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LAB REPORT

on

OPERATING SYSTEMS

Submitted by

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CERTIFICATE

This is to certify that the Lab work entitled "OPERATING SYSTEMS – 23CS4PCOPS" carried out by **TANMAY VASISHTA (1WA23CS012)**, 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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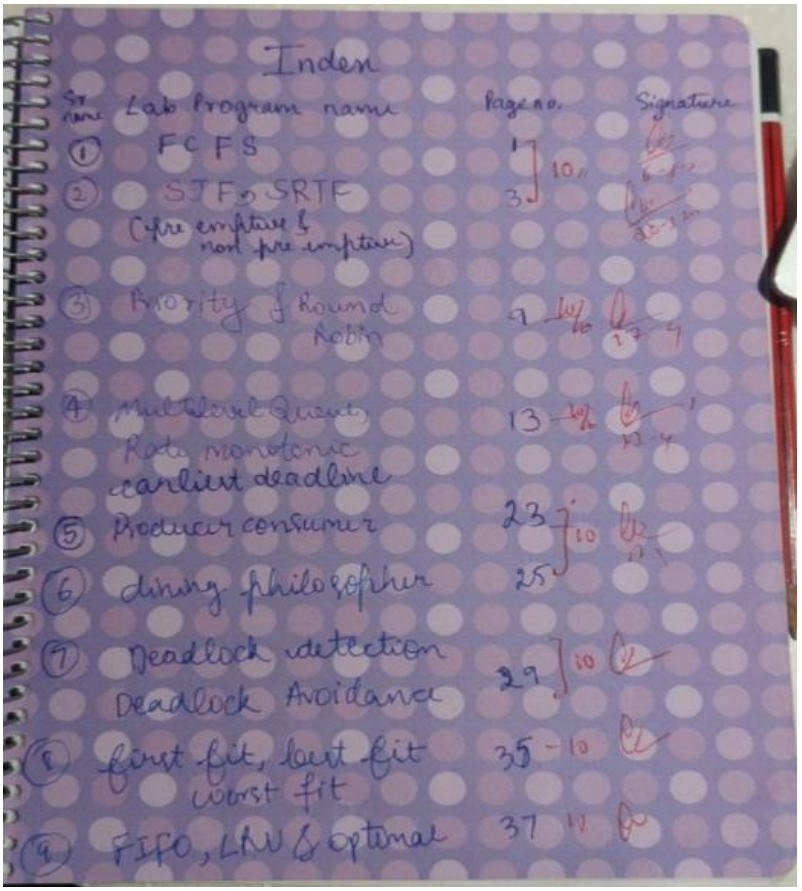
Course Outcomes

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.



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

*FCFS:

```
#include<stdio.h>

void CT(int processes[], int n, int bt[], int at[], int ct[]) {
    ct[0] = at[0] + bt[0];
    for (int i = 1; i < n; i++) {
        ct[i] = (ct[i - 1] > at[i] ? ct[i - 1] : at[i]) + bt[i];
    }
}

void TAT(int processes[], int n, int bt[], int at[], int ct[], int tat[]) {
    for (int i = 0; i < n; i++) {
        tat[i] = ct[i] - at[i];
    }
}

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

void AVG(int processes[], int n, int bt[], int at[]) {
```

```
    int wt[n], tat[n], ct[n];
    CT(processes, n, bt, at, ct);
    TAT(processes, n, bt, at, ct, tat);
    WT(processes, n, bt, at, tat, wt);

    int total_wt = 0, total_tat = 0;
    for (int i = 0; i < n; i++) {
        total_wt += wt[i];
        total_tat += tat[i];
    }

    printf("\navg bt= %.2f", (float)total_wt / n);
    printf("\navg tat = %.2f", (float)total_tat / n);
}

int main() {
    int n;

    printf("no. of processes: ");
    scanf("%d", &n);

    int processes[n], bt[n], at[n];


        printf("enter bt and tat: \n"); for (int i = 0; i < n; i++) { printf("bt %d: ", i + 1);
        scanf("%d", &bt[i]);
        printf("tat %d: ", i + 1);
        scanf("%d", &at[i]);
        processes[i] = i + 1;
    }
```

```
    AVG(processes, n, bt, at);

    return 0;
}
```

```
no. of processes: 4
enter bt and tat:
bt 1: 7
tat 1: 0
bt 2: 3
tat 2: 0
bt 3: 4
tat 3: 0
bt 4: 6
tat 4: 0

avg bt= 7.75
avg tat = 12.75
```

①

```
#include <stdio.h>

int main(){
    int size;
    printf("enter num of processes");
    scanf("%d", &size);
    int arrival[size], burst[size], TAT[size],
     wait[size], comp[size];
    printf("give arrival & burst time of
     each processes");
    for(int i=0; i<size; i++){
        scanf("%d %d", &arrival[i], &burst
        [i]);
    }
    int sum=0, sumburst=0, sumcomp=0;
    int sumwait=0;
    for(int i=0; i<size; i++){
        sum = sum + burst[i];
        Completion[i] = sum;
        sumburst = sumburst + burst[i];
        sumcomp = + completion[i];
        TAT[i] = Completion[i] - arrival[i];
        tatsum = tatsum + TAT[i];
        wait[i] = completion[i] - burst[i];
        sumwait = sumwait + wait[i]
    }
    float avgtat = tatsum / (float) size;
    float avgcomp = sumcomp / (float) size;
    float avgwait = sumwait / (float) size;
    printf("%f %f %f", avgtat, avgwait,
     avg comp);
}
```

O/P

```
enter no. of process 4
0 7
0 4
0 5
0 3
avgtat = 13.2500
avg comp = 18.2500
avg wait = 8.5000
```

*SJF(Non-preemptive):

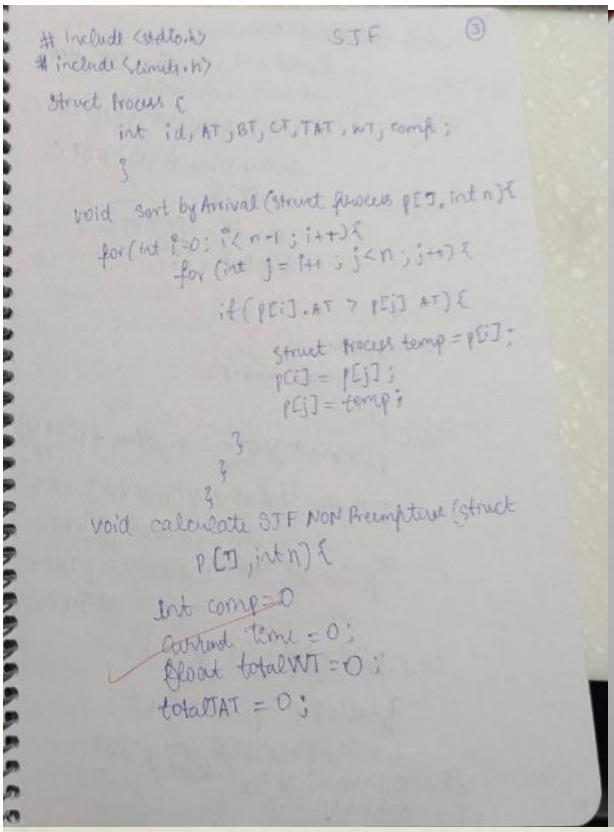
```
#include <stdio.h>
#include <stdlib.h>

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

int compareArrivalTime(const void *a, const void *b) {
    return ((struct Process*)a)->at - ((struct Process*)b)->at;
}

void calculateTimes(struct Process processes[], int n) {
    int time = 0;
    int completed = 0;

    while (completed < n) {
        int shortest = -1;
        int min_burst = 1000000;

        for (int i = 0; i < n; i++) {
            if (processes[i].at <= time && processes[i].ct == 0) {
                if (processes[i].bt < min_burst) {
                    min_burst = processes[i].bt;
                    shortest = i;
                }
            }
        }

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

```
        } else {
            processes[shortest].ct = time + processes[shortest].bt;
            processes[shortest].tat = processes[shortest].ct - processes[shortest].at;
            processes[shortest].wt = processes[shortest].tat - processes[shortest].bt;

            time = processes[shortest].ct;
            completed++;
        }
    }
}

void calculateAvg(struct Process processes[], int n) {
    int total_wt = 0, total_tat = 0;

    for (int i = 0; i < n; i++) {
        total_wt += processes[i].wt;
        total_tat += processes[i].tat;
    }

    printf("\navg wt = %.2f", (float)total_wt / n);
    printf("\navg tat = %.2f", (float)total_tat / n);
}

int main() {
    int n;

    printf("no. of processes: ");
    scanf("%d", &n);

    struct Process processes[n];

    printf("enter bt and at: \n");
    for (int i = 0; i < n; i++) {
        processes[i].id = i + 1;
        printf("bt %d: ", i + 1);
        scanf("%d", &processes[i].bt);
        printf("at %d: ", i + 1);
```

```
    scanf("%d", &processes[i].at);
    processes[i].ct = 0;
  }

  qsort(processes, n, sizeof(struct Process), compareArrivalTime);

  calculateTimes(processes, n);

  calculateAvg(processes, n);

  return 0;
  }
```

```
no. of processes: 4
enter bt and at:
bt 1: 7
at 1: 0
bt 2: 3
at 2: 8
bt 3: 4
at 3: 3
bt 4: 6
at 4: 5

avg wt = 4.00
avg tat = 9.00%
```

`



```
#include <stdio.h>                                SJF        ③
#include <limits.h>
struct Process {
    int id, AT, BT, CT, TAT, WT, comp;
};
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 calculate SJF NON Preemptive (struct
    p[], int n) {
int comp=0
current time = 0;
float totalWT = 0;
totalTAT = 0;
```

```
while (completed<n){
    int shortest = -1, minBT = INT_MAX;
    for (int i=0; i<n; i++){
        if (!p[i].completed && p[i].AT <=
        currenttime && p[i].BT <
        minBT){
            minBT = p[i].BT
            shortest = i;
    }
}
if (shortest == -1) {
    current time++;
}
else {
p[shortest]xCT = currentime + p[shortest].
                                    BT;
p[shortest]xTAT = p[shortest].CT -
                  p[shortest].AT;
p[shortest]xWT = p[shortest].TAT -
                 p[shortest].BT;
p[shortest]xcomp = 1;
totalWT += p[shortest].WT;
totalTAT += p[shortest].TAT;
currenttime = p[shortest].CT;
completed++;
```

```
printf("\n process \t WT \t TAT \n"); ⑤
for(int i=0; i<n; i++)
printf("Average WT : %.f", totalWT/n);
printf("\nAverage TAT : %.f", totalTAT/n);
}
```

*SJF (pre-emptive):

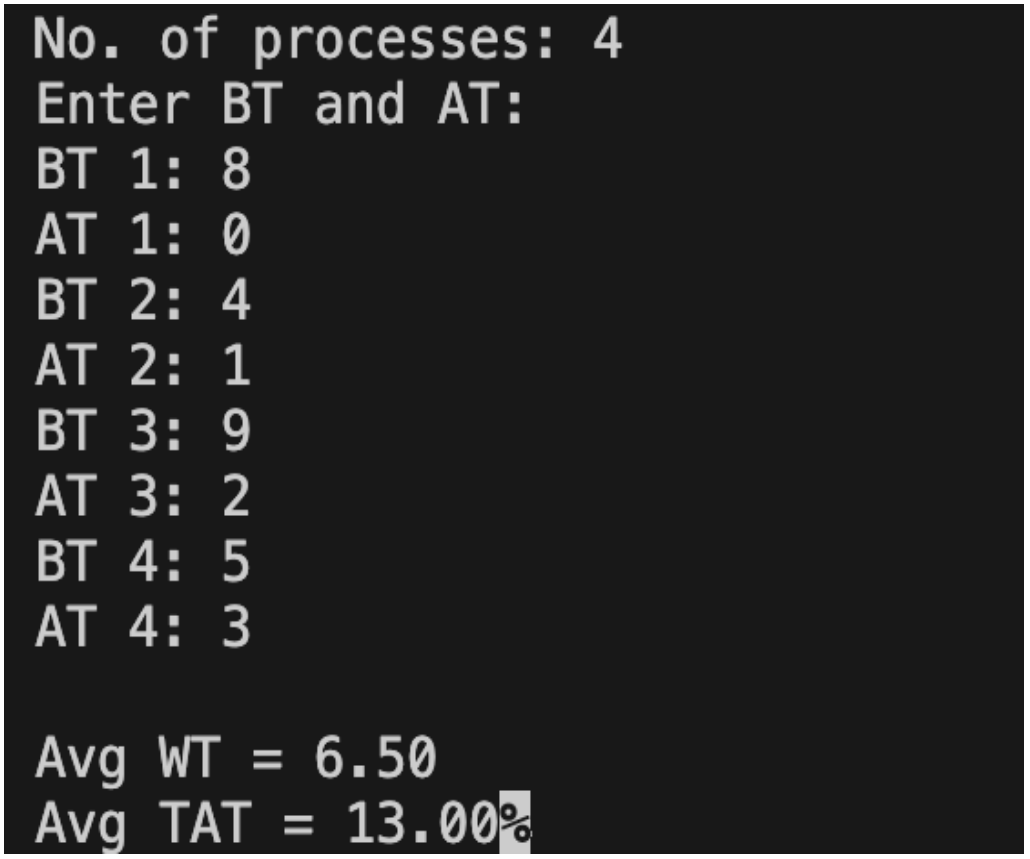
```
#include <stdio.h>
#include <limits.h>

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

void calculateTimes(struct Process processes[], int n) {
    int completed = 0, time = 0, shortest = -1;
    int min_burst = INT_MAX;

    while (completed < n) {
        shortest = -1;
        min_burst = INT_MAX;


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

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

`

```
        processes[shortest].rt--;
        time++;

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

void calculateAvg(struct Process processes[], int n) {
    int total_wt = 0, total_tat = 0;

    for (int i = 0; i < n; i++) {
        total_wt += processes[i].wt;
        total_tat += processes[i].tat;
    }

    printf("\nAvg WT = %.2f", (float)total_wt / n);
    printf("\nAvg TAT = %.2f", (float)total_tat / n);
}

int main() {
    int n;

    printf("No. of processes: ");
    scanf("%d", &n);

    struct Process processes[n];

    printf("Enter BT and AT: \n");
    for (int i = 0; i < n; i++) {
        processes[i].id = i + 1;
        printf("BT %d: ", i + 1);
        scanf("%d", &processes[i].bt);
        printf("AT %d: ", i + 1);
```

`

```
        scanf("%d", &processes[i].at);
        processes[i].rt = processes[i].bt;
    }

    calculateTimes(processes, n);

    calculateAvg(processes, n);

    return 0;
}
```



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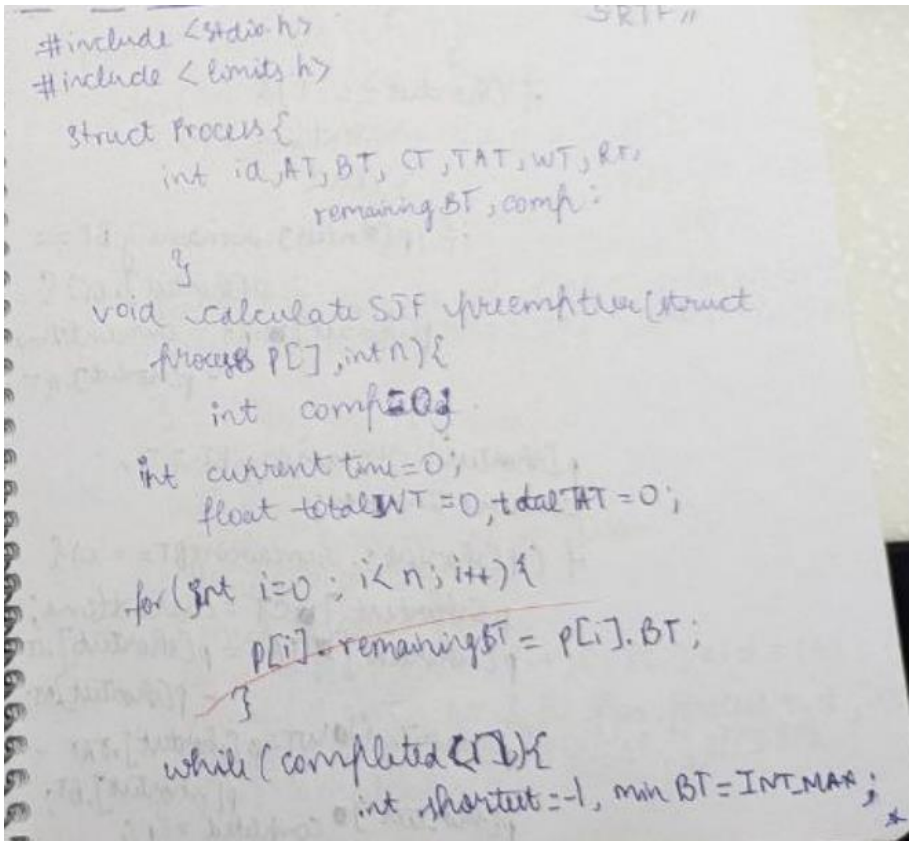
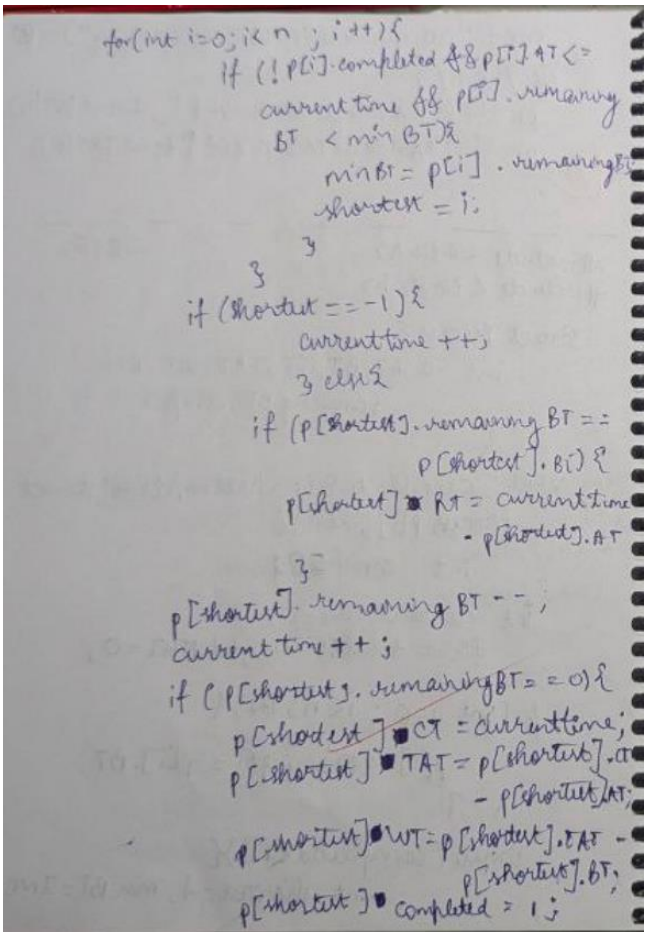
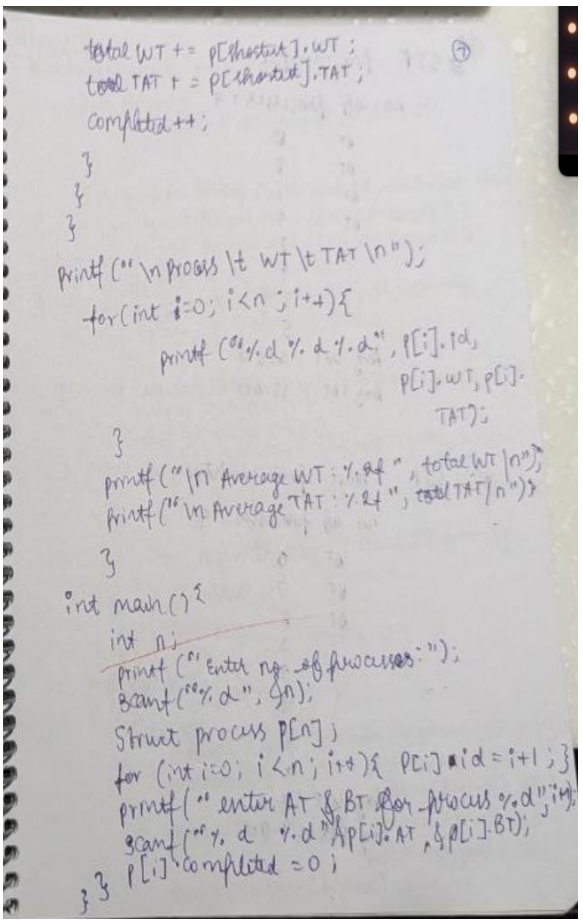


```
#include <stdio.h>
#include <limits.h>
struct Process {
    int id, AT, BT, CT, TAT, WT, RT,
        remainingBT, comp;
};
void calculateSJFpreemptive(struct
  Process p[], int n){
    int comp=0;
int currenttime=0;
    float totalWT=0, totalTAT=0;
for(int i=0; i<n; i++){
    p[i].remainingBT = p[i].BT;
}
while(completed<n){
        int shortest=-1, minBT=INT_MAX;
```



```
for(int i=0; i<n; i++){
    if(!p[i].completed && p[i].AT<=
      currenttime && p[i].remaining
      BT < minBT){
        minBT = p[i].remainingBT;
        shortest = i;
    }
}
if(shortest==-1){
    currenttime++;
}else{
    if(p[shortest].remainingBT ==
        p[shortest].BT){
        p[shortest].RT = currenttime
            - p[shortest].AT
    }
p[shortest].remainingBT--;
currenttime++;
if(p[shortest].remainingBT==0){
    p[shortest].CT = currenttime;
    p[shortest].TAT = p[shortest].CT
        - p[shortest].AT;
    p[shortest].WT = p[shortest].TAT -
        p[shortest].BT;
    p[shortest].completed = 1;
```



```
totalWT += p[shortest].WT;
totalTAT += p[shortest].TAT;
completed++;
}
}
}
printf("\nProcess\t WT\t TAT\n");
for(int i=0; i<n; i++){
    printf("%d %d %d", p[i].id,
        p[i].WT, p[i].
        TAT);
}
printf("\n Average WT: %.2f", totalWT/n);
printf("\n Average TAT: %.2f", totalTAT/n);
}
int main(){
    int n;
    printf("Enter no. of processes:");
    scanf("%d", &n);
    struct process p[n];
    for(int i=0; i<n; i++){ p[i].id = i+1; }
    printf("enter AT & BT for process %d", i+1);
    scanf("%d %d", &p[i].AT, &p[i].BT);
    p[i].completed = 0;
}
```

o/p

SJF pre-emptive

no. of processes : 4

AT	0
BT	8
AT	1
BT	4
:	2
:	9
:	3
	5

Avg WT : 6.50

Avg TAT : 13.00

SJF Non pre-emptive

no. of processes : 4

AT	0
BT	7
AT	8
:	3
:	3
:	4
	5
	6

Avg WT : 4.00

Avg TAT : 9.00

2. Write a C program to simulate the following CPU scheduling algorithm to find turnaround time and waiting time.

→ **Priority (Non-pre-emptive):**

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

struct Process {
    int id, bt, at, priority, ct, tat, wt;
};

int comparePriority(const void *a, const void *b) {
    struct Process *p1 = (struct Process *)a;
    struct Process *p2 = (struct Process *)b;
    if (p1->at == p2->at)
        return p1->priority - p2->priority;
    return p1->at - p2->at;
}

void calculateTimes(struct Process processes[], int n) {
    int time = 0, completed = 0;

    while (completed < n) {
        int highest = -1, highestPriority = 1000000;

        for (int i = 0; i < n; i++) {
            if (processes[i].at <= time && processes[i].ct == 0) {
                if (processes[i].priority < highestPriority) {
                    highestPriority = processes[i].priority;
                    highest = i;
                }
            }
        }

        if (highest == -1) {
```

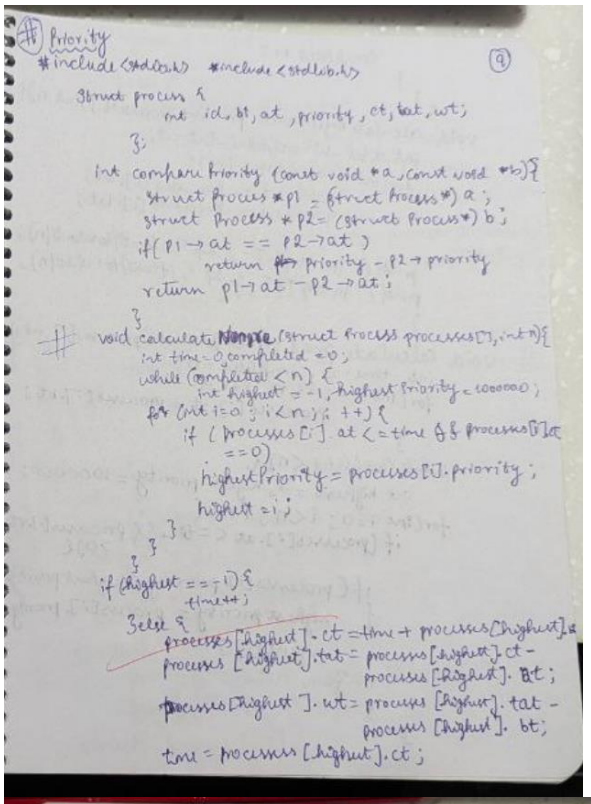
`

```
            time++;
        } else {
            processes[highest].ct = time + processes[highest].bt;
            processes[highest].tat = processes[highest].ct - processes[highest].at;
            processes[highest].wt = processes[highest].tat - processes[highest].bt;

            time = processes[highest].ct;
            completed++;
        }
    }
}

void calculateAvg(struct Process processes[], int n) {
    int total_wt = 0, total_tat = 0;
    for (int i = 0; i < n; i++) {
        total_wt += processes[i].wt;
        total_tat += processes[i].tat;
    }
    printf("\nAvg WT = %.2f", (float)total_wt / n);
    printf("\nAvg TAT = %.2f", (float)total_tat / n);
}

int main() {
    int n;
    printf("No. of processes: ");
    scanf("%d", &n);

    struct Process processes[n];

    for (int i = 0; i < n; i++) {
        processes[i].id = i + 1;
        printf("BT %d: ", i + 1);
        scanf("%d", &processes[i].bt);
        printf("AT %d: ", i + 1);
        scanf("%d", &processes[i].at);
        printf("Priority %d: ", i + 1);
        scanf("%d", &processes[i].priority);
        processes[i].ct = 0;
`
```

```
    }

    qsort(processes, n, sizeof(struct Process), comparePriority);

    calculateTimes(processes, n);
    calculateAvg(processes, n);

    return 0;
}
```

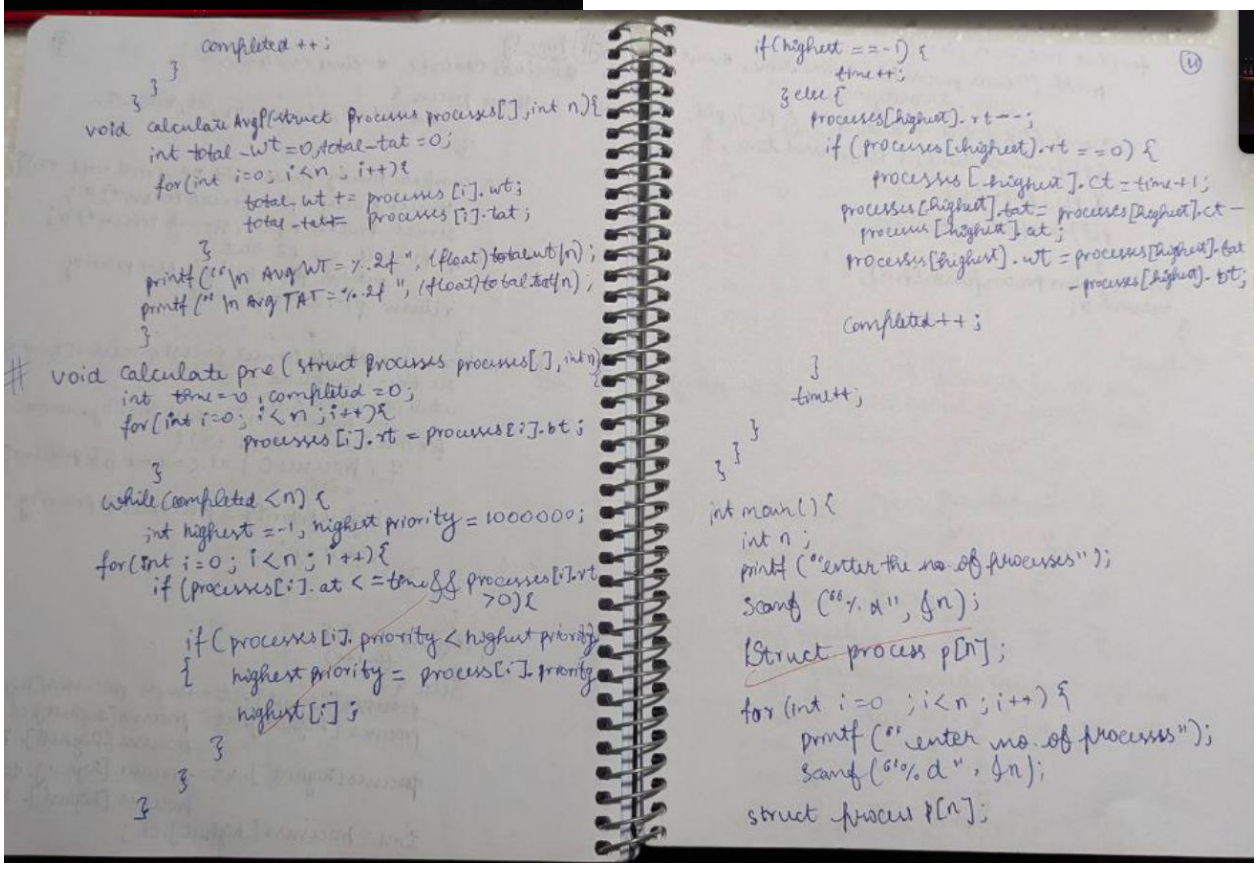
```
No. of processes: 5
BT 1: 3
AT 1: 0
Priority 1: 5
BT 2: 2
AT 2: 2
Priority 2: 3
BT 3: 5
AT 3: 3
Priority 3: 2
BT 4: 4
AT 4: 4
Priority 4: 4
BT 5: 1
AT 5: 6
Priority 5: 1

Avg WT = 3.20
Avg TAT = 6.20
```

`



Priority

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

struct process {
    int id, bt, at, priority, ct, tat, wt;
};

int compare_priority (const void *a, const void *b){
    struct process *p1 = (struct process*) a;
    struct process *p2 = (struct process*) b;
    if(p1->at == p2->at)
        return p1->priority - p2->priority
    return p1->at - p2->at;
}

void calculate_pre(struct process processes[], int n){
    int time=0, completed=0;
    while (completed < n) {
        int highest = -1, highest priority = 1000000;
        for (int i=0; i<n; i++) {
            if (processes[i].at <= time && processes[i].bt
                == 0)
                highestPriority = processes[i].priority;
                highest = i;
            }
        }
    if (highest == -1) {
        time++;
    } else {
        processes[highest].ct = time + processes[highest].
        processes[highest].tat = processes[highest].ct -
                                 processes[highest].bt;
        processes[highest].wt = processes[highest].tat -
                                processes[highest].bt;
        time = processes[highest].ct;
```



```
        completed++;
    }
}

void calculate_avg(struct process processes[], int n){
    int total_wt=0, total_tat=0;
    for(int i=0; i<n; i++){
        total_wt += processes[i].wt;
        total_tat += processes[i].tat;
    }
    printf("\n Avg WT = %.2f", (float)total_wt/n);
    printf("\n Avg TAT = %.2f", (float)total_tat/n);
}

void calculate_pre(struct processes processes[], int n){
    int time=0, completed=0;
    for(int i=0; i<n; i++){
        processes[i].rt = processes[i].bt;
    }
    while(completed<n){
        int highest=-1, highest priority = 1000000;
    for(int i=0; i<n; i++){
        if(processes[i].at <= time && processes[i].rt
                                      > 0){
            if(processes[i].priority < highest priority)
            {   highest priority = process[i].priority;
                highest[i];
            }
        }
    }
```

```
if(highest == -1) {
    time++;
} else {
    processes[highest].rt--;
    if (processes[highest].rt == 0) {
        processes[highest].ct = time+1;
        processes[highest].tat = processes[highest].ct -
            process[highest].at;
        processes[highest].wt = processes[highest].tat
                                - processes[highest].bt;
        completed++;
    }
    time++;
}
}

int main(){
    int n;
    printf("enter the no. of processes");
    scanf("%d", &n);
    struct process p[n];
    for (int i=0; i<n; i++) {
        printf("enter nos. of processes");
        scanf("%d", &n);
    struct process p[n];
```

```
for (int i=0; i<n; i++){
    printf ("enter process id, Arrival time, Burst
            time, priority:");
    scanf ("%d %d %d %d", &p[i].pid,
    &p[i].arrival time, &p[i].burst time, &
    &p[i].priority);
    p[i].completion time=0;
    }
Priority Non Preemptive (p,n);
return 0;
}
```

Output :-

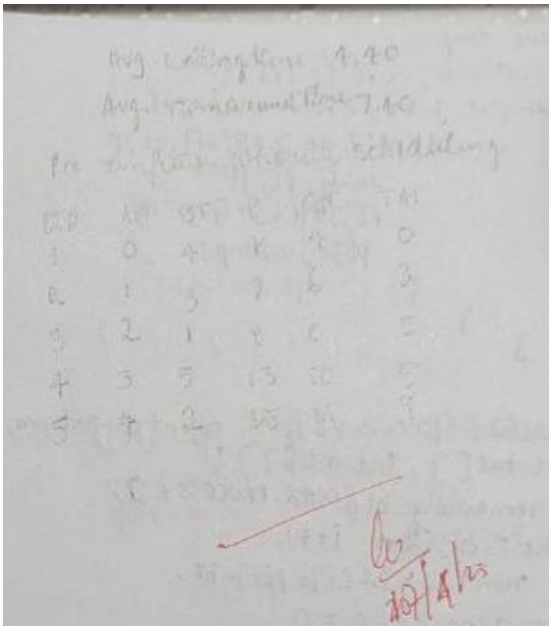
enter no of process 5

enter Process ID, Arrival time, Burst time, Priority

1	0	4	2
2	1	3	3
3	2	1	4
4	3	5	5
5	4	2	5

Non pre-emptive priority scheduling

PID	AT	BT	P	CT	TAT	WT
1	0	4	2	4	4	0
2	1	3	3	7	6	3
3	2	1	4	8	6	5
4	3	5	5	13	10	5
5	4	2	5	15	11	9



→ Priority (pre-emptive):

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

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

int compareArrival(const void *a, const void *b) {
    struct Process *p1 = (struct Process *)a;
    struct Process *p2 = (struct Process *)b;
    return p1->at - p2->at;
}

void calculateTimes(struct Process processes[], int n) {
    int time = 0, completed = 0, min_priority, shortest;
    for (int i = 0; i < n; i++) processes[i].rt = processes[i].bt;

    while (completed < n) {
        shortest = -1;
        min_priority = 1000000;

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

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

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

void calculateAvg(struct Process processes[], int n) {
    int total_wt = 0, total_tat = 0;
    for (int i = 0; i < n; i++) {
        total_wt += processes[i].wt;
        total_tat += processes[i].tat;
    }
    printf("\nAvg WT = %.2f", (float)total_wt / n);
    printf("\nAvg TAT = %.2f", (float)total_tat / n);
}

int main() {
    int n;
    printf("No. of processes: ");
    scanf("%d", &n);

    struct Process processes[n];

    for (int i = 0; i < n; i++) {
        processes[i].id = i + 1;
        printf("BT %d: ", i + 1);
        scanf("%d", &processes[i].bt);
        printf("AT %d: ", i + 1);
        scanf("%d", &processes[i].at);
        printf("Priority %d: ", i + 1);
        scanf("%d", &processes[i].priority);
`
```

```
    }

    qsort(processes, n, sizeof(struct Process), compareArrival);

    calculateTimes(processes, n);
    calculateAvg(processes,n);
    return 0;
}
```

```
No. of processes: 7
BT 1: 8
AT 1: 0
Priority 1: 3
BT 2: 2
AT 2: 1
Priority 2: 4
BT 3: 4
AT 3: 3
Priority 3: 4
BT 4: 1
AT 4: 4
Priority 4: 5
BT 5: 6
AT 5: 5
Priority 5: 2
BT 6: 5
AT 6: 6
Priority 6: 6
BT 7: 1
AT 7: 7
Priority 7: 1

Avg WT = 9.86
Avg TAT = 13.71
```

(pre emptive and non pre emptive is done in one program in lab)

`

Round Robin:

```
#include <stdio.h>

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

void roundRobin(struct Process processes[], int n, int quantum) {
    int time = 0, completed = 0;
    while (completed < n) {
        int done = 1;
        for (int i = 0; i < n; i++) {
            if (processes[i].rt > 0 && processes[i].at <= time) {
                done = 0;
                if (processes[i].rt > quantum) {
                    time += quantum;
                    processes[i].rt -= quantum;
                } else {
                    time += processes[i].rt;
                    processes[i].ct = time;
                    processes[i].tat = processes[i].ct - processes[i].at;
                    processes[i].wt = processes[i].tat - processes[i].bt;
                    processes[i].rt = 0;
                    completed++;
                }
            }
        }
```

`

```
        if (done) time++;
    }
}

void calculateAvg(struct Process processes[], int n) {
    int total_wt = 0, total_tat = 0;
    for (int i = 0; i < n; i++) {
        total_wt += processes[i].wt;
        total_tat += processes[i].tat;


    }
    printf("\nAvg WT = %.2f", (float)total_wt / n);
    printf("\nAvg TAT = %.2f", (float)total_tat / n);
}

int main() {
    int n, quantum;
    printf("No. of processes: ");
    scanf("%d", &n);

    struct Process processes[n];

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

    printf("Time Quantum: ");
    scanf("%d", &quantum);

    roundRobin(processes, n, quantum);
    calculateAvg(processes, n);

    return 0;
`
```

}

```
No. of processes: 5
BT 1: 8
AT 1: 0
BT 2: 2
AT 2: 5
BT 3: 7
AT 3: 1
BT 4: 3
AT 4: 6
BT 5: 5
AT 5: 8
Time Quantum: 3

Avg WT = 10.40
Avg TAT = 15.40
```

Q) Write a C prg of Round-Robin.

Soln)

```
#include<stdio.h>
struct Process {
    int id, bt, at, rt, ct, tat, wt;
    };
void RR(struct Process process[], int n, int quantum)
  { int time =0, completed =0;
    while (completed <n){
            int done =1;
            for (int i=0 ; i<n; i++){
              if (process[i].rt >0 &&
                  process[i]. at <= time){
              done =0;
            if (process[i].rt > quantum){
              time += quantum;
              process[i].rt -= quantum;
            }else {
              time += process[i].rt;
              process[i]. ct = time;
              process[i]. tat = process[i].ct - process[i].at;
              process[i]. wt = process[i]. tat - process[i]. bt;

              process[i]. rt =0;
              completed ++;
            }
          }
        }
        if (done) time ++;
      }
    }
void CalAvg (struct Process process[], int n){
        int totalwt =0, totaltat =0;
    for (int i=0; i<n; i++){
          total_wt += process [i]. wt;
          totaltat += process [i]. tat;
          }
```

O/p No. of processes: 5

Enter BT and AT:

BT1: 8
AT1: 0
BT2: 2
AT2: 5
BT3: 7
AT3: 1
BT4: 3
AT4: 6
BT5: 5
AT5: 8

→ Time Quantum: 3

Avg WT: 10.40

Avg TAT: 15.40

	AT	BT	CT	TAT	WT
P_1	0	8	22	22	14
P_2	5	2	11	6	4
P_3	1	7	23	22	15
P_4	6	3	14	8	5
P_5	8	5	25	17	12

GC:

P_1	P_3	P_1	P_2	P_4	P_3	P_5	P_1	P_3	P_5
0–3	3–6	6–9	9–11	11–14	14–17	17–20	20–22	22–23	23–25

`

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.

→Multilevel scheduling:

```
#include <stdio.h>

#define MAX_PROCESSES 10

typedef struct {
    int pid;
    int bt;
    int at;
    int queue;
} Process;

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

`

```
void roundRobin(Process p[], int n, int quantum, int wt[], int tat[], int rt[]) {
    int remaining_bt[MAX_PROCESSES];
    for (int i = 0; i < n; i++)
        remaining_bt[i] = p[i].bt;

    int t = 0, completed = 0;

    while (completed < n) {
        int executed = 0;
        for (int i = 0; i < n; i++) {
            if (remaining_bt[i] > 0) {
                if (rt[i] == -1) rt[i] = t;

                if (remaining_bt[i] > quantum) {
                    t += quantum;
                    remaining_bt[i] -= quantum;
                } else {
                    t += remaining_bt[i];
                    tat[i] = t - p[i].at;
                    wt[i] = tat[i] - p[i].bt;
                    remaining_bt[i] = 0;
                    completed++;
                }
                executed = 1;
            }
        }
        if (!executed) t++;
    }
}

void fcfs(Process p[], int n, int start_time, int wt[], int tat[], int rt[]) {
    int time = start_time;
    for (int i = 0; i < n; i++) {
        if (time < p[i].at) time = p[i].at;
        rt[i] = time - p[i].at;
        wt[i] = rt[i];
        tat[i] = wt[i] + p[i].bt;
        time += p[i].bt;
`
```

```
    }
}

int main() {
    int n, quantum;
    Process p[MAX_PROCESSES], sys[MAX_PROCESSES],
usr[MAX_PROCESSES];
    int sys_count = 0, usr_count = 0;
    int wt[MAX_PROCESSES], tat[MAX_PROCESSES], rt[MAX_PROCESSES];

    printf("NO. of process: ");
    scanf("%d", &n);

    for (int i = 0; i < n; i++) {
        printf("Enter BT,AT and Q (1=sys, 2=user) for P%d: ", i + 1);
        p[i].pid = i + 1;
        scanf("%d %d %d", &p[i].bt, &p[i].at, &p[i].queue);

        if (p[i].queue == 1)
            sys[sys_count++] = p[i];
        else
            usr[usr_count++] = p[i];

        wt[i] = 0;
        tat[i] = 0;
        rt[i] = -1;
    }

    printf("QT for RR: ");
    scanf("%d", &quantum);

    sortByArrival(sys, sys_count);
    sortByArrival(usr, usr_count);

    roundRobin(sys, sys_count, quantum, wt, tat, rt);
    int last_sys_time = (sys_count > 0) ? tat[sys_count - 1] + sys[sys_count - 1].at : 0;
    fcfs(usr, usr_count, last_sys_time, &wt[sys_count], &tat[sys_count],
&rt[sys_count]);
```
`

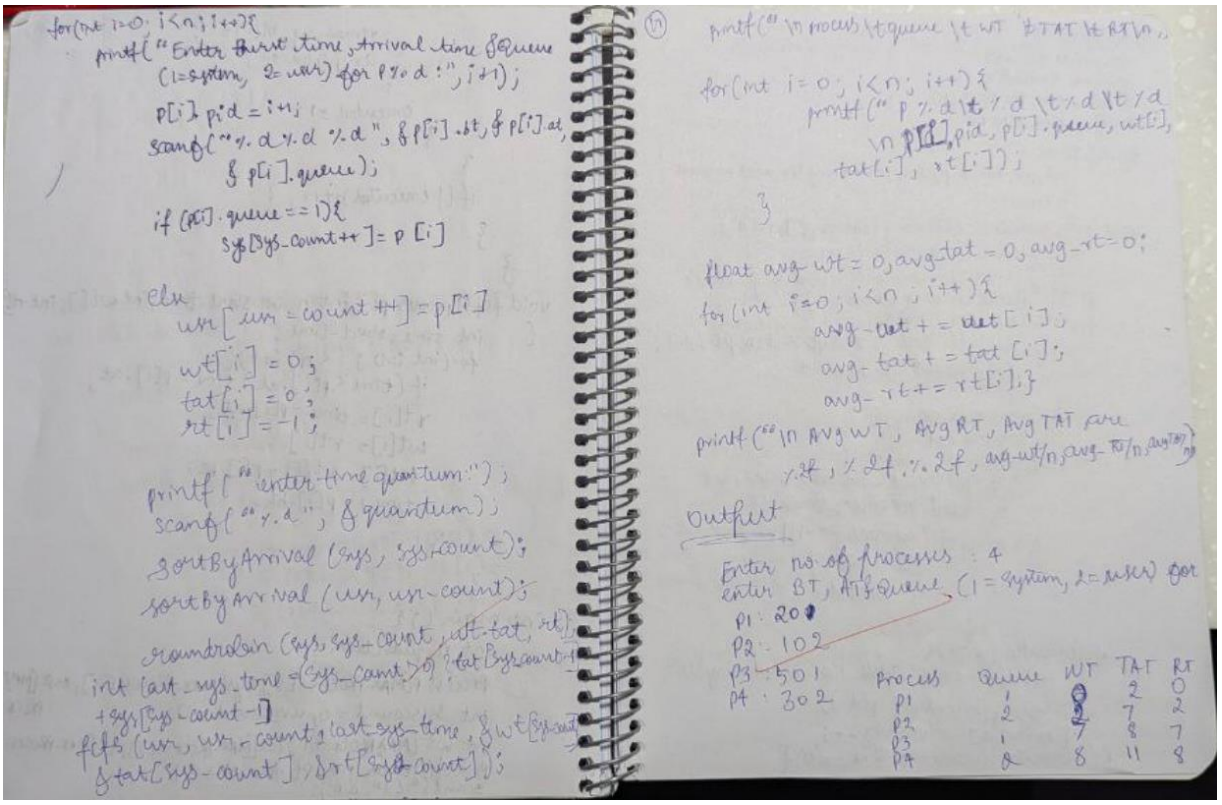
```
    printf("\nP\tQ\tWT\tTAT\tRT\n");
    for (int i = 0; i < n; i++)
        printf("P%d\t%d\t%d\t\t%d\t\t\t%d\n", p[i].pid, p[i].queue, wt[i], tat[i], rt[i]);

    float avg_wt = 0, avg_tat = 0, avg_rt = 0;
    for (int i = 0; i < n; i++) {
        avg_wt += wt[i];
        avg_tat += tat[i];
        avg_rt += rt[i];
    }

    printf("\nAVG WT: %.2f", avg_wt / n);
    printf("\nAVG TAT: %.2f", avg_tat / n);
    printf("\nAVG RT: %.2f\n", avg_rt / n);

    return 0;
    }
```

```
NO. of process: 4
Enter BT,AT and Q (1=sys, 2=user) for P1: 2 0 1
Enter BT,AT and Q (1=sys, 2=user) for P2: 1 0 2
Enter BT,AT and Q (1=sys, 2=user) for P3: 5 0 1
Enter BT,AT and Q (1=sys, 2=user) for P4: 3 0 2
QT for RR: 2

P       Q       WT      TAT     RT
P1      1       0               2                       0
P2      2       2               7                       2
P3      1       7               8                       7
P4      2       8               11                      8

AVG WT: 4.25
AVG TAT: 7.00
AVG RT: 4.25
```

`

Multilevel (FCFS & round robin)

```
#include <stdio.h>
#define MAX_PROCESSES 10
typedef struct {
    int pid
    int bt
    int at
    int queue
} process;
void sortbyArrival (Process p[], int n) {
    process temp;
    for (int i=0 ; i<n-1; i++){
        for(int j=0; j<n-i-1 ; j++){
            if(p[j].at > p[j+1].at){
                temp = p[j];
                p[j] = p[j+1] ;
                p[j+1] = temp;
            }
        }
    }
}
Void roundrobin (process p[], int n, int quantum,
int wt[], int tat[ ], int rt[ ] ) {
    int remaining_bt[MAX_PROCESSES];
    for(int i=0 ;i<n; i++)
        remaining_bt[i]= p[i]. bt;
    int t=0, completed = 0 ;
    while (completed <n ) {
        int executed =0;
        for (int i=0; i<n ; i++) {
            if (remaining_bt[i] > 0) {
                if (rt[i]= = -1) rt[i]= t;
                if (remaining_bt[i] > quantum) {
                    t+=quantum;
                    remaining_bt[i] -= quantum;
                } else {
                    t+=remaining_bt[i] ;
                    tat[i] = t- p[i].at ;
                    wt[i] = tat[i] - p[i].bt ;
                    remaining_bt[i] = 0;
                    completed ++ ;
                }
                executed =1 ;
            }
        }
        if(! executed){t++ ; }
    }
}
void fcfs(process p[],int n, int start_time ,int wt[], int tat[])
{
    int time = start_time ;
    for(int i=0 ; i < n; i++){
        if (time <p[i].at) time = p[i].at ;
        rt[i]= time - p[i].at ;
        wt[i]= rt[i]
        tat[i]= wt[i] +p[i].bt;
        time+= p[i].bt ;
    }
}
int main ( ) {
    int n, quantum ;
    PROCESS p[MAX_PROCESSES], sys[MAX_PROCESSES], usr[MAX_PROCESSES];
    int syscount = 0, usrcount = 0;
    int wt [MAX_PROCESSES], tat[MAX_PROCESSES], rt[MAX_PROCESSES];
    printf("enter no. of processes :");
    scanf("%d", &n);
```



```
for(int i=0; i<n; i++){
    printf("Enter burst time, arrival time & Queue
        (1=system, 2=user) for P%d :", i+1);
    p[i].pid = i+1;
    scanf("%d %d %d", &p[i].bt, &p[i].at,
        &p[i].queue);
    if(p[i].queue == 1){
        sys[sys_count++] = p[i];
    }
    else
        usr[usr_count++] = p[i];
    wt[i] = 0;
    tat[i] = 0;
    rt[i] = -1;
}
printf("enter time quantum:");
scanf("%d", &quantum);
sortByArrival(sys, sys_count);
sortByArrival(usr, usr_count);
roundRobin(sys, sys_count, wt, tat, rt);
int last_sys_time = (sys_count > 0) ? tat[sys_count-1]
    : sys[sys_count-1].bt;
fcfs(usr, usr_count, last_sys_time, &wt[sys_count],
    &tat[sys_count], &rt[sys_count]);
```

```
printf("\nProcess\tQueue\tWT\tTAT\tRT\n");
for(int i=0; i<n; i++){
    printf("P%d\t%d\t%d\t%d\t%d\n",
        p[i].pid, p[i].queue, wt[i],
        tat[i], rt[i]);
}
float avg_wt=0, avg_tat=0, avg_rt=0;
for(int i=0; i<n; i++){
    avg_wt += wt[i];
    avg_tat += tat[i];
    avg_rt += rt[i];
}
printf("\nAvg WT, Avg RT, Avg TAT are
    %.2f, %.2f, %.2f", avg_wt/n, avg_rt/n, avg_tat/n);
```

Output

```
Enter no of processes : 4
enter BT, AT & Queue (1=System, 2=user) for
P1: 20 1
P2: 10 2
P3: 50 1
P4: 30 2
```

Process	Queue	WT	TAT	RT
P1	1	0	2	0
P2	2	2	7	2
P3	1	7	8	7
P4	2	8	11	8

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

a) Rate- Monotonic:

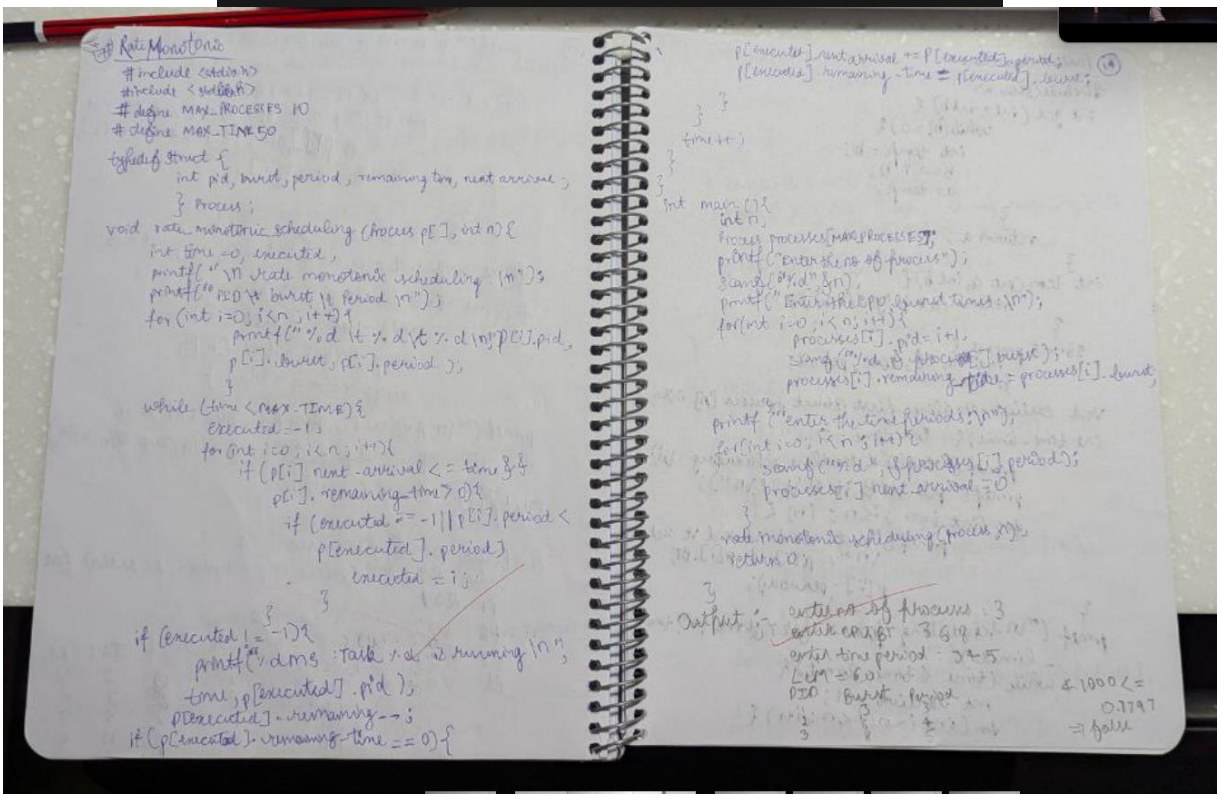
```
#include <stdio.h>
#include <stdlib.h>

#define MAX_PROCESSES 10
#define MAX_TIME 50  // Maximum simulation time

typedef struct {
    int pid;
    int burst;
    int period;
    int remaining_time;
    int next_arrival;
} Process;

void rate_monotonic_scheduling(Process p[], int n) {
    int time = 0, executed;
    printf("\nRate Monotonic Scheduling:\n");
    printf("PID\tBurst\tPeriod\n");
    for (int i = 0; i < n; i++)
        printf("%d\t%d\t%d\n", p[i].pid, p[i].burst, p[i].period);

    while (time < MAX_TIME) {
        executed = -1;

        for (int i = 0; i < n; i++) {
            if (p[i].next_arrival <= time && p[i].remaining_time > 0) {
                if (executed == -1 || p[i].period < p[executed].period)
                    executed = i;
```

`

```
            }
        }

        if (executed != -1) {
            printf("%dms : Task %d is running.\n", time, p[executed].pid);
            p[executed].remaining_time--;

            if (p[executed].remaining_time == 0) {
                p[executed].next_arrival += p[executed].period;
                p[executed].remaining_time = p[executed].burst; // Reset for periodic
execution
            }
        }
        time++;
    }
}

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

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

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

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

    rate_monotonic_scheduling(processes, n);

`
```

```
    return 0;
}
```

```
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
```



`

b)Earliest-deadline:

```
#include    <stdio.h>

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

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

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

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

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

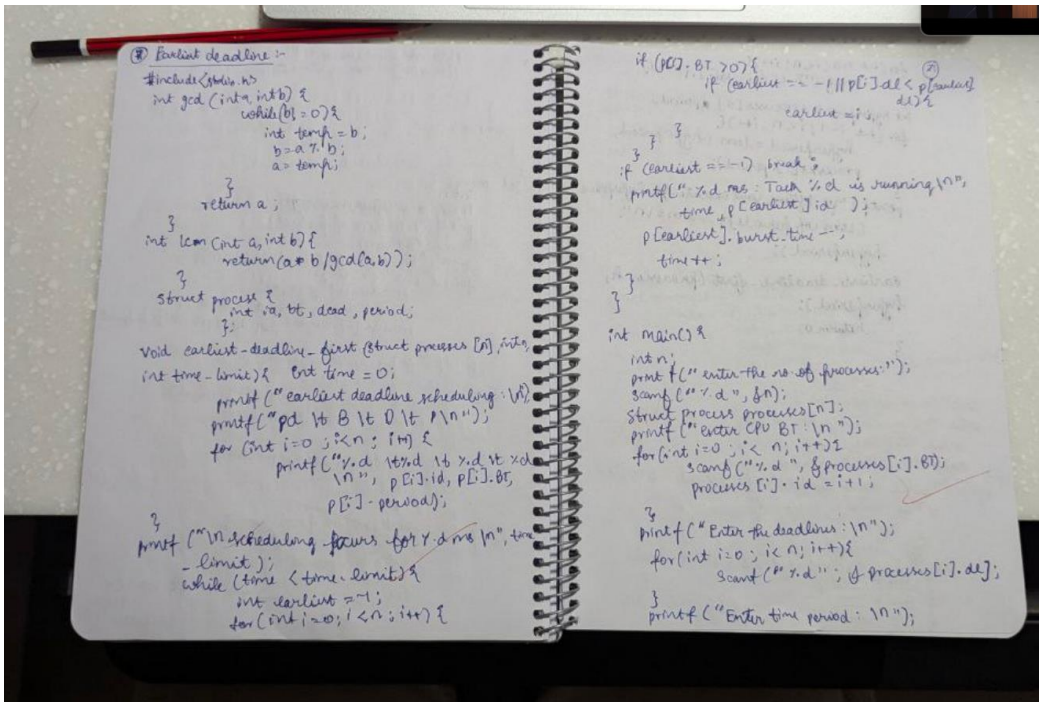
`

```
            }
        }
    }

    if (earliest == -1) break;

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

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

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

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

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

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

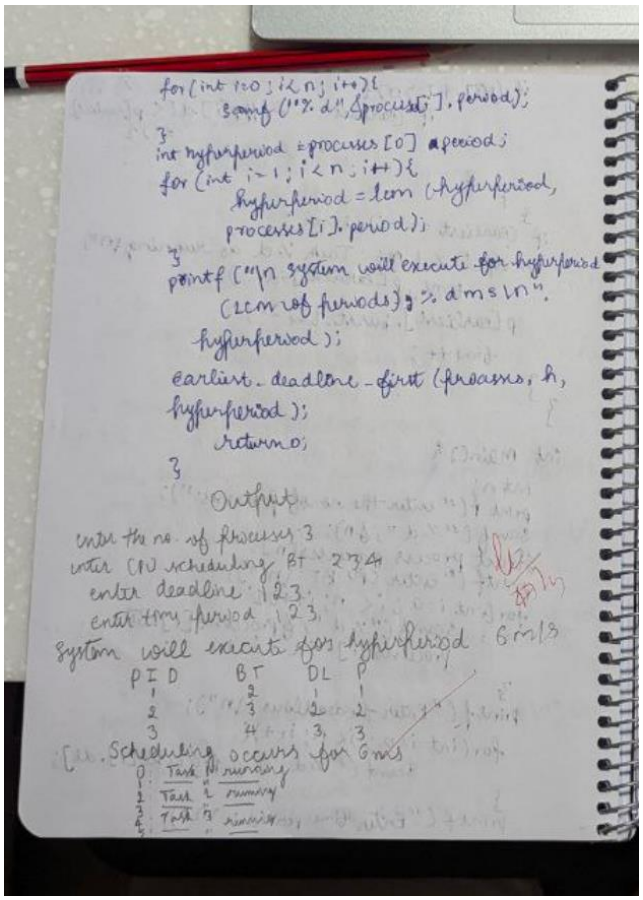
```
    printf("\nSystem will execute for hyperperiod (LCM of periods): %d ms\n",
 hyperperiod);

    earliest_deadline_first(processes, n, hyperperiod);

    return 0;
}
```

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

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

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

`



```
⑦ Earliest deadline :-
#include<stdio.h>
int gcd (int a, int b) {
        while(b != 0){
            int temp = b;
            b = a % b;
            a = temp;
        }
    return a;
}
int lcm (int a, int b) {
    return (a * b / gcd(a,b));
}
struct process {
    int id, bt, dead, period;
};
void earliest_deadline_first (struct process p[n], int n,
int time_limit) {  int time = 0;
    printf (" earliest deadline scheduling : \n");
    printf("pid \t B \t D \t P \n");
    for (int i=0 ; i<n ; i++) {
        printf("%d \t%d \t %d \t %d \t %d
        \n", p[i].id, p[i].BT,
        p[i] - period);
}
printf ("\n scheduling occurs for %d ms \n", time
    - limit);
while (time < time_limit) {
    int earliest = -1;
    for (int i=0; i<n ; i++) {
if (p[i].BT >0) {
    if (earliest == -1 || p[i].dl < p[earliest]
                                    .dl) {
        earliest = i;
    }
}
if (earliest == -1) break;
printf(" %d ms : Task %d is running \n",
    time, p[earliest].id );
p[earliest].burst_time --;
time++;
}
}
int main() {
int n;
printf(" enter the no of processes:");
scanf(" %d ", &n);
struct process processes[n];
printf (" enter CPU BT : \n ");
for(int i=0 ; i< n; i++)
    scanf(" %d ", &processes[i].BT);
    processes[i].id = i+1;
}
printf(" Enter the deadlines : \n");
for(int i=0 ; i< n; i++){
    scanf(" %d " , &processes[i].dl);
}
printf (" Enter time period : \n");
```



```
for(int i=0 ; i< n; i++){
    scanf("%d",&processes[i].period);
}
int hyperperiod = processes[0].period;
for (int i=1; i<n ; i++){
    hyperperiod = lcm (hyperperiod,
    processes[i].period);
}
printf ("\n system will execute for hyperperiod
    (LCM of periods) : %d ms \n",
    hyperperiod );
earliest_deadline_first (processes, n,
hyperperiod );
    return 0;
}
```

Output

```
enter the no of processes 3
enter CPU scheduling BT 2 3 4
enter deadline 1 2 3
enter time period 1 2 3
System will execute for hyperperiod 6 ms
PID    BT    DL    P
1      2     1     1
2      3     2     2
3      4     3     3
Scheduling occurs for 6 ms
0 Task 1 running
1 Task 2 running
2 Task 3 running
```

`

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

producer-consumer:

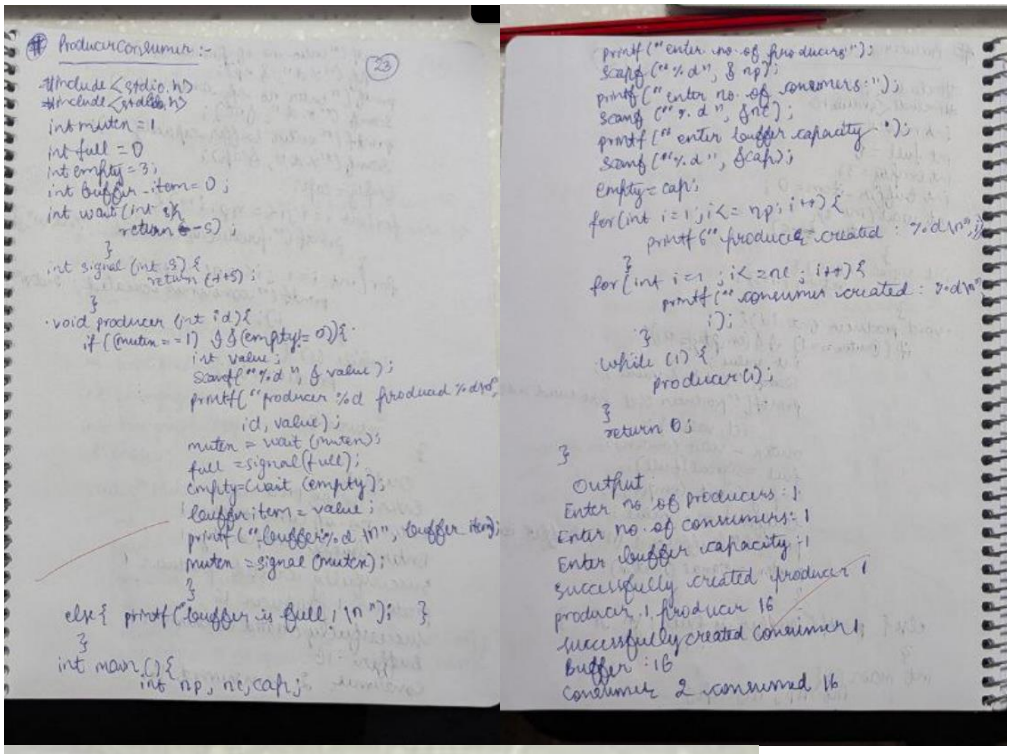
```
#include <stdio.h>
#include <stdlib.h>

int mutex = 1;
int full = 0;
int empty=3;
int buffer_item = 0;

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

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

void producer(int id) {
   if ((mutex == 1) && (empty != 0)) {
      int value;
      scanf("%d", &value);
      printf("producer %d produced %d\n", id, value);
      mutex = wait(mutex);
      full = signal(full);
      empty = wait(empty);
      buffer_item = value;
      printf("buffer:%d\n", buffer_item);
      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);
        printf("consumer %d consumed %d\n", id + 1, buffer_item);
        printf("current buffer len: 0\n");
        mutex = signal(mutex);
    } else {
        printf("buffer is empty!\n");
    }
}

int main() {
    int np, nc, cap;

    printf("enter no. of producers:");
    scanf("%d", &np);
    printf("enter no. of consumers:");
    scanf("%d", &nc);
    printf("enter buffer capacity:");
    scanf("%d", &cap);

    empty = cap;

    for (int i = 1; i <= np; i++) {
        printf("producer created: %d\n", i);
    }

    for (int i = 1; i <= nc; i++) {
        printf("consumer created: %d\n", i);
    }

    while (1) {
        producer(1);
```

```
            consumer(1);
        }
        return 0;
    }
```

```
enter no. of producers:1
enter no. of consumers:1
enter buffer capacity:1
producer created: 1
consumer created: 1
16
producer 1 produced 16
buffer:16
consumer 2 consumed 16
current buffer len: 0
32
producer 1 produced 32
buffer:32
consumer 2 consumed 32
current buffer len: 0
4
producer 1 produced 4
buffer:4
consumer 2 consumed 4
current buffer len: 0
0
producer 1 produced 0
buffer:0
consumer 2 consumed 0
current buffer len: 0
```

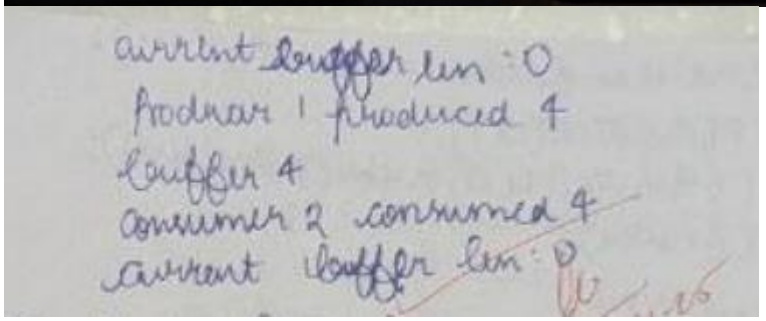
`



```
Producer Consumer :-

#include <stdio.h>
#include <stdlib.h>
int mutex = 1
int full = 0
int empty = 3;
int buffer_item = 0;
int wait (int s)
    return (--s);
}
int signal (int s) {
    return (++s);
}
void producer (int id) {
    if (mutex == 1) && (empty != 0)) {
        int value;
        scanf ("%d", &value);
        printf ("producer %d produced %d\n",
            id, value);
        mutex = wait (mutex);
        full = signal (full);
        empty = wait (empty);
        buffer item = value;
        printf ("buffer %d \n", buffer item);
        mutex = signal (mutex);
    }
    else { printf ("buffer is full \n"); }
}
int main () {
    int np, nc, cap;
    printf ("enter no of producers");
    scanf ("%d", &np);
    printf ("enter no of consumers:");
    scanf ("%d", &nc);
    printf ("enter buffer capacity ");
    scanf ("%d", &cap);
    empty = cap;
    for (int i=1; i<=np; i++) {
        printf ("producer created : %d\n", i);
    }
    for (int i=1; i<=nc; i++) {
        printf ("consumer created : %d\n"
            i);
    }
    while (1) {
        producer (i);
    }
    return 0;
}
```

Output

```
Enter no of producers : 1
Enter no of consumers: 1
Enter buffer capacity :1
successfully created producer 1
producer 1 produced 16
successfully created consumer 1
buffer :16
consumer 2 consumed 16
```



current buffer len : 0
Prodnar 1 produced 4
buffer 4
consumer 2 consumed 4
current buffer len : 0

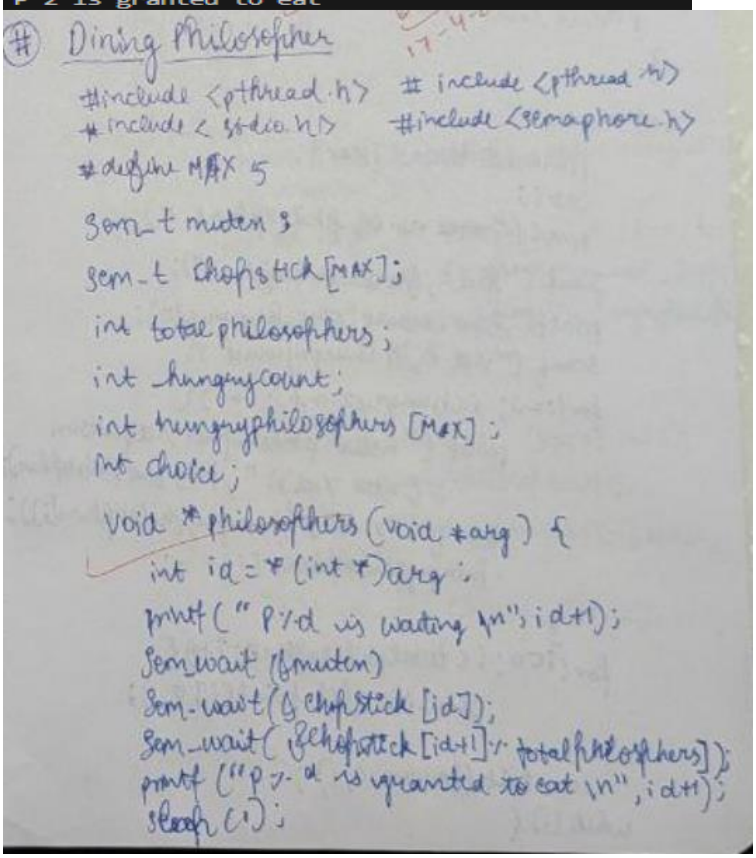
6.Write a C program to simulate the concept of Dining Philosophers problem.

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

#define MAX 5
sem_t mutex;
sem_t chopstick[MAX];
int totalPhilosophers;
int hungryCount;
int hungryPhilosophers[MAX];
int choice;

void *philosopher(void *arg) {
    int id = *(int *)arg;
    printf("P %d is waiting\n", id + 1);
    sem_wait(&mutex);
    sem_wait(&chopstick[id]);
    sem_wait(&chopstick[(id + 1) % totalPhilosophers]);
    printf("P %d is granted to eat\n", id + 1);
    sleep(1);
    printf("P %d has finished eating\n", id + 1);
    sem_post(&chopstick[id]);
    sem_post(&chopstick[(id + 1) % totalPhilosophers]);
    sem_post(&mutex);
    pthread_exit(NULL);
}

int main() {
    pthread_t thread[MAX];
    int i;
`
```

```
    printf("Enter the total number of philosophers: ");
    scanf("%d", &totalPhilosophers);
    printf("How many are hungry: ");
    scanf("%d", &hungryCount);
    for (i = 0; i < hungryCount; i++) {
        printf("Enter philosopher %d position (1 to %d): ", i + 1, totalPhilosophers);
        scanf("%d", &hungryPhilosophers[i]);
        hungryPhilosophers[i]--;
    }
    for (i = 0; i < totalPhilosophers; i++) {
        sem_init(&chopstick[i], 0, 1);
    }
    sem_init(&mutex, 0, 1);
    while (1) {
        printf("\n1. One can eat at a time\n");
        printf("2. Two can eat at a time\n");
        printf("3. Exit\n");
        printf("Enter your choice: ");
        scanf("%d", &choice);
        if (choice == 3) {
            break;
        }
        if (choice == 1) {
            printf("Allow one philosopher to eat at any time\n");
            for (i = 0; i < hungryCount; i++) {
                for (int j = 0; j < hungryCount; j++) {
                    printf("P %d is waiting\n", hungryPhilosophers[j] + 1);
                }
                int *id = malloc(sizeof(int));
                *id = hungryPhilosophers[i];
                pthread_create(&thread[i], NULL, philosopher, id);
                pthread_join(thread[i], NULL);
            }
        }
    }
    return 0;
}
```

`

```
How many are hungry: 3
Enter philosopher 1 position (1 to 5): 2
Enter philosopher 2 position (1 to 5): 4
Enter philosopher 3 position (1 to 5): 5

1. One can eat at a time
2. Two can eat at a time
3. Exit
Enter your choice: 1
Allow one philosopher to eat at any time
P 2 is waiting
P 4 is waiting
P 5 is waiting
P 2 is waiting
P 2 is granted to eat
P 2 has finished eating
P 2 is waiting
P 4 is waiting
P 5 is waiting
P 4 is waiting
P 4 is granted to eat
P 4 has finished eating
P 2 is waiting
P 4 is waiting
P 5 is waiting
P 5 is waiting
P 5 is granted to eat
P 5 has finished eating

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

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

1. One can eat at a time
2. Two can eat at a time
3. Exit
Enter your choice: 1
Allow one philosopher to eat at any time
P 2 is waiting
P 4 is waiting
P 5 is waiting
P 2 is waiting
P 2 is granted to eat
```



Dining Philosopher

```
#include <pthread.h>
#include <stdio.h>
#define MAX 5
sem_t mutex;
sem_t chopstick[MAX];
int totalphilosophers;
int hungrycount;
int hungryphilosophers[MAX];
int choice;
void *philosophers(void *arg) {
    int id = *(int *)arg;
    printf("P %d is waiting\n", id+1);
    sem_wait(&mutex)
    sem_wait(&chopstick[id]);
    sem_wait(&chopstick[(id+1) % totalphilosophers]);
    printf("P %d is granted to eat\n", id+1);
    sleep(1);
```

#include <pthread.h>
#include <semaphore.h>

`

```
printf("P %d has finished eating \n", id+1);
sem_post (&chopstick[id]);
sem_post (&chopstic[(id+1) % total philosophers]);
sem_post (&mealten);
pthread_exit(NULL);
}

int main() {
    pthread_t thread [max];
    int i;
    printf ("total no. of philosophers : ");
    scanf ("%d", &total philosophers");
    printf("how many are hungry?");
    scanf ("%d ", & hungrycount );
    for(i=0; i<hungrycount ; i++){
        printf ("enter philosopher %d position
            (1 to %d): ", i+1, total philosophers);
        scanf ("%d", &hungryphilosophers[i]);
        hungryphilosophers [i]--;
    }
    for (i=0 ; i < total philosophers; i++){
        sem_init (&chopstick[i],0,1);
    }
    sem_init (&mealten ,0, 1) ;
while(1) {
```

```
printf ("\n 1. one can eat at a time \n");
printf (" 2. two can eat at a time \n");
printf ("3. Exit \n");
printf (" Enter your choice:" );
scanf ("%d ", &choice);
if (choice == 3){
    break;
}
if (choice == 1){
    printf (" Allow philosopher to eat many at
        a time \n");
    for (int i=0 ; i< hungrycount ; i++) {
        for(int j=0 ; j< hungrycound ; j++){
            printf ("P %d is waiting \n", hungryphilosoph
                -ers[j] +1);
        }
        int *id = malloc (size of(int));
        *id = hungryphilosophers[i];
        pthread_create (&thread[i], NULL,
        philosopher , id) ;
        pthread_join (thread[i],NULL);
    }
}
return 0;
}
```

input

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

output

1. one can eat at time 2 two can eat at a time 3. exit

Enter your choice : 1
Allow philosopher
P3 is granted to eat
P3 is waiting
P5 is waiting
P0 " "
P5 is granted
P0 is waiting
P0 is granted to eat
P0 is waiting

1. one can eat at a time 2. 2 can eat at a time
3. exit

Enter your choice : 3

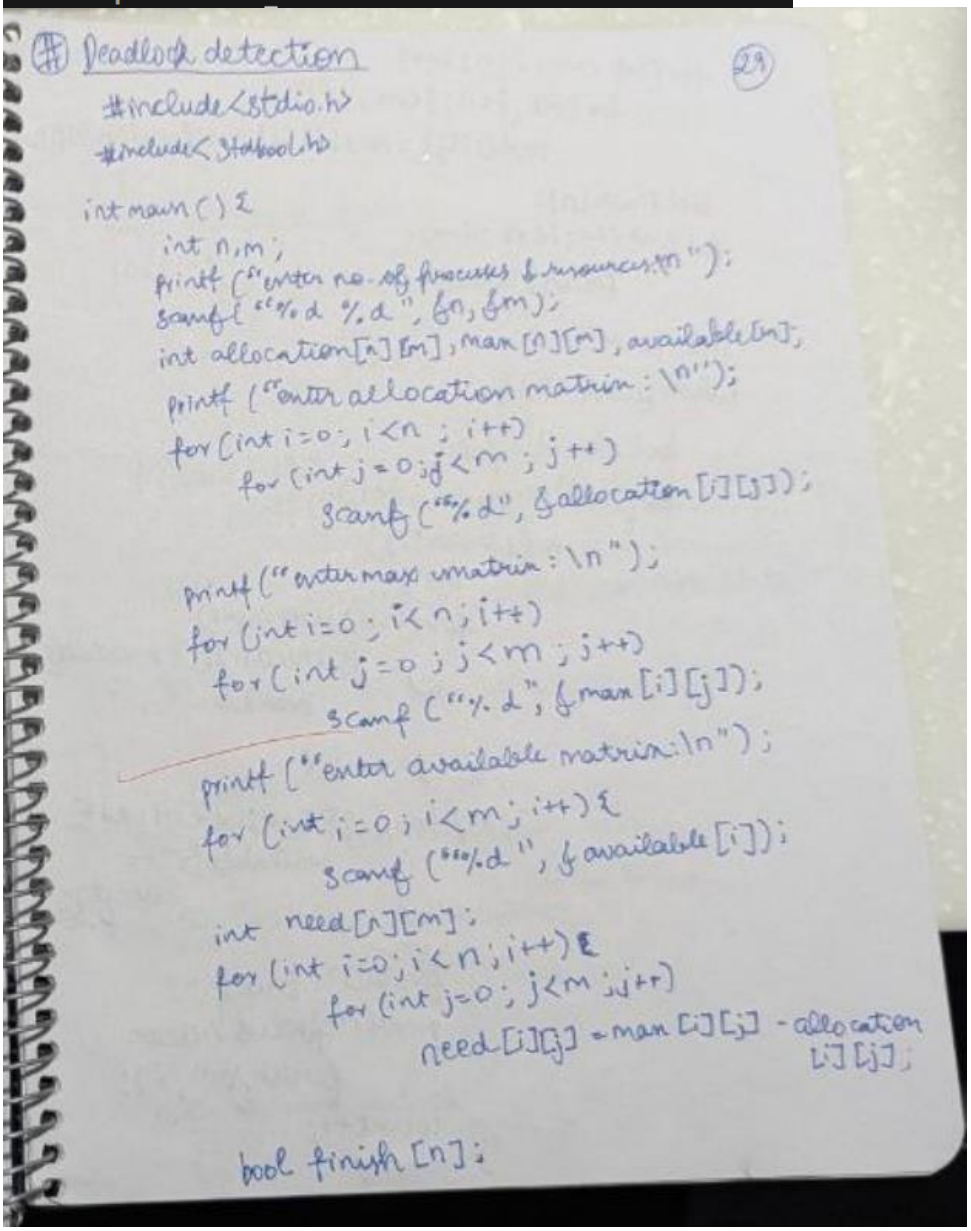
7.Write a C program to simulate Bankers algorithm for the purpose of deadlock avoidance.

```
#include <stdio.h>
#include
<stdbool.h> int
main() {
    int n, m;
    printf("enter number of processes and resources:\n");
    scanf("%d %d", &n, &m);
    int alloc[n][m], max[n][m],
    avail[m]; printf("enter allocation
    matrix:\n"); for (int i = 0; i < n;
    i++)
        for (int j = 0; j < m; j++)
            scanf("%d",
            &alloc[i][j]);
    printf("eter max
    matrix:\n"); for (int i = 0; i
    < n; i++)
        for (int j = 0; j < m; j++)
            scanf("%d",
            &max[i][j]);
    printf("enter available
    matrix:\n"); for (int i = 0; i < m;
    i++)
        scanf("%d",
    &avail[i]); int
    need[n][m];
    for (int i = 0; i < n; i++)
        for (int j = 0; j < m;
        j++)
            need[i][j] = max[i][j] -
    alloc[i][j]; bool finish[n];
    for (int i = 0; i < n; i++)
        finish[i] = false;
    int
    safeSeq[n];
    int
    work[m];
    for (int i = 0; i < m; i++)
`
```

```
        work[i] = avail[i];
    int count = 0;
    while (count <
    n) {
        bool found = false;
        for (int p = 0; p < n; p++)
            { if (!finish[p]) {

                int j;
                for (j = 0; j < m; j++)
                    if (need[p][j] > work[j])
                        break;
                if (j == m) {
                    for (int k = 0; k < m; k++)
                        work[k] += alloc[p][k];

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

`

```
5 3
enter allocation matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
eter max matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
enter available matrix:
3 3 2
sys is in safe state.
safe sequence is: P1 -> P3 -> P4 -> P0 -> P2
```



Deadlock detection

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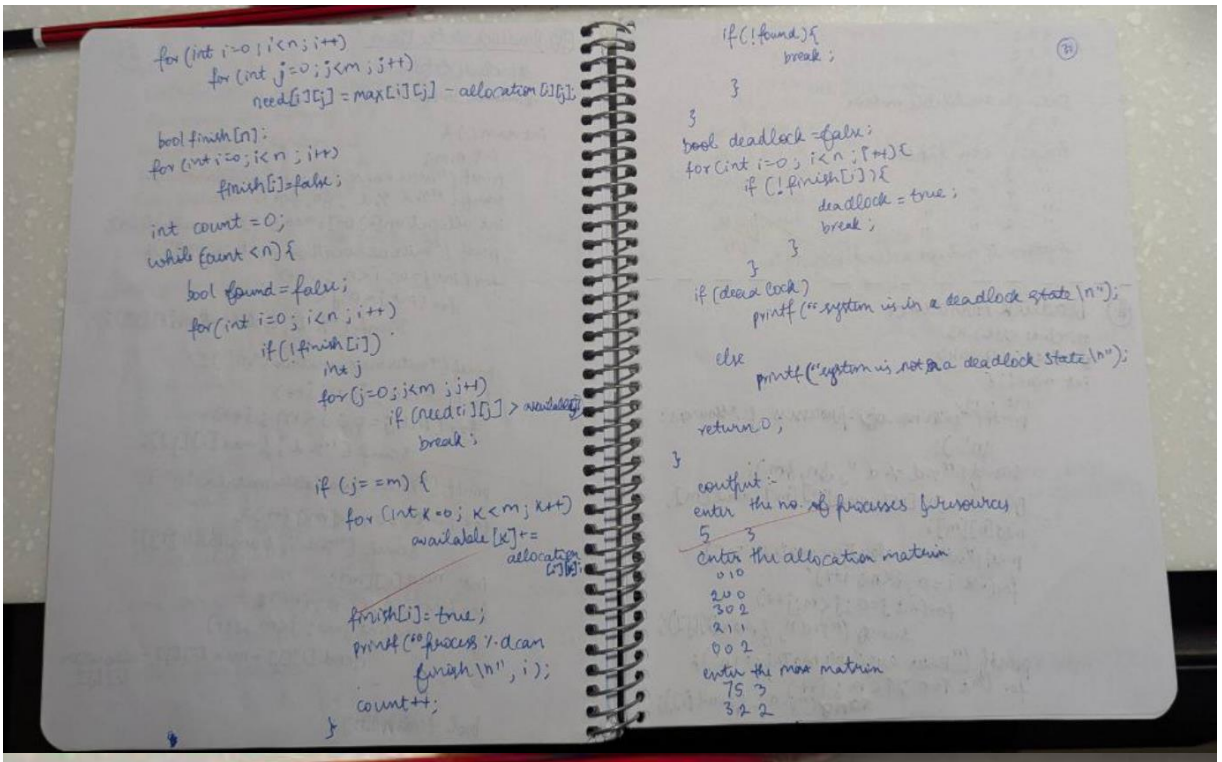
```
#include<stdio.h>
#include<stdbool.h>

int main(){
    int n,m;
    printf("enter no. of processes & resources:");
    scanf("%d %d",&n,&m);
    int allocation[n][m],max[n][m],available[m];
    printf("enter allocation matrix:\n");
    for(int i=0;i<n;i++)
        for(int j=0;j<m;j++)
            scanf("%d",&allocation[i][j]);

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

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

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

    bool finish[n];
```



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

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

int count=0;
while (count<n) {
    bool found=false;
    for (int i=0; i<n; i++)
        if (!finish[i])
            int j
            for (j=0; j<m; j++)
                if (need[i][j] > available[j])
                    break;

            if (j==m) {
                for (int k=0; k<m; k++)
                    available[k] += allocation[i][k];

                finish[i]=true;
                printf("process %d can finish\n", i);
                count++;
            }
```

```
        if (!found) {
            break;
        }
    }
    bool deadlock=false;
    for (int i=0; i<n; i++) {
        if (!finish[i]) {
            deadlock = true;
            break;
        }
    }
    if (deadlock)
        printf("system is in a deadlock state\n");

    else
        printf("system is not a deadlock state\n");

    return 0;
}
```

output :-

```
enter the no. of processes & resources
5 3
enter the allocation matrix
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
enter the max matrix
7 5 3
3 2 2
```

```
9 0 2
2 2 2
4 3 3

Enter the available matrix
3 3 2

Process 1 can finish
"  3  "  "
"  4  "  "
"  0  "  "
"  2  "  "

system is not in a deadlock state
```

8.Write a C program to simulate deadlock detection

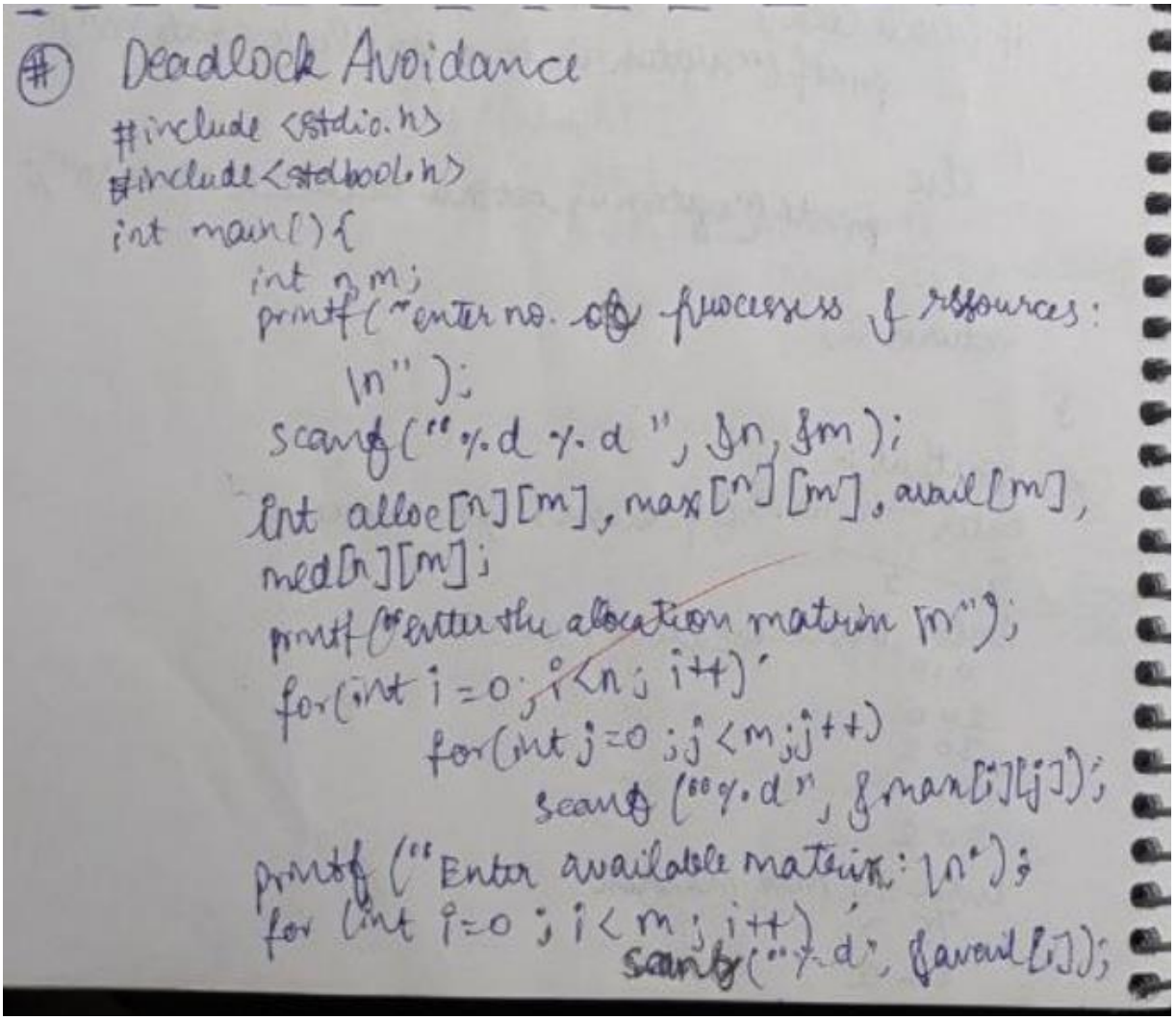
```
#include <stdio.h>
#include
<stdbool.h> int
main() {
    int n, m;
    printf("enter num of processes and number of resources:\n");
    scanf("%d %d", &n, &m);
    int alloc[n][m], request[n][m], avail[m];
    printf("enter alloc matrix (%d x %d):\n", n,
    m); for (int i = 0; i < n; i++)
     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

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

`

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

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

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

    if (!progress)
        break;
}
printf("\nDLD result:\n");
bool deadlock = false;

for (int i = 0; i < n;
    i++) { if (!finish[i])
    {
        printf("process P%d is deadlocked\n", i);
        deadlock = true;
    } else {
        printf("process P%d is not deadlocked\n", i);
    }
}
if (!deadlock)
    printf("\nno deadlock detected in the system.\n");
    return 0;
    }
```

`

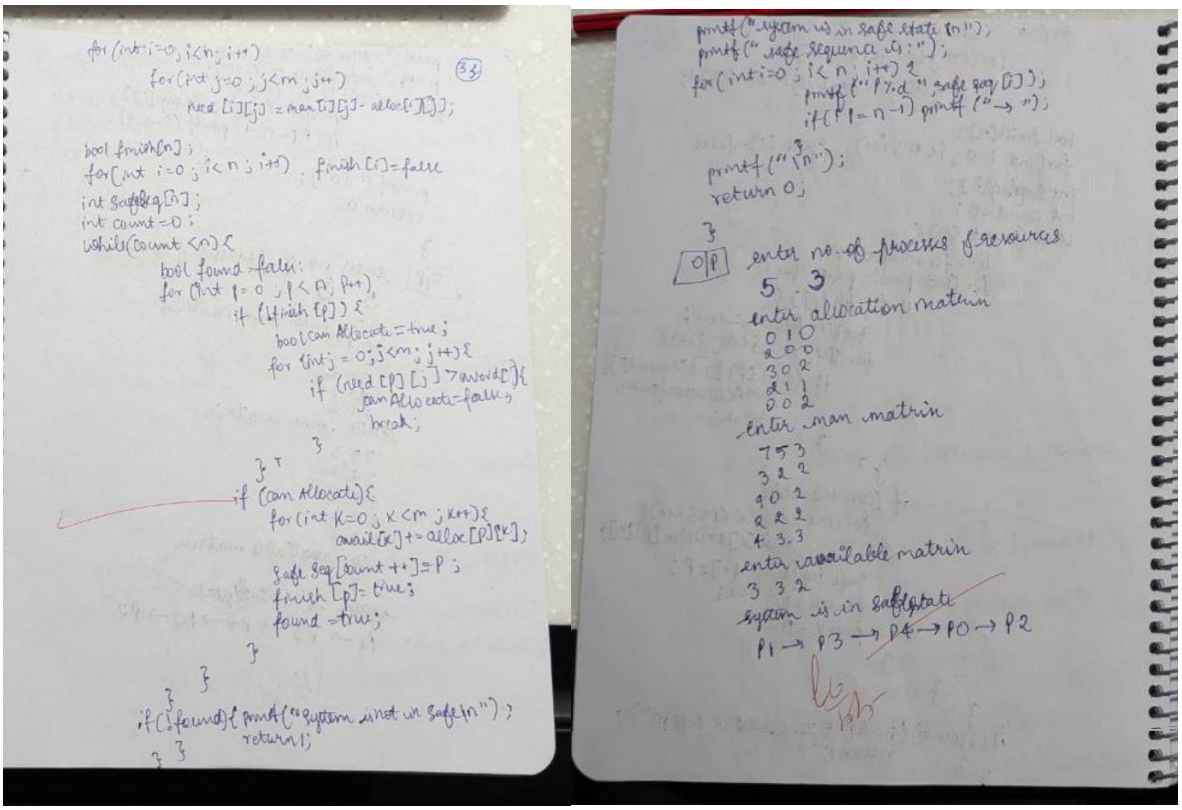
```
enter num of processes and number of resources:
5 3
enter alloc matrix (5 x 3):
0 1 0
2 0 0
3 0 3
2 1 1
0 0 2
enter req matrix (5 x 3):
0 0 0
2 0 2
0 0 1
1 0 0
0 0 2
enter avail resource (3 values):
0 0 0

DLD result:
process P0 is not deadlocked
process P1 is deadlocked
process P2 is deadlocked
process P3 is deadlocked
process P4 is deadlocked
```



Deadlock Avoidance

```
#include <stdio.h>
#include<stdbool.h>
int main(){
    int n,m;
    printf("enter no. of processes & resources:
    \n");
    scanf("%d %d", &n, &m);
int alloc[n][m], max[n][m], avail[m],
need[n][m];
printf("enter the allocation matrix \n");
for(int i=0; i<n; i++)
    for(int j=0; j<m; j++)
        scanf("%d", &max[i][j]);
printf("Enter available matrix: \n");
for (int i=0; i<m; i++)
    scanf("%d", &avail[i]);
```

`



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

bool finish[n];
for(int i=0; i<n; i++) finish[i]=false
int safeSeq[n];
int count=0;
while(count<n){
        bool found=false;
        for(int p=0; p<n; p++)
            if(!finish[p]){
                bool canAllocate=true;
                for(int j=0; j<m; j++){
                    if(need[p][j] > avail[j]){
                        canAllocate=false;
                        break;
                    }
                }
                if(canAllocate){
                    for(int k=0; k<m; k++)
                        avail[k] += alloc[p][k];
                    safeSeq[count++]=p;
                    finish[p]=true;
                    found=true;
                }
            }
        if(!found){ printf("System is not in safe\n");
            return 1;
        }
```

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

enter no of process & 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
P1 → P3 → P4 → P0 → P2

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

a) Worst-fit

b) Best-fit

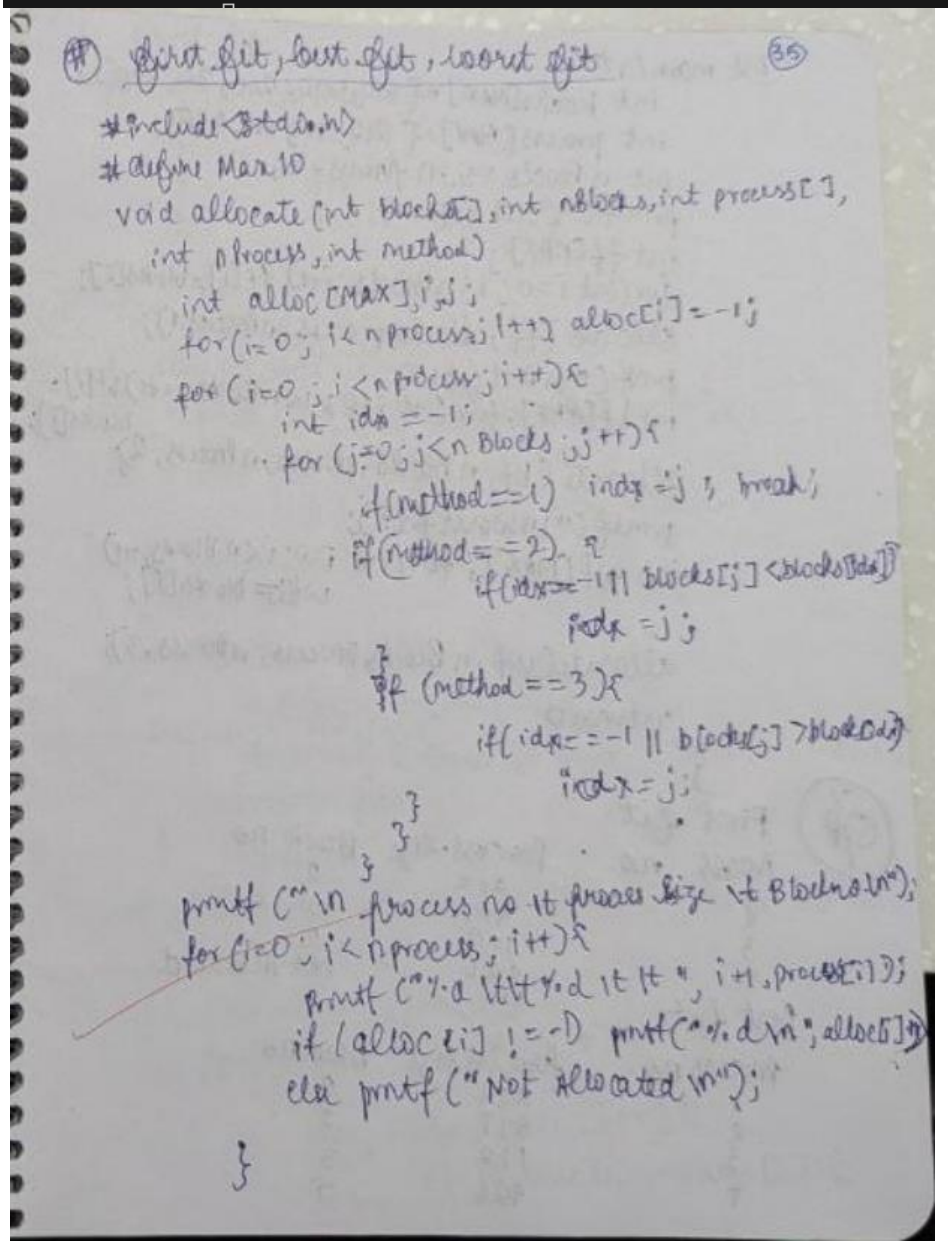
c) First-fit

```
#include <stdio.h>

struct Block {
    int size;
    int
    is_free;
};

struct
    File {
    int
    size;
};

void firstFit(struct Block blocks[], int n_blocks, struct File files[], int n_files) {
    printf("\nfirst fit alloc\n");
    printf("file no\tfile size\tblock no\tblock size\tfrag\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].size >= files[i].size) {
                blocks[j].is_free = 0;
                printf("%d\t%d\t\t%d\t\t%d\t\t%d\n", i + 1, files[i].size, j + 1,
blocks[j].size, blocks[j].size - files[i].size);
                allocated = 1;
                break;
            }
        }
        if (!allocated) {
            printf("file %d cannot be allocated\n", i + 1);
        }
    }
}

        }
        if (worst_block != -1) {
```

```
            blocks[worst_block].is_free = 0;
            printf("%d\t%d\t\t%d\t\t%d\t\t%d\n", i + 1, files[i].size, worst_block + 1,
blocks[worst_block].size, max_fragment);
        } else {
            printf("file %d cannot be allocated\n", i + 1);
        }
    }
}

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]; struct File
    files[n_files];

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

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

    firstFit(blocks, n_blocks, files, n_files);

    for (int i = 0; i < n_blocks; i++) blocks[i].is_free = 1;

    bestFit(blocks, n_blocks, files, n_files);

    for (int i = 0; i < n_blocks; i++) blocks[i].is_free = 1;

    worstFit(blocks, n_blocks, files, n_files);

    return 0;
`
```

```
}
```

```
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: 420

first fit alloc
file no file size       block no        block size      frag
1       212             2               500             288
2       417             5               600             183
3       112             3               200             88
file 4 cannot be allocated
est fit alloc
file no file size       block no        block size      frag
1       212             4               300             88
2       417             2               500             83
3       112             3               200             88
4       420             5               600             180

worst fit alloc
file no file size       block no        block size      frag
1       212             5               600             388
2       417             2               500             83
3       112             4               300             188
file 4 cannot be allocated
```



(35)

(A) first fit, best fit, worst fit

```
#include<stdio.h>
#define MAX 10
void allocate(int blocks[], int nBlocks, int process[],
  int nProcess, int method)
  int alloc[MAX], i, j;
  for(i=0; i<nprocess; i++) alloc[i]=-1;
  for(i=0; i<nprocess; i++){
      int idx=-1;
      for(j=0; j<nBlocks; j++){
          if(method==1) idx=j; break;
          if(method==2){
              if(idx==-1 || blocks[j]<blocks[idx])
                  idx=j;
          }
          if(method==3){
              if(idx==-1 || b[idx[j]>blockCap)
                  idx=j;
          }
      }
  }
printf("\n process no\t process size\t Block no\n");
for(i=0; i<nprocess; i++){
    printf("%d\t\t%d\t\t", i+1, process[i]);
    if(alloc[i]!=-1) printf("%d\n", alloc[i]);
    else printf("Not Allocated\n");
}
}
```

```
int main(){
    int blocks[MAX]={100,500,200,300,600};
    int process[MAX]={212,417,112,426};
    int nBlocks=5,nProcess=4;
    printf("First fit:");
    int ff[MAX];
    for(int i=0;i<nBlocks;i++) ff[i]=blocks[i];
    allocate(ff,nBlocks,process,nProcess,1);
    printf("\n Best fit:");
    int bf[MAX]; for(int i=0; i<nBlocks;i++) bf[i]=
                                        blocks[i];
    allocate(bf,nBlocks,process,nProcess,2);
    printf("\n worst fit:");
    int wf[MAX]; for(int i=0;i<nBlocks;i++)
                    wf[i]=blocks[i];

    allocate(wf,nBlocks,process,nProcess,3);
    return 0;
}
```

(O/P)

First fit

Process no.	Process size	Block no
1	212	2
2	417	5
3	112	2
4	426	Not Allocated

Best fit

Process no.	Process size	Block no
1	212	4
2	417	2
3	112	3
4	426	5

Worst fit.

Process no.	Process size	Block no
1	212	5
2	417	2
3	112	5
4	426	not Allocated

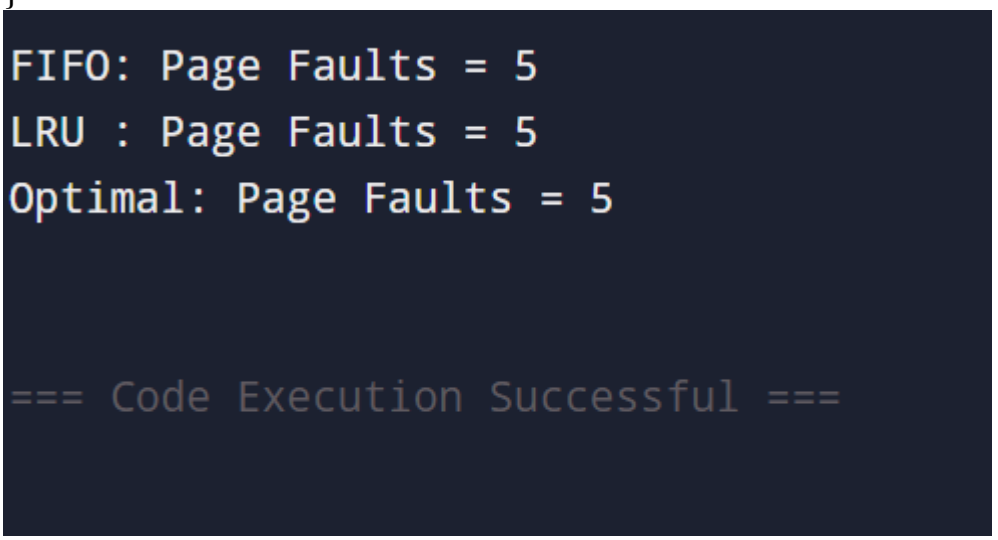
10. Write a C program to simulate page replacement algorithms of fifo, LRU and optimal

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

#define SIZE 7
#define FRAMES 3

int findLRU(int time[], int n) {
    int min = time[0], pos = 0;
    for (int i = 1; i < n; i++) {
        if (time[i] < min) {
            min = time[i];
            pos = i;
        }
    }
    return pos;
}

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

void fifo(int pages[]) {
    int frames[FRAMES], front = 0, count = 0, faults = 0;
    printf("\nFIFO: ");
    for (int i = 0; i < SIZE; i++) {
        bool hit = false;
        for (int j = 0; j < count; j++)
            if (frames[j] == pages[i]) hit = true;

        if (!hit) {
            if (count < FRAMES)
`
```

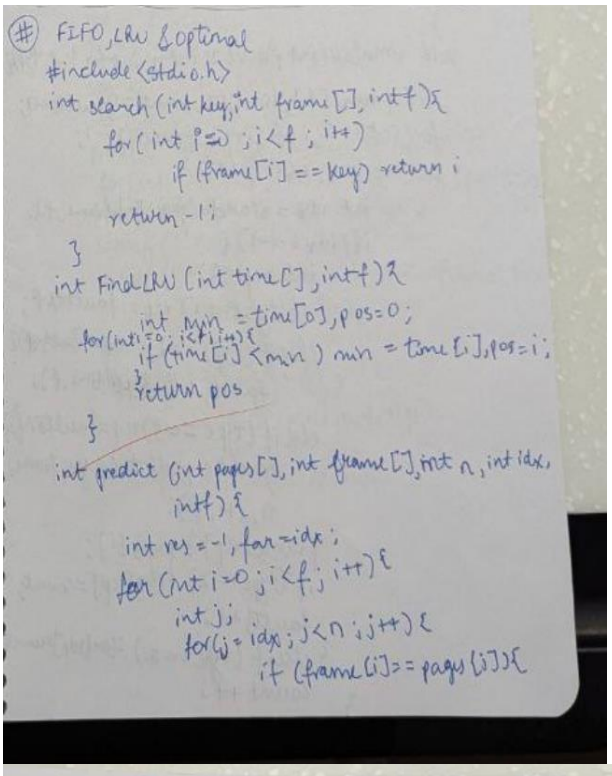
```
            frames[count++] = pages[i];
        else {
            frames[front] = pages[i];
            front = (front + 1) % FRAMES;
        }
        faults++;
    }
  }
  printf("Page Faults = %d\n", faults);
}

void lru(int pages[]) {
  int frames[FRAMES], time[FRAMES], count = 0, faults = 0;
  printf("LRU : ");
  for (int i = 0; i < SIZE; i++) {
    bool hit = false;
    for (int j = 0; j < count; j++) {
      if (frames[j] == pages[i]) {
        hit = true;
        time[j] = i;
        break;
      }
    }
    if (!hit) {
      if (count < FRAMES) {
        frames[count] = pages[i];
        time[count] = i;
        count++;
      } else {
        int pos = findLRU(time, FRAMES);
        frames[pos] = pages[i];
        time[pos] = i;
      }
      faults++;
    }
  }
  printf("Page Faults = %d\n", faults);
}

void optimal(int pages[]) {
  int frames[FRAMES], count = 0, faults = 0;
  printf("Optimal: ");
  for (int i = 0; i < SIZE; i++) {
    bool hit = false;
    for (int j = 0; j < count; j++) {
      if (frames[j] == pages[i]) {
        hit = true;
```

`

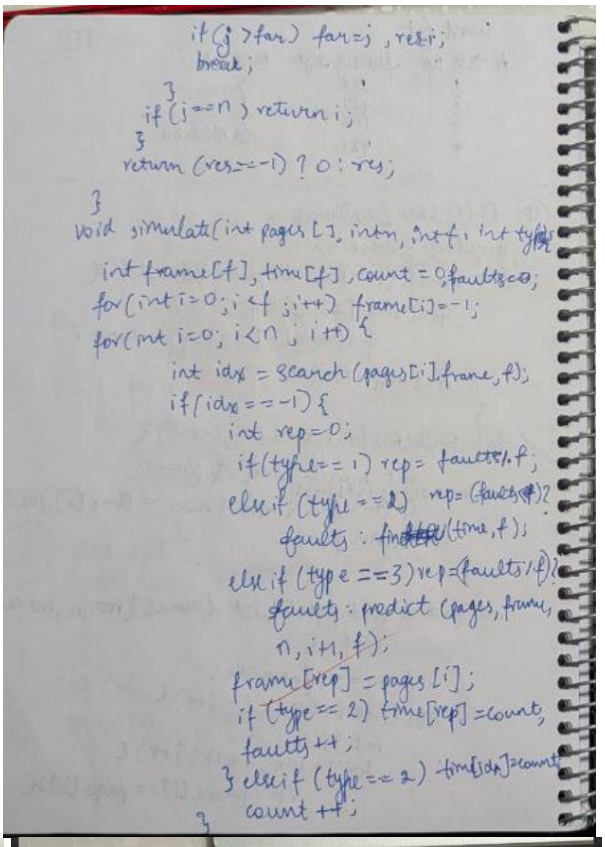
```
            break;
        }
    }
    if (!hit) {
        if (count < FRAMES)
            frames[count++] = pages[i];
        else {
            int pos = findOptimal(pages, frames, SIZE, i + 1);
            frames[pos] = pages[i];
        }
        faults++;
    }
  }
  printf("Page Faults = %d\n", faults);
}

int main() {
  int pages[SIZE] = {1, 2, 3, 2, 1, 4, 5};

  fifo(pages);
  lru(pages);
  optimal(pages);

  return 0;
}
```



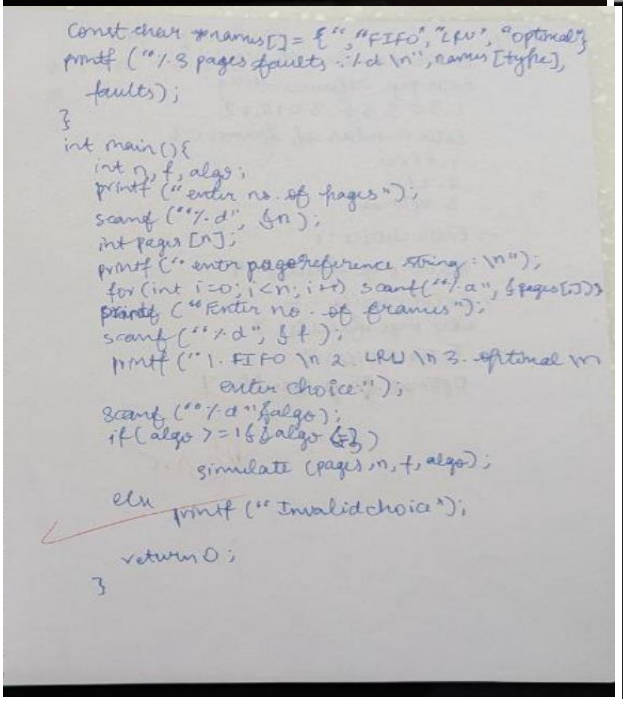
`



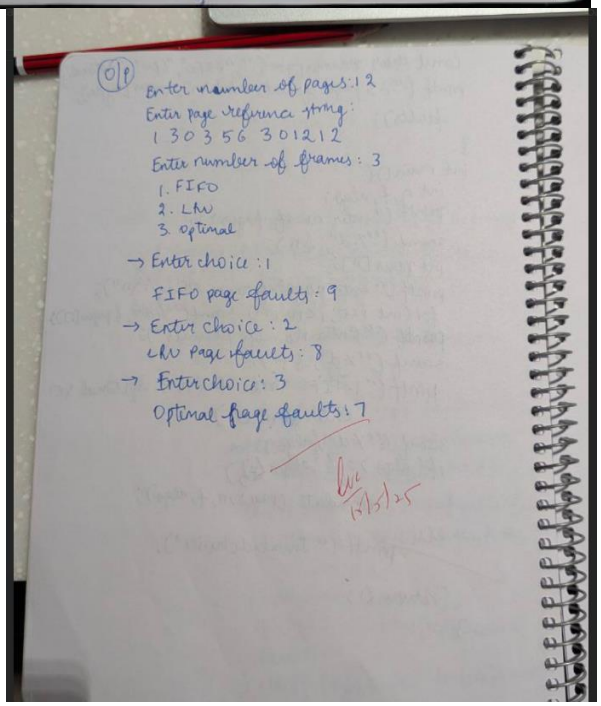
#include <stdio.h>
int search (int key, int frame[], int f){
for(int i=0; i<f; i++)
if (frame[i] == key) return i;
return -1;
}
int FindLRU (int time[], int f){
int min = time[0], pos = 0;
for(int i=0; i<f; i++){
if (time[i] < min) { min = time[i]; pos = i; }
}
return pos;
}
int predict (int pages[], int frame[], int n, int idx,
int f) {
int res = -1, far = idx;
for (int i=0; i<f; i++) {
int j;
for(j = idx; j<n; j++) {
if (frame[i] == pages[j]){



if (j > far) { far = j; res = i; }
break;
}
if (j == n) return i;
}
return (res == -1) ? 0 : res;
}
void simulate(int pages[], int n, int f, int type){
int frame[f], time[f], count = 0, faults = 0;
for(int i=0; i<f; i++) frame[i] = -1;
for(int i=0; i<n; i++) {
int idx = search(pages[i], frame, f);
if(idx == -1) {
int rep = 0;
if(type == 1) rep = faults % f;
else if (type == 2) rep = (faults < f) ?
faults : FindLRU(time, f);
else if (type == 3) rep = (faults < f) ?
faults : predict (pages, frame,
n, i+1, f);
frame[rep] = pages[i];
if (type == 2) time[rep] = count;
faults++;
} else if (type == 2) time[idx] = count;
count++;
}



const char *names[] = {"", "FIFO", "LRU", "optimal"};
printf("%s pages faults : %d \n", names[type],
faults);
}
int main(){
int n, f, algo;
printf("enter no. of pages");
scanf("%d", &n);
int pages[n];
printf("enter page reference string : \n");
for(int i=0; i<n; i++) scanf("%d", &pages[i]);
printf("Enter no. of frames");
scanf("%d", &f);
printf("1. FIFO \n 2. LRU \n 3. optimal \n
enter choice:");
scanf("%d", &algo);
if(algo >= 1 && algo <= 3)
simulate(pages, n, f, algo);
else printf("Invalid choice");
return 0;
}



O/P
Enter number of pages: 12
Enter page refrence string:
1 3 0 3 5 6 3 0 1 2 1 2
Enter number of frames: 3
1. FIFO
2. LRU
3. optimal
→ Enter choice: 1
FIFO page faults: 9
→ Enter choice: 2
LRU Page faults: 8
→ Enter choice: 3
Optimal page faults: 7