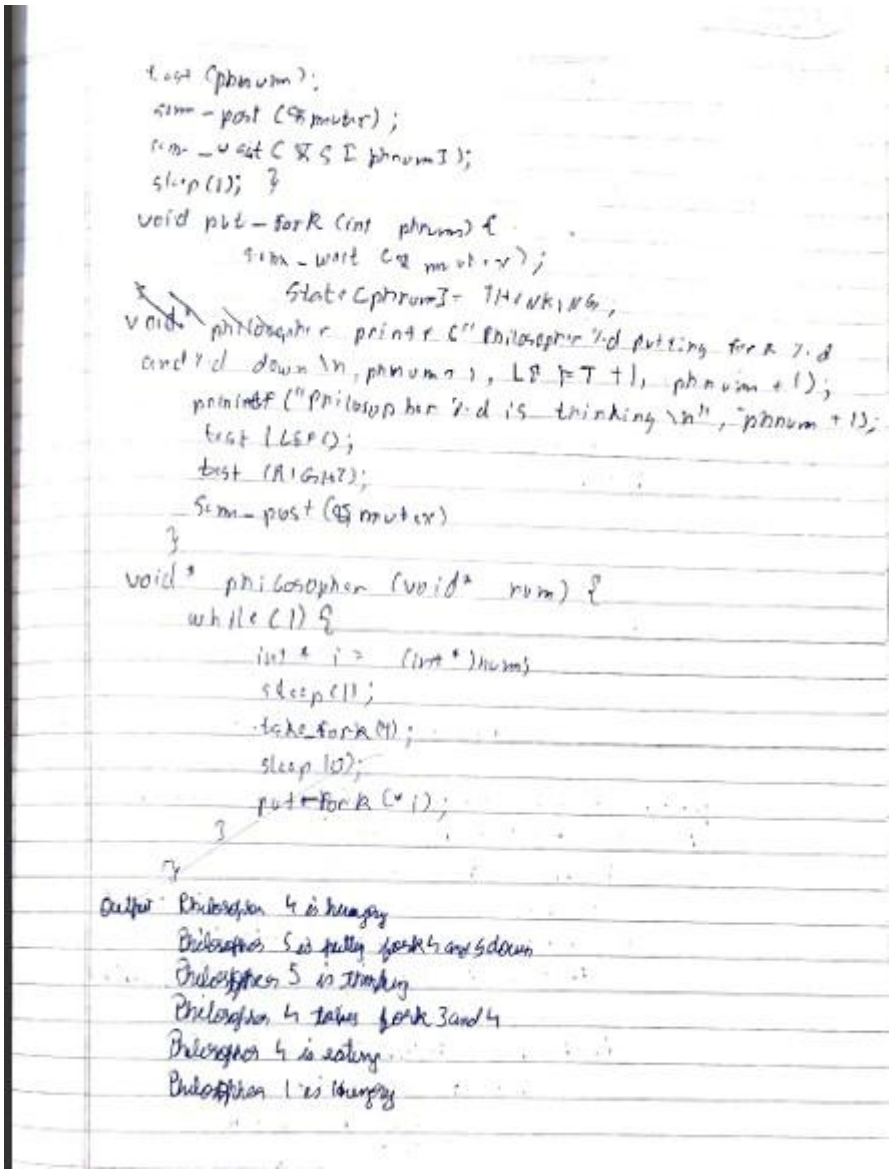
Output:


C:\Users\Admin\Documents\t
Philosopher 4 is Hungry
Philosopher 5 putting fork 4 and 5 down
Philosopher 5 is thinking
Philosopher 4 takes fork 3 and 4
Philosopher 4 is Eating
Philosopher 1 is Hungry
Philosopher 3 is Hungry
Philosopher 2 putting fork 1 and 2 down
Philosopher 2 is thinking
Philosopher 1 takes fork 5 and 1
Philosopher 1 is Eating
Philosopher 5 is Hungry
Philosopher 4 putting fork 3 and 4 down
Philosopher 4 is thinking
Philosopher 3 takes fork 2 and 3
Philosopher 3 is Eating
Philosopher 2 is Hungry
Philosopher 1 putting fork 5 and 1 down
Philosopher 1 is thinking
Philosopher 5 takes fork 4 and 5
Philosopher 5 is Eating
Philosopher 4 is Hungry
Philosopher 3 putting fork 2 and 3 down
Philosopher 3 is thinking
Philosopher 2 takes fork 1 and 2
Philosopher 2 is Eating
Philosopher 1 is Hungry
Philosopher 5 putting fork 4 and 5 down
Philosopher 5 is thinking
Philosopher 4 takes fork 3 and 4
Philosopher 4 is Eating
Philosopher 2 putting fork 1 and 2 down
Philosopher 2 is thinking
Philosopher 1 takes fork 5 and 1
Philosopher 1 is Eating
Philosopher 3 is Hungry
Philosopher 5 is Hungry
Philosopher 4 putting fork 3 and 4 down
Philosopher 4 is thinking



Dining Philosopher

```
#include <pthread.h>
#include <semaphore.h>
#include <stdio.h>
#include <unistd.h>
#define LEFT (phnum + 4) % N
#define RIGHT (phnum+1) % N

#define N 5
#define THINKING 2
#define HUNGRY 1
#define EATING 0

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){
        state[phnum] = EATING;
        sleep(2);
        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);
```



Program 7

Question

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

=> Banker's Algorithm / Deadlock Avoidance

Code

```
#include <stdio.h>
#include <stdlib.h>
int condition(int **need, int *work, int i, int m)
{
    for (int j = 0; j < m; j++)
```

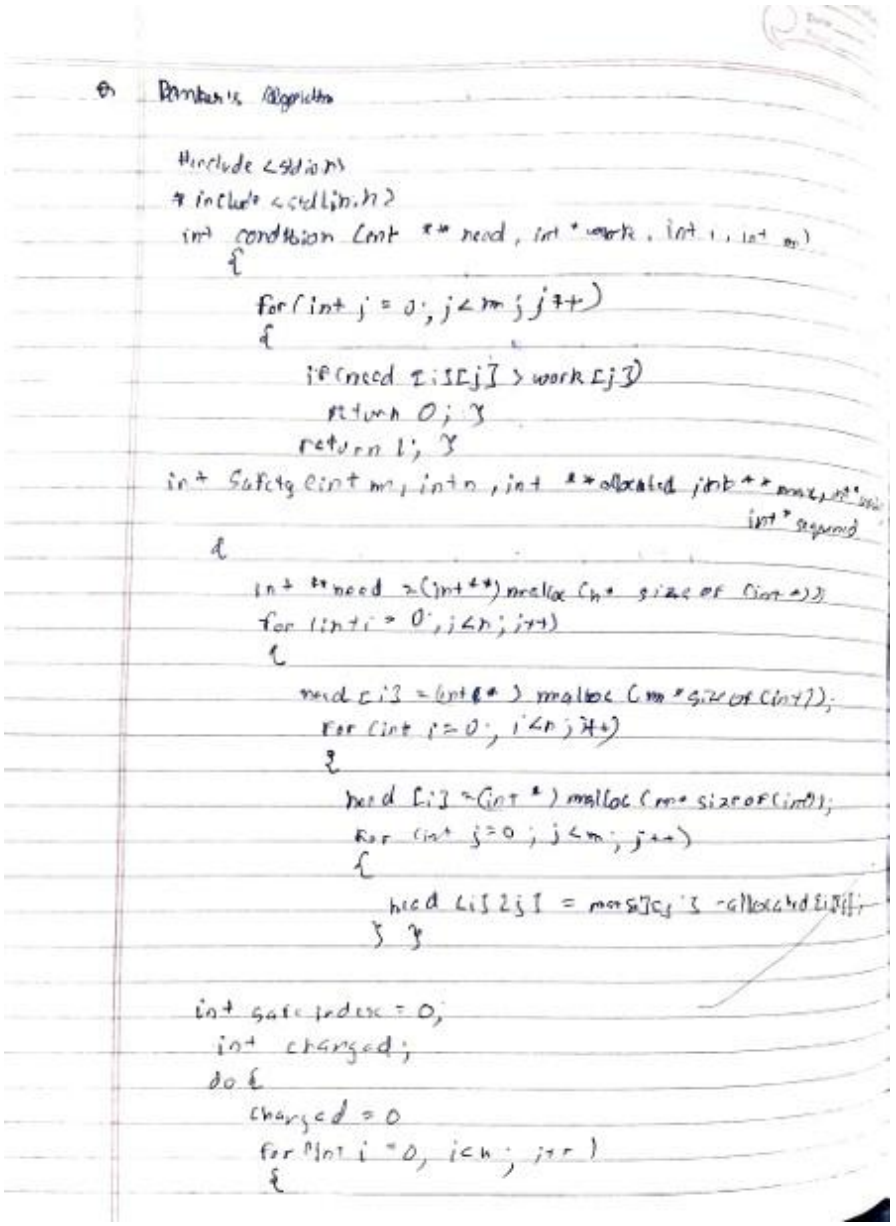
```
    {
        if (need[i][j] > work[j])
            return 0;
    }
    return 1;
}
int safety(int m, int n, int **allocated, int **max, int
*available, int *sequence)
{
    // Need Matrix
    int **need = (int**) malloc(n * sizeof(int*));
    for (int i = 0; i < n; i++)
    {
        need[i] = (int*) malloc(m * sizeof(int));
        for (int j = 0; j < m; j++)
        {
            need[i][j] = max[i][j] - allocated[i][j];
        }
    }
    // Work array
    int *work = (int*) malloc(m * sizeof(int));
    for (int i = 0; i < m; i++)
    {
        work[i] = available[i];
    }
    // Finish array
    int *finish = (int*) malloc(n * sizeof(int));
    for (int i = 0; i < n; i++)
    {
        finish[i] = 0;
    }

    int safeIndex = 0;
    int changed;
    do {
        changed = 0;
        for (int i = 0; i < n; i++)
        {
            if (!finish[i] && condition(need, work, i, m))
            {
                for (int j = 0; j < m; j++)
                {
                    work[j] += allocated[i][j];
                }
                finish[i] = 1;
                sequence[safeIndex++] = i;
```

```
                changed = 1;
            }
        }
    } while (changed);

    for (int i = 0; i < n; i++)
    {
        if (!finish[i])
        {
            return 0;
        }
    }
    return 1;
}
int main()
{
    int n, m;
    printf("Enter number of processes and resources (n x m order):
");
    scanf("%d",&n);
    scanf("%d",&m);
    // Allocation Matrix
    printf("Enter Allocation Matrix:\n");
    int **allocated = (int **) malloc(n * sizeof(int*));
    for (int i = 0; i < n; i++)
    {
        allocated[i] = (int*) malloc(m * sizeof(int));
        for (int j = 0; j < m; j++)
        {
            scanf("%d", &allocated[i][j]);
        }
    }

    // Max Matrix
    printf("Enter Max Matrix:\n");
    int **max = (int **) malloc(n * sizeof(int*));
    for (int i = 0; i < n; i++)
    {
        max[i] = (int*) malloc(m * sizeof(int));
        for (int j = 0; j < m; j++)
        {
            scanf("%d", &max[i][j]);
        }
    }
    // Available Matrix
    printf("Enter Available matrix:\n");
```

```
    int *available = (int *) malloc(m * sizeof(int));
    for (int i = 0; i < m; i++)
    {
        scanf("%d", &available[i]);
    }
    // Sequence Matrix
    int *sequence = (int *) malloc(n * sizeof(int));

    int safe = safety(m, n, allocated, max, available, sequence);
    if (safe)
    {
        printf("System is in a Safe State.\nSafe Sequence: ");
        for (int i = 0; i < n; i++)
        {
            printf("P%d\t", sequence[i]);
        }
        printf("\n");
    }
    else
    {
        printf("System is not in a Safe State.\n");
    }
    return 0;
}
```

Output:

```
Enter number of processes and resources (n x m order): 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 a Safe State.
Safe Sequence: P1       P3      P4      P0      P2
```



6. Bankers Algorithm

```
#include <stdio.h>
#include <stdlib.h>
int condition (int **need, int *work, int i, int m)
{
    for(int j = 0; j < m; j++)
    {
        if(need[i][j] > work[j])
            return 0; }
        return 1; }
int Safety(int m, int n, int **allocated, int **max, int *available
                                                    int *sequence)
{
    int **need = (int**)malloc(n * sizeof(int*));
    for(int i = 0; i<n; i++)
    {
        need[i] = (int*) malloc(m * sizeof(int));
        for(int j=0; j<n; j++)
        {
            need[i] = (int*) malloc(m*sizeof(int));
            for(int j=0; j<m; j++)
            {
                need[i][j] = max[i][j] - allocated[i][j];
            } }

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

```
if (!Finish[i] && condition(need, work, i, m))
{
  for (int j = 0; j < m; j++)
    {
      work[j] += allocated[i][j]; }
      Finish[i] = 1;
      Sequence[safeIndex++] = i;
      changed = 1; } }
} while (changed);
for (int i = 0; i < n; i++)
{
  if (!Finish[i]) {
    return 0; } } return 1; }
int main()
{
  int n, m;
  printf("Enter number of processes and resources (n x m) order):");
  scanf("%d", &n);
  scanf("%d", &m);
  printf("Enter Allocation Matrix:\n");
  int **allocated = (int **) malloc(n * sizeof(int*));
  for (int i = 0; i < n; i++) {
    allocated[i] = (int*) malloc(m * sizeof(int));
    for (int j = 0; j < m; j++) {
      scanf("%d", &allocated[i][j]); } }
  printf("Enter Max Matrix:\n");
  int **max = (int **) malloc(n * sizeof(int*));
  {
    max[i] = (int*) malloc(m * sizeof(int*));
    for (int i=0; i<n; i++)
    { max[i] = (int*) malloc(m * sizeof(int)); }
```

```
Enter Available matrix
3 3 2
System is in Safe State
Safe sequence: P1 P3 P4 P0 P2
```

Program 8

Question

Write a C program to simulate deadlock detection

=> Deadlock Detection

Code

```
#include <stdio.h>
#include <stdbool.h>
#define P 5
#define R 3
int main() {
    int finish[P] = {0};
    int work[R];
    int need[P][R] = {
        {7, 5, 3},
        {3, 2, 2},
        {9, 0, 2},
        {2, 2, 2},
        {4, 3, 3}
    };
    int allocation[P][R] = {
        {0, 1, 0},
        {2, 0, 0},
        {3, 0, 2},
        {2, 1, 1},
        {0, 0, 2}
    };
    int available[R] = {3, 3, 2};
    for (int i = 0; i < R; i++) {
        work[i] = available[i];
    }
    bool deadlock = false;
    int count = 0;

    while (count < P) {
        bool found = false;
        for (int p = 0; p < P; p++) {
            if (finish[p] == 0) {
                bool canFinish = true;
                for (int r = 0; r < R; r++) {
                    if (need[p][r] - allocation[p][r] > work[r]) {
                        canFinish = false;
                        break;
                    }
                }
```

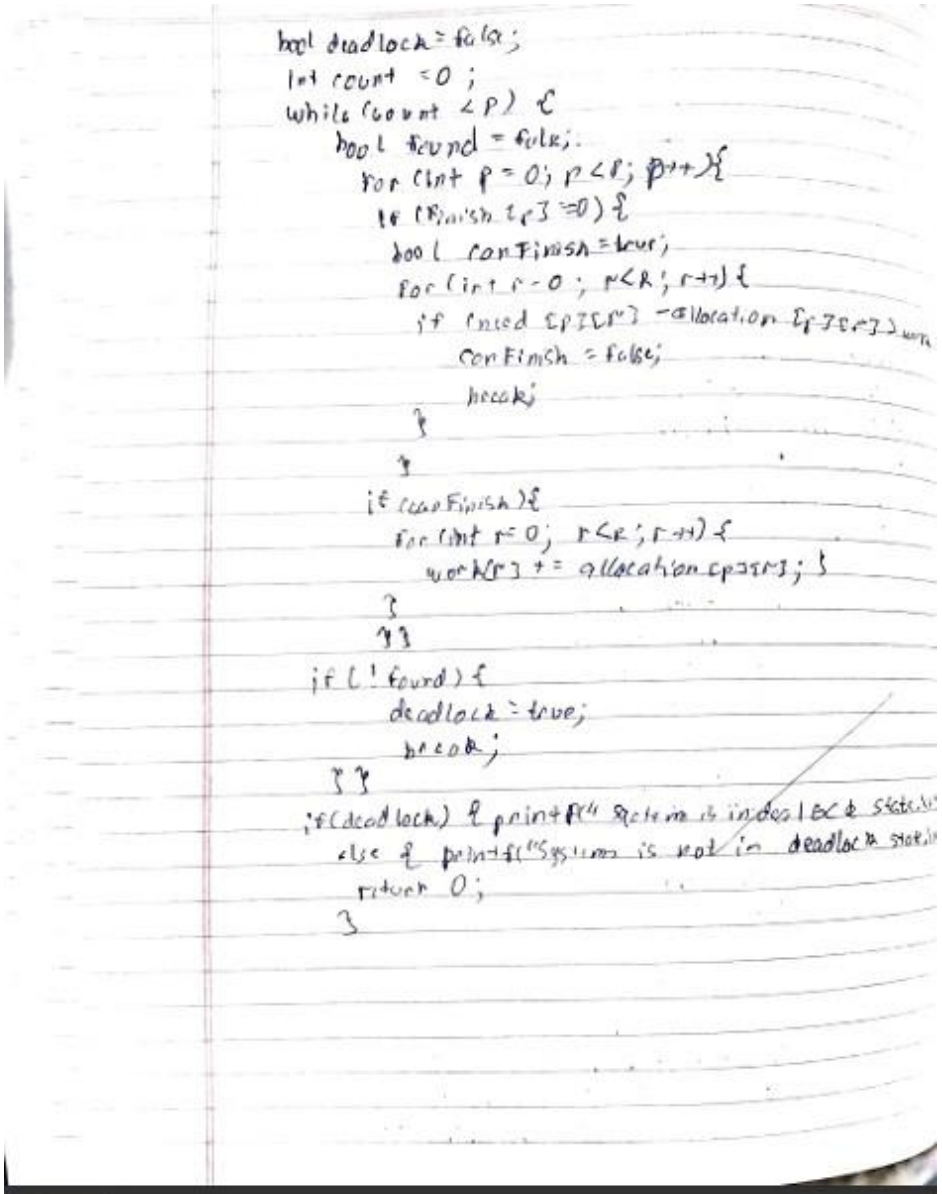
```
                if (canFinish) {
                    for (int r = 0; r < R; r++) {
                        work[r] += allocation[p][r];
                    }
                    printf("Process %d can finish.\n", p);
                    finish[p] = 1;
                    found = true;
                    count++;
                }
            }
        }
        if (!found) {
            deadlock = true;
            break;
        }
    }
    if (deadlock) {
        printf("System is in a deadlock state.\n");
    } else {
        printf("System is not in a deadlock state.\n");
    }
    return 0;
}
```

Output:

```
Process 1 can finish.
Process 3 can finish.
Process 4 can finish.
Process 0 can finish.
Process 2 can finish.
System is not in a deadlock state.
```

6. Deadlock Detection

```
#include <stdio.h>
#include <stdbool.h>
#define P 5
#define R 3
int main () {
    int finish[P] = {0};
    int work[R];
    int need[P][R] = {
     {7, 5, 3},
     {3, 2, 2},
     {9, 0, 2},
     {2, 2, 2},
     {4, 3, 3} };
    int allocation[P][R] = {
     {0, 1, 0},
     {2, 0, 0},
     {3, 0, 2},
     {2, 1, 1},
     {0, 0, 2} };
    int available[R] = {3, 3, 2};
    for (int i = 0; i < R; i++) {
        work[i] = available[i]; }
```



```
bool deadlock = false;
int count = 0;
while (count < P) {
    bool found = false;
    for (int p = 0; p < P; p++) {
        if (finish[p] == 0) {
            bool canFinish = true;
            for (int r = 0; r < R; r++) {
                if (need[p][r] > allocation[p][r])
                    canFinish = false;
                    break;
                }
            }
            if (canFinish) {
                for (int r = 0; r < R; r++)
                    work[r] += allocation[p][r]; }
            }
        }
    if (!found) {
        deadlock = true;
        break;
    }
}
if(deadlock) printf("System is in deadlock state\n");
else printf("System is not in deadlock state\n");
return 0;
}
```

Output:

```
Process 1 can finish
Process 3 can finish
Process 4 can finish
Process 0 can finish
Process 2 can finish
System is not in a deadlock state
```

Program 9

Question

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

=> Best fit, worst fit, first fit

Code

```
#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("Memory 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; // Initialize with a large 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\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);
        }
    }
}

void firstFit(struct Block blocks[], int n_blocks, struct File
files[], int n_files) {
    printf("Memory 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 found = 0;
        for (int j = 0; j < n_blocks; j++) {
            if (blocks[j].is_free && blocks[j].block_size >=
files[i].file_size) {
                blocks[j].is_free = 0;
                int fragment = blocks[j].block_size -
files[i].file_size;
                printf("%d\t\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);
                found = 1;
                break;
            }
        }
        if (!found) {
            printf("No suitable block found for File %d\n",
files[i].file_no);
        }
    }
}

void worstFit(struct Block blocks[], int n_blocks, struct File
files[], int n_files) {
    printf("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; // Initialize with a small 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 > max_fragment) {
                    max_fragment = fragment;
                    worst_fit_block = j;
                }
            }
        }

        if (worst_fit_block != -1) {
            blocks[worst_fit_block].is_free = 0;
            printf("%d\t\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);
        }
    }
}

int main() {
    int n_blocks, n_files;
    printf("Enter the number of blocks: ");
    scanf("%d", &n_blocks);
    printf("Enter the number of files: ");
    scanf("%d", &n_files);

    struct Block blocks[n_blocks];
    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;
    }

    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);
    }
    while(1) {
```

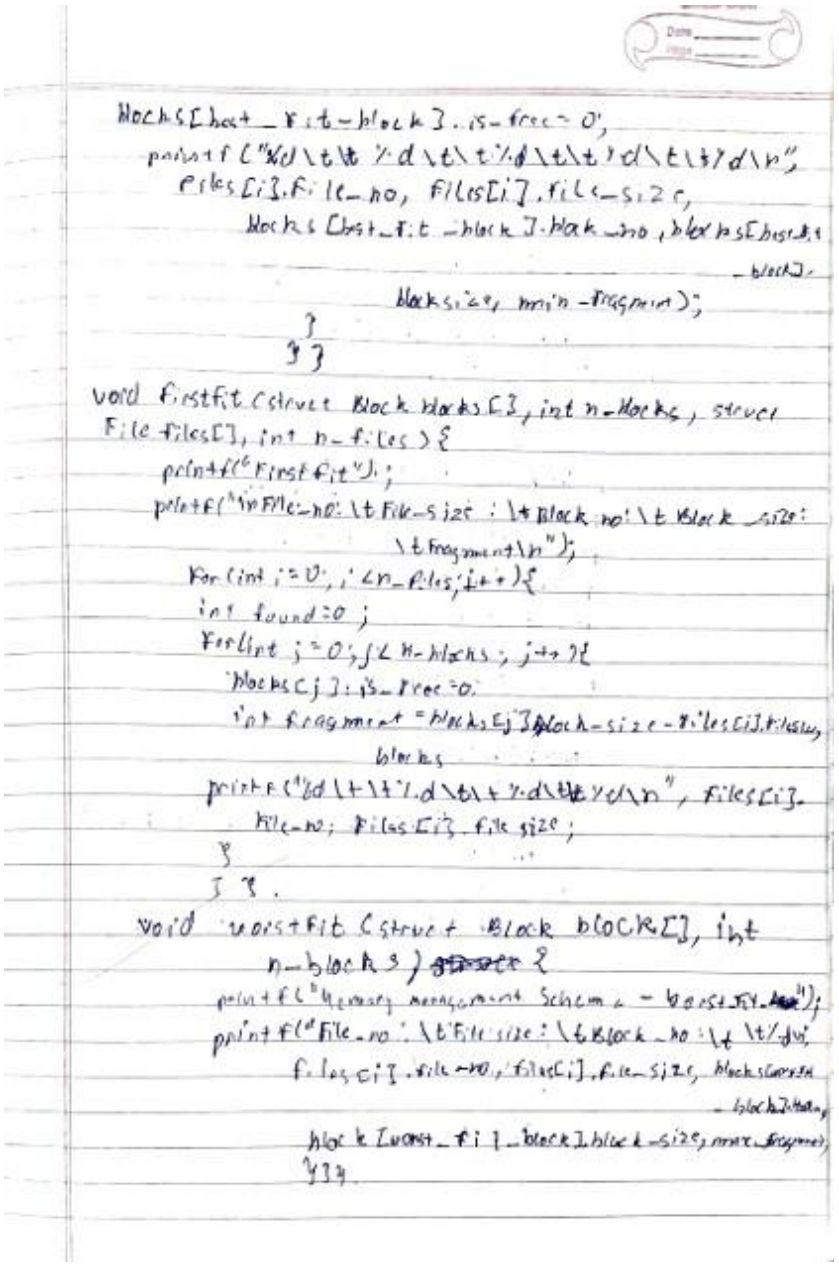
```
    int choice;
    printf("Choose Memory Management Scheme:\n");
    printf("1. Best Fit\n");
    printf("2. First Fit\n");
    printf("3. Worst Fit\n");
    printf("[ANY KEY]. Exit\n");
    printf("Enter your choice: ");
    scanf("%d", &choice);

    // Reset blocks for allocation scheme
    for (int i = 0; i < n_blocks; i++) {
        blocks[i].is_free = 1;
    }

    switch (choice) {
        case 1:
            bestFit(blocks, n_blocks, files, n_files);
            break;
        case 2:
            firstFit(blocks, n_blocks, files, n_files);
            break;
        case 3:
            worstFit(blocks, n_blocks, files, n_files);
            break;
        default:
        printf("Closing...");
            return 0;
    } }

    return 0;
}
```

Output:

```
Enter the number of blocks: 5
Enter the number of files: 4
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 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
Choose Memory Management Scheme:
1. Best Fit
2. First Fit
3. Worst Fit
[ANY KEY]. Exit
Enter your choice: 1
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             88
4               426             5               600             174
Choose Memory Management Scheme:
1. Best Fit
2. First Fit
3. Worst Fit
[ANY KEY]. Exit
Enter your choice: 2
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
No suitable block found for File 4
Choose Memory Management Scheme:
1. Best Fit
2. First Fit
3. Worst Fit
[ANY KEY]. Exit
Enter your choice: 5
Closing...
```

8. worst fit, best fit, first fit algorithm

```
#include<stdio.h>
define structure Block with block_no, block_...
define structure File with file_no, file_size.

void WorstFit (struct Block blocks[], int n_blocks,
File files
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
                                        int n_files){
printf("File_no: \t Filesize: \t Block_no: \t Block Size: \t
for(int i = 0; i < n_files; i++){
        int best_fit_block = -1;
        int min_fragment = 100000;
    for(int j = 0; j < n_blocks; j++){
        if(blocks[j]. is_free && 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\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);
}
}
}

void firstfit(struct Block blocks[], int n_blocks, struct
File files[], int n_files){
printf("First Fit");
printf("\nFile_no:\tFile_size:\tBlock no:\tBlock_size:
\tFragment\n");
for(int i=0; i<n_files; i++){
int found=0;
for(int j=0; j<n_blocks; j++){
blocks[j].is_free=0;
int fragment = blocks[j].block_size - files[i].files[i].filesize,
blocks
printf("%d\t\t%d\t\t%d\t\t%d\t\t%d\n", files[i].
file_no; files[i].file_size;
}
}.
void worstfit(struct Block block[], int
n_blocks){
printf("Memory management Scheme - Worst Fit");
printf("File_no:\tFile_size:\tBlock_no:\t\t%d",
files[i].file_no, files[i].file_size, blocks[worst_fit
_block].block_no,
block[worst_fit_block].block_size, max_fragment);
}}.
```

Output: Memory management Demo:

Enter the number of blocks : 5.

Enter the number of files : 4

Enter the size of the blocks:

Block 1: 100

Block 2: 500

Block 3: 200

Block 4: 300

Block 5: 600

Enter the size of the files:

File 1: 212

File 2: 417

File 3: 112

File 4: 426

1. First Fit

2. Best Fit

3. Worst Fit

[ANY KEY] Exit

Enter your choice: 1

Best fit

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

Program 10

Question

Write a C program to simulate page replacement algorithms a) FIFO
d) LRU
e) Optimal

=> LRU & Optimal

Code

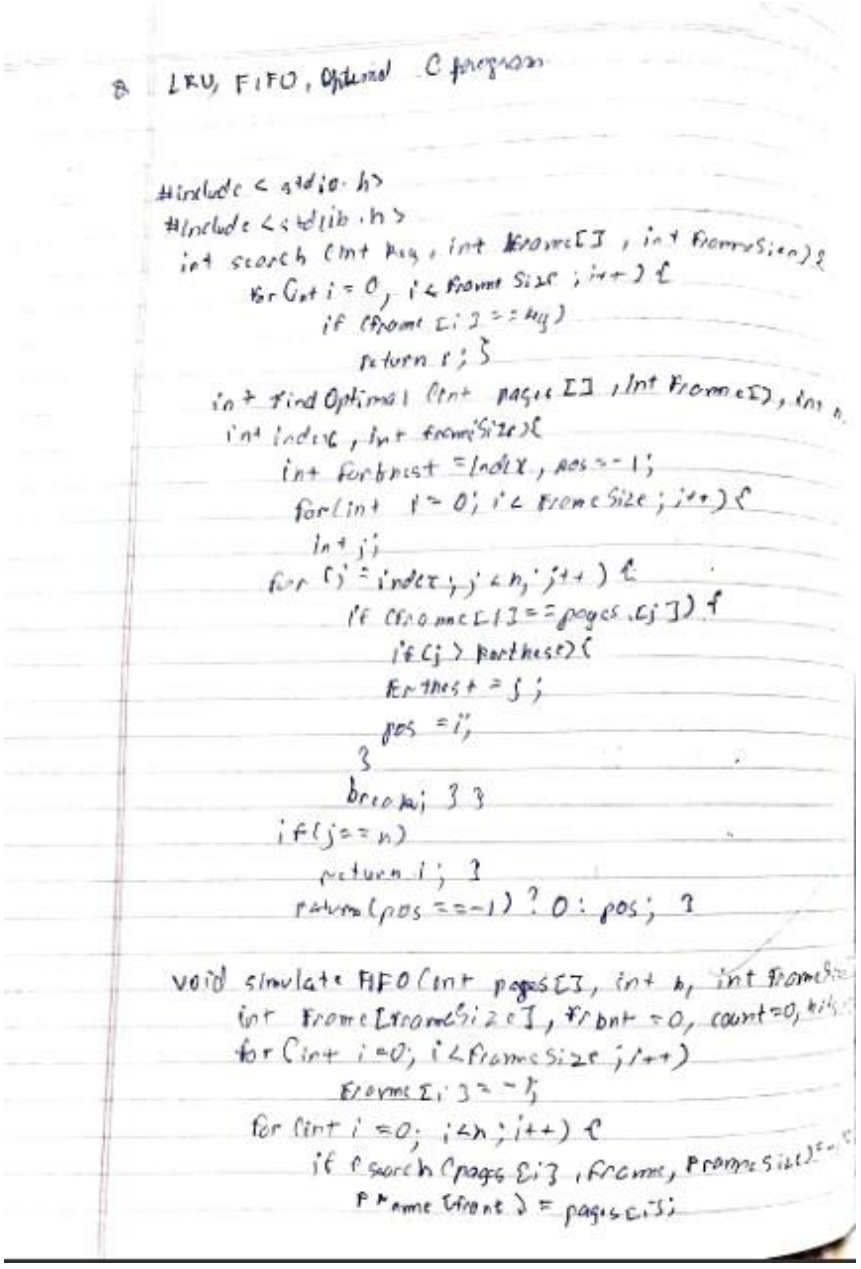
```
#include <stdio.h>
#include <stdlib.h>

int search(int key, int frame[], int frameSize) {
    for (int i = 0; i < frameSize; i++) {
        if (frame[i] == key)
            return i;
    }
    return -1;
}

int findOptimal(int pages[], int frame[], int n, int index, int
frameSize) {
    int farthest = index, pos = -1;
    for (int i = 0; i < frameSize; i++) {
        int j;
        for (j = index; j < n; j++) {
            if (frame[i] == pages[j]) {
                if (j > farthest) {
                    farthest = j;
                    pos = i;
                }
                break;
            }
        }
        if (j == n)
            return i;
    }
    return (pos == -1) ? 0 : pos;
}

void simulateFIFO(int pages[], int n, int frameSize) {
    int frame[frameSize], front = 0, 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) {
            frame[front] = pages[i];
            front = (front + 1) % frameSize;
            count++;
        } else {
            hits++;
        }
    }
    printf("FIFO Page Faults: %d, Page Hits: %d\n", count, hits);
}

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[replaceIndex] = pages[i];
            }
            count++;
        } else {
            hits++;
        }
    }
    printf("Optimal Page Faults: %d, Page Hits: %d\n", count,
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);
    simulateOptimal(pages, n, frameSize);
    simulateLRU(pages, n, frameSize);

    return 0;
}
```

Output:

```
Enter the size of the pages: 7
Enter the page strings: 1 3 0 3 5 6 3
Enter the no of page frames: 3
FIFO Page Faults: 6, Page Hits: 1
Optimal Page Faults: 5, Page Hits: 2
LRU Page Faults: 5, Page Hits: 2
```



8 LRU, FIFO, Optimal C program

```
#include <stdio.h>
#include <stdlib.h>
int search(int key, int frame[], int frameSize){
    for(int i = 0; i < frameSize; i++){
        if(frame[i] == key)
            return i; }
int findOptimal(int pages[], int frame[], int n,
int index, int frameSize){
    int farthest = index, pos = -1;
    for(int i = 0; i < frameSize; i++){
        int j;
        for(j = index; j < n; j++){
            if(frame[i] == pages[j]){
                if(j > farthest){
                farthest = j;
                pos = i;
            }
            break; }
        if(j == n)
            return i; }
        return(pos == -1) ? 0 : pos; }

void simulateFIFO(int pages[], int n, int frameSize
    int frame[frameSize], front = 0, count = 0, hit
    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;
            count++; }
        else {
            hits++;
        } }
printf("FIFO Page Faults: %d, Page Hits: %d \n",
        count, hits); }

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 simulate Optimal(int page[], int n, int frameSize){
    int frame[frameSize], count = 0, hits = 0;
    for(int i=0; i<frameSize; i++)
        frame[i] = -1;
```

```
simulateLRU(pages, n, framesize);
return 0;
}
```

output:

```
Enter the size of the pages:
7
Enter the no of page strings:
1 3 0 3 5 6 3
Enter the no of page frames:
3
FIFO Page Faults: 6, Page Hits: 1
Optimal Page faults: 5, Page Hits: 2
LRU Page Faults: 5, Page Hits: 2
```