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LAB REPORT
on

OPERATING SYSTEMS

Submitted by

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in partial fulfillment for the award of the degree of
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CERTIFICATE

This is to certify that the Lab work entitled "OPERATING SYSTEMS – 23CS4PCOPS" carried out by **NAVANITH KRISHNA R (1BM22CS172),** who is bonafide student of **B. M. S. College of Engineering.** It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2024. 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

CO1: Apply the different concepts and functionalities of Operating System.

CO2: Analyze various Operating system strategies and techniques.

CO3: Demonstrate the different functionalities of Operating System.

CO4: Conduct practical experiments to implement the functionalities of Operating system.

Lab Program – 1

Question:

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

a) FCFS

b) SJF (Non-preemptive)

Code:

(a) FCFS

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

struct P{
    int id;
    int bt;
    int at;
    int wt;
    int tat;
    int rt;
    int st;
    int et;
    int v;
};

void main(){
    int n,ct=0;
    float awt=0,atat=0,art=0,tp;
    printf("Enter number of processes: ");
    scanf("%d",&n);
    struct P p[n];
    struct P temp;
    for(int i=0;i<n;i++){
        printf("Enter Process %d ID: ",i+1);
```

```
    scanf("%d",&p[i].id);
    printf("Enter Burst Time and Arrival Time %d: ",i+1);
    scanf("%d %d",&p[i].bt,&p[i].at);
}

for(int i=0;i<n;i++){
    for(int j=i+1;j<n;j++){
        if(p[i].at>p[j].at){
            temp=p[i];
            p[i]=p[j];
            p[j]=temp;
        }
    }
}

for(int i=0;i<n;i++){
    if(p[i].at<ct){
        p[i].st=ct;
    }
    else{
        p[i].st=p[i].at;
    }
    p[i].et=p[i].st+p[i].bt;
    ct+=p[i].bt;
}
for(int i=0;i<n;i++){
    p[i].tat=p[i].et-p[i].at;
    p[i].wt=p[i].tat-p[i].bt;
    p[i].rt=p[i].st-p[i].at;
}

printf("Process\tWaiting Time\tTurn Around Time\tResponse Time\n");
for(int i=0;i<n;i++){
    printf("%d\t\t%d\t\t%d\t\t%d\n",p[i].id,p[i].wt,p[i].tat,p[i].rt);
    awt+=p[i].wt;
    atat+=p[i].tat;
```

```
        art+=p[i].rt;
    }

    tp=(float)p[n-1].et/n;
    printf("Average Waiting Time: %.2f\n",awt/n);
    printf("Average Turn Around Time: %.2f\n",atat/n);
    printf("Average Response Time: %.2f\n",art/n);
    printf("Throughput: %.2f",tp);

}
```

b) SJF (Non-preemptive)

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

struct P{
    int id;
    int bt;
    int at;
    int wt;
    int tat;
    int rt;
    int st;
    int et;
    int v;
};

void main(){
    int n,ct=0;
    float awt=0,atat=0,art=0,tp;
    printf("Enter number of processes: ");
    scanf("%d",&n);
    struct P p[n];
    struct P temp;
    for(int i=0;i<n;i++){
        p[i].id=i+1;
```

```
    p[i].v=0;
    printf("Enter Burst Time and Arrival Time of P%d: ",i+1);
    scanf("%d %d",&p[i].bt,&p[i].at);
}

for(int i=0;i<n;i++){
    for(int j=i+1;j<n;j++){
        if(p[i].at>p[j].at){
            temp=p[i];
            p[i]=p[j];
            p[j]=temp;
        }
        if(p[i].at==p[j].at){
            if(p[i].bt>p[j].bt){
            temp=p[i];
            p[i]=p[j];
            p[j]=temp;
        }
        }
    }
}

int cf=p[0].bt, min=INT_MAX,m,count=0;
p[0].v=1;

while(count<n-1){
for(int i=0;i<n;i++){
    if(p[i].at<=cf && p[i].v==0){
        if(p[i].bt<min){
            min=p[i].bt;
            m=i;
        }
    }
}
p[m].v=1;
cf+=p[m].bt;
```

```
    min=INT_MAX;

    temp=p[count+1];
    p[count+1]=p[m];
    p[m]=temp;

    count++;
    }

    printf("Process\tWaiting Time\tTurn Around Time\tResponse Time\n");

    for(int i=0;i<n;i++){
        if(p[i].at<ct){
            p[i].st=ct;
        }
        else{
            p[i].st=p[i].at;
        }
        p[i].et=p[i].st+p[i].bt;
        ct+=p[i].bt;

        p[i].tat=p[i].et-p[i].at;
        p[i].wt=p[i].tat-p[i].bt;
        p[i].rt=p[i].st-p[i].at;

        printf("%d\t\t%d\t\t%d\t\t%d\n",p[i].id,p[i].wt,p[i].tat,p[i].rt);
        awt+=p[i].wt;
        atat+=p[i].tat;
        art+=p[i].rt;
    }
    tp=(float)p[n-1].et/n;
    printf("Average Waiting Time: %.2f\n",awt/n);
    printf("Average Turn Around Time: %.2f\n",atat/n);
    printf("Average Response Time: %.2f\n",art/n);
    printf("Throughput: %.2f",tp);
}
```

Output:

a)

```
Enter number of processes: 4
Enter Process 1 ID: 1
Enter Burst Time and Arrival Time 1: 3 0
Enter Process 2 ID: 2
Enter Burst Time and Arrival Time 2: 5 2
Enter Process 3 ID: 3
Enter Burst Time and Arrival Time 3: 7 3
Enter Process 4 ID: 4
Enter Burst Time and Arrival Time 4: 10 5
Process Waiting Time    Turn Around Time        Response Time
1               0               3               0
2               1               6               1
3               5               12              5
4               10              20              10
Average Waiting Time: 4.00
Average Turn Around Time: 10.25
Average Response Time: 4.00
Throughput: 6.25
```

b)

```
Enter number of processes: 5
Enter Burst Time and Arrival Time of P1: 3 0
Enter Burst Time and Arrival Time of P2: 4 2
Enter Burst Time and Arrival Time of P3: 8 6
Enter Burst Time and Arrival Time of P4: 11 9
Enter Burst Time and Arrival Time of P5: 15 12
Process Waiting Time    Turn Around Time        Response Time
1               0               3               0
2               1               5               1
3               1               9               1
4               6               17              6
5               14              29              14
Average Waiting Time: 4.40
Average Turn Around Time: 12.60
Average Response Time: 4.40
Throughput: 8.20
```

Lab Program - 2

Question:

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

a) SJF (Preemptive)

b) Round Robin Algorithm

Code:

(a) SJF (Preemptive)

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

struct P{
   int id;
   int bt;
   int at;
   int wt;
   int tat;
   int rt;
   int st;
   int et;
   int v;
   int b;
};

void main(){
   int n,ct=0;
   float awt=0,atat=0,art=0,tp;
   printf("Enter number of processes: ");
   scanf("%d",&n);
   struct P p[n];
   struct P temp;
   for(int i=0;i<n;i++){
      p[i].id=i+1;
      p[i].v=0;
      p[i].st=-1;
      printf("Enter Burst Time and Arrival Time of P%d: ",i+1);
      scanf("%d %d",&p[i].bt,&p[i].at);
      p[i].b=p[i].bt;
```

```
}

int cf=0, min=INT_MAX,m=0,count=0;
while(count<n){
   for(int i=0;i<n;i++){
      if(p[i].at<=cf){
         if(p[i].bt==min){
            min=p[i].at>p[m].at?p[i].bt:p[m].bt;
         }
         if(p[i].bt<min && p[i].v!=1){
            min=p[i].bt;
            m=i;
         }
      }
   }
   p[m].bt-=1;

   if(p[m].st<0)
   p[m].st=cf;

   cf+=1;
   if(p[m].bt==0){
      p[m].et=cf;
      count++;
      p[m].v=1;
   }
   min=INT_MAX;

}
printf("Process\tWaiting Time\tTurn Around Time\tResponse Time\n");

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

   p[i].tat=p[i].et-p[i].at;
   p[i].wt=p[i].tat-p[i].b;
   p[i].rt=p[i].st-p[i].at;

   printf("%d\t\t%d\t\t%d\t\t%d\n",p[i].id,p[i].wt,p[i].tat,p[i].rt);
   awt+=p[i].wt;
   atat+=p[i].tat;
```

```
        art+=p[i].rt;
    }

    tp=(float)cf/n;
    printf("Average Waiting Time: %.2f\n",awt/n);
    printf("Average Turn Around Time: %.2f\n",atat/n);
    printf("Average Response Time: %.2f\n",art/n);
    printf("Throughput: %.2f",tp);

}
```

(b) Round Robin

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

#define MAX_PROCESSES 10

struct Process {
    int id;
    int at;
    int bt;
    int wt;
    int tat;
    int st;
    int et;
    int rt;
    int vi;
    int obt;
};

int main() {
```

```
struct Process p[MAX_PROCESSES];
int n;
int total_wt = 0;
int total_tat = 0;
int total_rt = 0;
int total_time = 0;
int tq = 0;

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



for (int i = 0; i < n; i++) {
    p[i].id = i + 1;
    printf("Enter arrival time and burst time for process %d: ", p[i].id);
    scanf("%d %d", &p[i].at, &p[i].bt);
    p[i].obt = p[i].bt;
    p[i].st = -1;
    p[i].et = -1;
    p[i].vi = 0;
}
int count = 0;
int ind = 0;
int curr_time = 0;
```

```
while(1){
    int skipped = 0;
    if(p[ind].at > curr_time){
        ind = (ind + 1) % n;
        continue;
    }
    if(p[ind].st == -1){
        p[ind].st = curr_time;
    }
    if(p[ind].bt > tq){
        p[ind].bt -= tq;
        skipped = tq;
    }
    else if(p[ind].bt > 0){
        skipped = p[ind].bt;
        p[ind].bt = 0;
        p[ind].et = curr_time + skipped;
        total_time = curr_time;
        count++;
    }
    curr_time += skipped;
    ind = (ind + 1) % n;
    if(count == n){
        break;
    }
}
```

```
    for(int i = 0; i < n; i++){
        p[i].tat = p[i].et - p[i].at;
        p[i].wt = p[i].tat - p[i].obt;
        p[i].rt = p[i].st - p[i].at;
        total_wt += p[i].wt;
        total_tat += p[i].tat;
        total_rt += p[i].rt;
    }

    printf("\nProcess\tArrival Time\tBurst Time\tWaiting Time\tTurnaround Time\tResponse
Time\n");
    for (int i = 0; i < n; i++) {
        printf("%d\t%d\t\t%d\t\t%d\t\t%d\t\t%d\n", p[i].id, p[i].at, p[i].obt, p[i].wt, p[i].tat, p[i].rt);
    }

    printf("\nAverage Waiting Time: %.2f\n", (float)total_wt / n);
    printf("Average Turnaround Time: %.2f\n", (float)total_tat / n);
    printf("Throughput: %.2f\n", (float)total_time / n);
    printf("Average Response Time: %.2f\n", (float)total_rt / n);



    return 0;
}
```

Output:

a) **SJF (Pre-emptive)**

```
Enter number of processes: 5
Enter Burst Time and Arrival Time of P1: 6 2
Enter Burst Time and Arrival Time of P2: 2 5
Enter Burst Time and Arrival Time of P3: 8 1
Enter Burst Time and Arrival Time of P4: 3 0
Enter Burst Time and Arrival Time of P5: 4 4
Process Waiting Time    Turn Around Time        Response Time
1               7               13              1
2               0               2               0
3               14              22              14
4               0               3               0
5               2               6               0
Average Waiting Time: 4.60
Average Turn Around Time: 9.20
Average Response Time: 3.00
Throughput: 4.60
```

b) **Round Robin**

```
Enter the number of processes: 6
Enter time quantum: 5
Enter arrival time and burst time for process 1: 0 7
Enter arrival time and burst time for process 2: 1 4
Enter arrival time and burst time for process 3: 2 15
Enter arrival time and burst time for process 4: 3 11
Enter arrival time and burst time for process 5: 4 20
Enter arrival time and burst time for process 6: 9 4

Process Arrival Time    Burst Time      Waiting Time    Turnaround Time Response Time
1       0               7               23              30              0
2       1               4               4               8               4
3       2               15              33              48              7
4       3               11              37              48              11
5       4               20              37              57              15
6       9               4               15              19              15

Average Waiting Time: 24.83
Average Turnaround Time: 35.00
Throughput: 9.33
Average Response Time: 8.67
```

Lab Program - 3

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)

Code:

a) Pre-emptive

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

struct P{
   int id;
   int bt;
   int at;
   int p;
   int wt;
   int tat;
   int rt;
   int st;
   int et;
   int v;
   int b;
};

void main(){
   int n,ct=0;
   float awt=0,atat=0,art=0,tp;
   printf("Enter number of processes: ");
   scanf("%d",&n);
   struct P p[n];
   struct P temp;
```

```
for(int i=0;i<n;i++){
   p[i].id=i+1;
   p[i].v=0;
   p[i].st=-1;
   printf("Enter Burst Time, Arrival Time and Priority of P%d: ",i+1);
   scanf("%d %d %d",&p[i].bt,&p[i].at,&p[i].p);
   p[i].b=p[i].bt;
}

int cf=0, min=INT_MAX,m=0,count=0;
while(count<n){
   for(int i=0;i<n;i++){
      if(p[i].at<=cf){
         if(p[i].p<min && p[i].v!=1){
            min=p[i].p;
            m=i;
         }
      }
   }
   p[m].bt-=1;

   if(p[m].st<0)
   p[m].st=cf;

   cf+=1;
   if(p[m].bt==0){
      p[m].et=cf;
      count++;
      p[m].v=1;
   }
   min=INT_MAX;
```

```
    }
    printf("Process\tWaiting Time\tTurn Around Time\tResponse Time\n");

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

        p[i].tat=p[i].et-p[i].at;
        p[i].wt=p[i].tat-p[i].b;
        p[i].rt=p[i].st-p[i].at;

        printf("%d\t\t%d\t\t%d\t\t%d\n",p[i].id,p[i].wt,p[i].tat,p[i].rt);
        awt+=p[i].wt;
        atat+=p[i].tat;
        art+=p[i].rt;
    }

    tp=(float)cf/n;
    printf("Average Waiting Time: %.2f\n",awt/n);
    printf("Average Turn Around Time: %.2f\n",atat/n);
    printf("Average Response Time: %.2f\n",art/n);
    printf("Throughput: %.2f",tp);
}
```

b) Non-Pre-emptive

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

struct P{
    int id;
    int bt;
    int at;
    int p;
    int wt;
    int tat;
    int rt;
    int st;
    int et;
```

```
    int v;
};

void main(){
    int n,ct=0;
    float awt=0,atat=0,art=0,tp;
    printf("Enter number of processes: ");
    scanf("%d",&n);
    struct P p[n];
    struct P temp;
    for(int i=0;i<n;i++){
        p[i].id=i+1;
        p[i].v=0;
        printf("Enter Burst Time, Arrival Time and Priority of P%d: ",i+1);
        scanf("%d %d %d",&p[i].bt,&p[i].at,&p[i].p);
    }

    for(int i=0;i<n;i++){
        for(int j=i+1;j<n;j++){
            if(p[i].at>p[j].at){
                temp=p[i];
                p[i]=p[j];
                p[j]=temp;
            }
            if(p[i].at==p[j].at){
                if(p[i].p>p[j].p){
                temp=p[i];
                p[i]=p[j];
                p[j]=temp;
            }
            }
        }
    }

    int cf=p[0].bt, min=INT_MAX,m,count=0;
    p[0].v=1;

    while(count<n-1){
    for(int i=0;i<n;i++){
        if(p[i].at<=cf && p[i].v==0){
```

```
        if(p[i].p<min){
            min=p[i].p;
            m=i;
        }
    }
}
p[m].v=1;
cf+=p[m].bt;
min=INT_MAX;

temp=p[count+1];
p[count+1]=p[m];
p[m]=temp;

count++;
}

printf("\nProcess\tWaiting Time\tTurn Around Time\tResponse Time\n");

for(int i=0;i<n;i++){
    if(p[i].at<ct){
        p[i].st=ct;
    }
    else{
        p[i].st=p[i].at;
    }
    p[i].et=p[i].st+p[i].bt;
    ct+=p[i].bt;

    p[i].tat=p[i].et-p[i].at;
    p[i].wt=p[i].tat-p[i].bt;
    p[i].rt=p[i].st-p[i].at;

    printf("%d\t\t%d\t\t%d\t\t%d\n",p[i].id,p[i].wt,p[i].tat,p[i].rt);
    awt+=p[i].wt;
    atat+=p[i].tat;
    art+=p[i].rt;
}

tp=(float)p[n-1].et/n;
```

```
    printf("Average Waiting Time: %.2f\n",awt/n);
    printf("Average Turn Around Time: %.2f\n",atat/n);
    printf("Average Response Time: %.2f\n",art/n);
    printf("Throughput: %.2f",tp);

}
```

Output:

a) **Pre-emptive**

```
Enter number of processes: 5
Enter Burst Time, Arrival Time and Priority of P1: 3 0 5
Enter Burst Time, Arrival Time and Priority of P2: 2 2 3
Enter Burst Time, Arrival Time and Priority of P3: 5 3 2
Enter Burst Time, Arrival Time and Priority of P4: 4 4 4
Enter Burst Time, Arrival Time and Priority of P5: 1 6 1
Process Waiting Time    Turn Around Time        Response Time
1               12              15              0
2               6               8               0
3               1               6               0
4               6               10              6
5               0               1               0
Average Waiting Time: 5.00
Average Turn Around Time: 8.00
Average Response Time: 1.20
Throughput: 3.00
```

a) **Non- Pre-emptive**

```
Enter number of processes: 5
Enter Burst Time, Arrival Time and Priority of P1: 3 0 5
Enter Burst Time, Arrival Time and Priority of P2: 2 2 3
Enter Burst Time, Arrival Time and Priority of P3: 5 3 2
Enter Burst Time, Arrival Time and Priority of P4: 4 4 4
Enter Burst Time, Arrival Time and Priority of P5: 1 6 1

Process Waiting Time    Turn Around Time        Response Time
1               0               3               0
3               0               5               0
5               2               3               2
2               7               9               7
4               7               11              7
Average Waiting Time: 3.20
Average Turn Around Time: 6.20
Average Response Time: 3.20
Throughput: 3.00
```

Lab Program - 4

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.

Code:

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

struct P{
    int id;
    int bt;
    int at;
    int q;
    int wt;
    int tat;
    int rt;
    int st;
    int et;
    int v;
};

void main(){
    int n,ct=0;
    float awt=0,atat=0,art=0,tp;
    printf("Queue 1 is system process\nQueue 2 is User Process\n");
    printf("Enter number of processes: ");
    scanf("%d",&n);
    struct P p[n];
    struct P temp;
```

```
for(int i=0;i<n;i++){
   p[i].id=i+1;
   p[i].v=0;
   printf("Enter Burst Time, Arrival Time and Queue of P%d: ",i+1);
   scanf("%d %d %d",&p[i].bt,&p[i].at,&p[i].q);
}

for(int i=0;i<n;i++){
   for(int j=i+1;j<n;j++){
      if(p[i].at>p[j].at){
         temp=p[i];
         p[i]=p[j];
         p[j]=temp;
      }
      if(p[i].at==p[j].at){
         if(p[i].q>p[j].q){
         temp=p[i];
         p[i]=p[j];
         p[j]=temp;
      }
      }
   }
}

int cf=p[0].bt, min=INT_MAX,m,count=0;
p[0].v=1;

while(count<n-1){
for(int i=0;i<n;i++){
   if(p[i].at<=cf && p[i].v==0){
      if(p[i].q<min){
         min=p[i].q;
```

```
            m=i;
        }
    }
}
p[m].v=1;
cf+=p[m].bt;
min=INT_MAX;

temp=p[count+1];
p[count+1]=p[m];
p[m]=temp;

count++;
}

printf("\nProcess\tWaiting Time\tTurn Around Time\tResponse Time\n");

for(int i=0;i<n;i++){
    if(p[i].at<ct){
        p[i].st=ct;
    }
    else{
        p[i].st=p[i].at;
    }
    p[i].et=p[i].st+p[i].bt;
    ct+=p[i].bt;

    p[i].tat=p[i].et-p[i].at;
    p[i].wt=p[i].tat-p[i].bt;
    p[i].rt=p[i].st-p[i].at;

    printf("%d\t\t%d\t\t%d\t\t%d\n",p[i].id,p[i].wt,p[i].tat,p[i].rt);
```

```
        awt+=p[i].wt;
        atat+=p[i].tat;
        art+=p[i].rt;
    }

    tp=(float)p[n-1].et/n;
    printf("Average Waiting Time: %.2f\n",awt/n);
    printf("Average Turn Around Time: %.2f\n",atat/n);
    printf("Average Response Time: %.2f\n",art/n);
    printf("Throughput: %.2f",tp);

}
```

Output:

```
Queue 1 is system process
Queue 2 is User Process
Enter number of processes: 5
Enter Burst Time, Arrival Time and Queue of P1: 4 0 1
Enter Burst Time, Arrival Time and Queue of P2: 2 1 2
Enter Burst Time, Arrival Time and Queue of P3: 3 2 2
Enter Burst Time, Arrival Time and Queue of P4: 2 2 1
Enter Burst Time, Arrival Time and Queue of P5: 5 8 1

Process Waiting Time    Turn Around Time        Response Time
1               0               4               0
4               2               4               2
2               5               7               5
5               0               5               0
3               11              14              11
Average Waiting Time: 3.60
Average Turn Around Time: 6.80
Average Response Time: 3.60
Throughput: 3.20
```

Lab Program - 5

Question:

Write a C program to simulate Real Time CPU Scheduling Algorithms:

a) Rate- Monotonic

b) Earliest Deadline First

c) Proportional Scheduling

Code:

a) Rate-Monotonic

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

struct P{
   int id;
   float et;
   int tp;
   int v;
   int b;
};
int gcd(int a, int b){
   if (b == 0)
      return a;
   return gcd(b, a % b);
}
int findlcm(int arr[], int n)
{
   int ans = arr[0];

   for (int i = 1; i < n; i++)
      ans = (((arr[i] * ans)) /(gcd(arr[i], ans)));

   return ans;
}
```

```
void main(){
    int n,ct=0,f=0;
    float awt=0,atat=0,art=0,tp;
    printf("Enter number of processes: ");
    scanf("%d",&n);
    struct P p[n];
    struct P temp;
    int a[n];
    for(int i=0;i<n;i++){
        p[i].id=i+1;
        p[i].v=0;
        printf("Enter Excecution Time and Time Period of P%d: ",i+1);
        scanf("%f %d",&p[i].et,&p[i].tp);
        p[i].b=p[i].et;
        a[i]=p[i].tp;
    }

    for(int i=0;i<n;i++){
        for(int j=i+1;j<n;j++){
            if(p[i].tp>p[j].tp){
                temp=p[i];
                p[i]=p[j];
                p[j]=temp;
            }
        }
    }
    int ans=findlcm(a,n);

    for(int i=0;i<ans;i++){
        f=0;
        for(int j = 0;j<n;j++){
            if (i%p[j].tp==0) {
```

```
            p[j].v=0;
            p[j].et=p[j].b;
        }
    }
        for(int j=0;j<n;j++){
            if(p[j].v==0){
                f=1;
                p[j].et-=1;
                printf("%d to %d P%d\n",i,i+1,p[j].id);
                if(p[j].et==0){
                    p[j].v=1;
                }
                break;
            }
        }

        if(f==0){
            printf("%d to %d -\n",i,i+1);
        }
    }
}
```

b) Earliest Deadline First

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

#define MAX_TSKS 10

typedef struct {
    int p;
    int c;
    int d;
    int rt;
```

```
    int nd;
    int id;
} Task;

void Input(Task tsks[], int *n_tsk) {
    printf("Enter number of tasks (max %d): ", MAX_TSKS);
    scanf("%d", n_tsk);

    if (*n_tsk > MAX_TSKS) {
        printf("Number of tasks exceeds the maximum limit of %d.\n", MAX_TSKS);
        exit(EXIT_FAILURE);
    }

    for (int i = 0; i < *n_tsk; i++) {
        tsks[i].id = i + 1;
        printf("Enter period (p) of task %d: ", i + 1);
        scanf("%d", &tsks[i].p);
        printf("Enter execution time (c) of task %d: ", i + 1);
        scanf("%d", &tsks[i].c);
        printf("Enter deadline (d) of task %d: ", i + 1);
        scanf("%d", &tsks[i].d);

        tsks[i].rt = tsks[i].c;
        tsks[i].nd = tsks[i].d;
    }
}

void EDF(Task tsks[], int n_tsk, int tf) {
    printf("\nEarliest-Deadline First Scheduling:\n");
    for (int t = 0; t < tf; t++) {
        int s_tsk = -1;
```

```
        for (int i = 0; i < n_tsk; i++) {
            if (t % tsks[i].p == 0) {
                tsks[i].rt = tsks[i].c;
                tsks[i].nd = t + tsks[i].d;
            }
        }

        for (int i = 0; i < n_tsk; i++) {
            if (tsks[i].rt > 0 && (s_tsk == -1 || tsks[i].nd < tsks[s_tsk].nd)) {
                s_tsk = i;
            }
        }

        if (s_tsk != -1) {
            printf("Time %d: Task %d\n", t, tsks[s_tsk].id);
            tsks[s_tsk].rt--;
        } else {
            printf("Time %d: Idle\n", t);
        }
    }
}

int main() {
    Task tsks[MAX_TSKS];
    int n_tsk;
    int tf;

    Input(tsks, &n_tsk);

    printf("Enter time frame for simulation: ");
    scanf("%d", &tf);
```

```
    EDF(tsks, n_tsk, tf);

    return 0;
}
```

c) Proportional Scheduling

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

int main() {
    int n, sOT = 0;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    int pid[n];
    int l[n + 1];
    l[0] = 0;

    printf("\nEnter the number of tickets for each process:\n");
    for (int i = 0; i < n; i++) {
        printf("PID%d: ", i + 1);
        scanf("%d", &pid[i]);
        sOT += pid[i];
        l[i + 1] = pid[i];
    }

    int t = 1;
    int sum = sOT;
    for (int i = 0; i < n; i++) {
        printf("Probability of servicing process %d is %d%%\n", i + 1, (pid[i] * 100) / sOT);
    }
```

```
    srand(time(NULL));
    while (sum > 0) {
        int x = rand() % sOT;
        int j;
        for (j = 0; j < n; j++) {
            if (x < l[j + 1]) {
                printf("%d ms: Servicing Ticket of process %d\n", t, j + 1);
                //l[j + 1]--;
                pid[j]--;
                sum--;
                t++;
                break;
            }
        }
    }

    for (int i = 0; i < n; i++) {
        if (pid[i] == 0) {
            printf("PID%d has finished executing\n", i + 1);
        }
    }
    return 0;
}
```

Output:

a) Rate Monotonic

```
Enter number of processes: 3
Enter Excecution Time and Time Period of P1: 3 20
Enter Excecution Time and Time Period of P2: 10 5
Enter Excecution Time and Time Period of P3: 20 2
0 to 1 P3
1 to 2 P3
2 to 3 P3
3 to 4 P3
4 to 5 P3
5 to 6 P3
6 to 7 P3
7 to 8 P3
8 to 9 P3
9 to 10 P3
10 to 11 P3
11 to 12 P3
12 to 13 P3
13 to 14 P3
14 to 15 P3
15 to 16 P3
16 to 17 P3
17 to 18 P3
18 to 19 P3
19 to 20 P3
```

b) Earliest Deadline First

```
Enter number of tasks (max 10): 3
Enter period (p) of task 1: 20
Enter execution time (c) of task 1: 3
Enter deadline (d) of task 1: 7
Enter period (p) of task 2: 5
Enter execution time (c) of task 2: 2
Enter deadline (d) of task 2: 4
Enter period (p) of task 3: 10
Enter execution time (c) of task 3: 2
Enter deadline (d) of task 3: 8
Enter time frame for simulation: 20

Earliest-Deadline First Scheduling:
Time 0: Task 2
Time 1: Task 2
Time 2: Task 1
Time 3: Task 1
Time 4: Task 1
Time 5: Task 3
Time 6: Task 3
Time 7: Task 2
Time 8: Task 2
Time 9: Idle
Time 10: Task 2
Time 11: Task 2
Time 12: Task 3
Time 13: Task 3
Time 14: Idle
Time 15: Task 2
Time 16: Task 2
Time 17: Idle
Time 18: Idle
Time 19: Idle
```

c) Proportional Scheduling

```
Enter the number of processes: 2

Enter the number of tickets for each process:
PID1: 3
PID2: 2
Probability of servicing process 1 is 60%
Probability of servicing process 2 is 40%
1 ms: Servicing Ticket of process 1
2 ms: Servicing Ticket of process 1
3 ms: Servicing Ticket of process 1
4 ms: Servicing Ticket of process 1
5 ms: Servicing Ticket of process 1
```

Lab Program - 6

Question:

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

Code:

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

#define BUF_SIZE 10
#define MAX_ITMS 20

int buf[BUF_SIZE];
int cnt = 0;
int in = 0;
int out = 0;
int prod_cnt = 0;
int cons_cnt = 0;

pthread_mutex_t mtx;
pthread_cond_t cond_prod;
pthread_cond_t cond_cons;

void* prod(void* param) {
   while (1) {
      int item = rand() % 100;

      pthread_mutex_lock(&mtx);

      if (prod_cnt >= MAX_ITMS) {
```

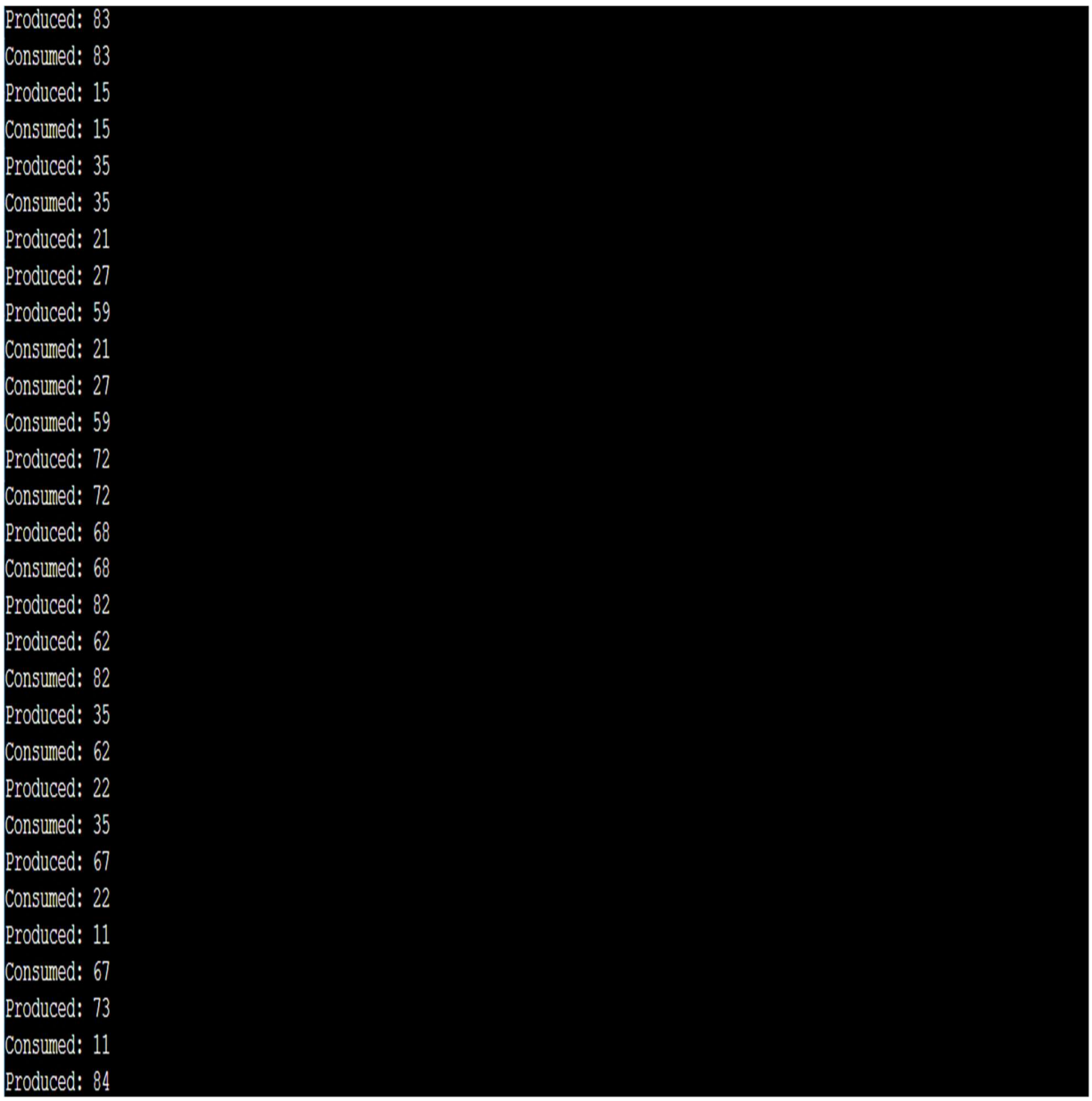
```
            pthread_mutex_unlock(&mtx);
            break;
        }

        while (cnt == BUF_SIZE) {
            pthread_cond_wait(&cond_prod, &mtx);
        }

        buf[in] = item;
        in = (in + 1) % BUF_SIZE;
        cnt++;
        prod_cnt++;
        printf("Produced: %d\n", item);

        pthread_cond_signal(&cond_cons);
        pthread_mutex_unlock(&mtx);

        sleep(rand() % 2);
    }
    return NULL;
}

void* cons(void* param) {
    while (1) {
        pthread_mutex_lock(&mtx);

        if (cons_cnt >= MAX_ITMS) {
            pthread_mutex_unlock(&mtx);
            break;
        }

        while (cnt == 0) {
```

```
            pthread_cond_wait(&cond_cons, &mtx);
        }

        int item = buf[out];
        out = (out + 1) % BUF_SIZE;
        cnt--;
        cons_cnt++;
        printf("Consumed: %d\n", item);

        pthread_cond_signal(&cond_prod);
        pthread_mutex_unlock(&mtx);

        sleep(rand() % 2);
    }
    return NULL;
}

int main() {
    pthread_t tid_prod, tid_cons;

    pthread_mutex_init(&mtx, NULL);
    pthread_cond_init(&cond_prod, NULL);
    pthread_cond_init(&cond_cons, NULL);

    pthread_create(&tid_prod, NULL, prod, NULL);
    pthread_create(&tid_cons, NULL, cons, NULL);

    pthread_join(tid_prod, NULL);
    pthread_join(tid_cons, NULL);

    printf("Production & Consumption complete\n");
```

```
    pthread_mutex_destroy(&mtx);
    pthread_cond_destroy(&cond_prod);
    pthread_cond_destroy(&cond_cons);

    return 0;
}
```

Output:

Producer-Consumer



Lab Program - 7

Question:

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

Code:

```
#include <pthread.h>
#include <semaphore.h>
#include <stdio.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]);
    }
}

// take up chopsticks
void take_fork(int phnum)
{

    sem_wait(&mutex);

    // state that hungry
    state[phnum] = HUNGRY;

    printf("Philosopher %d is Hungry\n", phnum + 1);

    // eat if neighbours are not eating
    test(phnum);

    sem_post(&mutex);

    // if unable to eat wait to be signalled
    sem_wait(&S[phnum]);

    sleep(1);
}

// put down chopsticks
```

```
void put_fork(int phnum)
{

    sem_wait(&mutex);

    // state that thinking
    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 = num;

        sleep(1);

        take_fork(*i);

        sleep(0);

        put_fork(*i);
```

```
    }
}

int main()
{

    int i;
    pthread_t thread_id[N];

    // initialize the semaphores
    sem_init(&mutex, 0, 1);

    for (i = 0; i < N; i++)

        sem_init(&S[i], 0, 0);

    for (i = 0; i < N; i++) {

        // create philosopher processes
        pthread_create(&thread_id[i], NULL,
                       philosopher, &phil[i]);

        printf("Philosopher %d is thinking\n", i + 1);
    }

    for (i = 0; i < N; i++)

        pthread_join(thread_id[i], NULL);
}
```

Output:

Dining-Philosopher

```
Philosopher 1 is thinking
Philosopher 2 is thinking
Philosopher 3 is thinking
Philosopher 4 is thinking
Philosopher 5 is thinking
Philosopher 1 is Hungry
Philosopher 2 is Hungry
Philosopher 3 is Hungry
Philosopher 4 is Hungry
Philosopher 5 is Hungry
Philosopher 5 takes fork 4 and 5
Philosopher 5 is Eating
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 takes fork 5 and 1
Philosopher 1 is Eating
Philosopher 4 putting fork 3 and 4 down
Philosopher 4 is thinking
Philosopher 3 takes fork 2 and 3
Philosopher 3 is Eating
Philosopher 5 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
```

Lab Program - 8

Question:

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

Code:

```
// Banker's Algorithm
#include <stdio.h>
int main()
{
   // P0, P1, P2, P3, P4 are the Process names here

   int n, m, i, j, k;
   n = 5; // Number of processes
   m = 3; // Number of resources
   int alloc[5][3] = { { 0, 1, 0 }, // P0    // Allocation Matrix
                       { 2, 0, 0 }, // P1
                       { 3, 0, 2 }, // P2
                       { 2, 1, 1 }, // P3
                       { 0, 0, 2 } }; // P4

   int max[5][3] = { { 7, 5, 3 }, // P0    // MAX Matrix
                     { 3, 2, 2 }, // P1
                     { 9, 0, 2 }, // P2
                     { 2, 2, 2 }, // P3
                     { 4, 3, 3 } }; // P4

   int avail[3] = { 3, 3, 2 }; // Available Resources

   int f[n], ans[n], ind = 0;
   for (k = 0; k < n; k++) {
      f[k] = 0;
   }
   int need[n][m];
   for (i = 0; i < n; i++) {
```

```
    for (j = 0; j < m; j++)
        need[i][j] = max[i][j] - alloc[i][j];
}
int y = 0;
for (k = 0; k < 5; k++) {
    for (i = 0; i < n; i++) {
        if (f[i] == 0) {

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

            if (flag == 0) {
                ans[ind++] = i;
                for (y = 0; y < m; y++)
                    avail[y] += alloc[i][y];
                f[i] = 1;
            }
        }
    }
}

 int flag = 1;

 for(int i=0;i<n;i++)
{
 if(f[i]==0)
 {
   flag=0;
    printf("The following system is not safe");
   break;
 }
```

```
    }

     if(flag==1)
    {
     printf("Following is the SAFE Sequence\n");
     for (i = 0; i < n - 1; i++)
       printf(" P%d ->", ans[i]);
     printf(" P%d", ans[n - 1]);
    }


    return (0);

    // This code is contributed by Deep Baldha (CandyZack)
}
```

Output:

Bankers Algorithm (Deadlock Avoidance and Detection)

```
Following is the SAFE Sequence
 P1 -> P3 -> P4 -> P0 -> P2
```

Lab Program - 9

Question:

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

a) Worst-fit

b) Best-fit

c) First-fit

Code:

```
#include<stdio.h>
#include<limits.h>
struct hole{
   int size;
   int v;
}hole;

struct p{
   int size;
   int d;
}p;

void main(){
   int n1,n2,n,m=-1;

   printf("Enter number of holes: \n");
   scanf("%d",&n1);
   struct hole h[n1];
   printf("Enter hole size: \n");
```

```
for(int i=0;i<n1;i++){
   scanf("%d",&h[i].size);
   h[i].v=-1;
}

printf("Enter number of processes: \n");
scanf("%d",&n2);
struct p p[n2];
printf("Enter processes size: \n");
for(int i=0;i<n2;i++){
   scanf("%d",&p[i]);
   p[i].d=-1;
}

for(int i=0;i<n2;i++){
   for(int j=0;j<n1;j++){
      if(p[i].size<=h[j].size && h[j].v==-1){
         p[i].d=1;
         h[j].v=i;
         break;
      }
   }
}
printf("\nFirst fit \n");
for(int i=0;i<n1;i++){
      if(h[i].v==-1){
         printf(" -- ");
```

```
        }
        else{
        printf(" P%d ",h[i].v+1);
        }
}
printf("\n");
for(int i=0;i<n2;i++){
    if(p[i].d==-1){
        printf("Process P%d(%d) is unfinished\n",(i+1),p[i].size);
    }
}

for(int i=0;i<n1;i++){
    h[i].v=-1;
}
for(int i=0;i<n2;i++){
    p[i].d=-1;
}
printf("\nBest fit \n");
for(int i=0;i<n2;i++){
    n=INT_MAX;
    for(int j=0;j<n1;j++){
        if(p[i].size<=h[j].size && h[j].v==-1 && h[j].size<n){
            m=j;
            n=h[j].size;
        }
    }
```

```
    if(n!=INT_MAX){
        p[i].d=1;
        h[m].v=i;
    }
}

for(int i=0;i<n1;i++){
        if(h[i].v==-1){
            printf(" -- ");
        }
        else{
        printf(" P%d ",h[i].v+1);
        }
}
printf("\n");
for(int i=0;i<n2;i++){
    if(p[i].d==-1){
        printf("Process P%d(%d) is unfinished\n",(i+1),p[i].size);
    }
}

 for(int i=0;i<n1;i++){
    h[i].v=-1;
}
for(int i=0;i<n2;i++){
    p[i].d=-1;
}
```

```
printf("\nWorst fit \n");
for(int i=0;i<n2;i++){
   n=-1;
   for(int j=0;j<n1;j++){
      if(h[j].v==-1 && h[j].size>n){
         m=j;
         n=h[j].size;
      }
   }
   if(n!=-1 && p[i].size<=h[m].size){
      p[i].d=1;
      h[m].v=i;
   }
}

for(int i=0;i<n1;i++){
      if(h[i].v==-1){
         printf(" -- ");
      }
      else{
      printf(" P%d ",h[i].v+1);
      }
}
printf("\n");
for(int i=0;i<n2;i++){
   if(p[i].d==-1){
      printf("Process P%d(%d) is unfinished\n",(i+1),p[i].size);
```

```
    }
  }
}
```

Output:

Memory Allocation (First Fit, Best Fit, Worst Fit)

```
Enter number of holes:
5
Enter hole size:
100 500 200 300 600
Enter number of processes:
4
Enter processes size:
212 417 112 476

First fit
 --  P1  P3  --  P2
Process P4(476) is unfinished

Best fit
 --  P2  P3  P1  P4

Worst fit
 --  P2  --  P3  P1
Process P4(476) is unfinished
```

Lab Program - 10

Question:

Please execute the page Replacement Algorithms: FIFO, OPTIMAL and LRU

Code:

```
#include <stdio.h>


// Function to check if the page is present in the frames
int isPagePresent(int frames[], int n, int page) {
    for (int i = 0; i < n; i++) {
        if (frames[i] == page) {
            return 1;
        }
    }
    return 0;
}


// Function to print the frames
void printFrames(int frames[], int n) {
    for (int i = 0; i < n; i++) {
        if (frames[i] != -1) {
            printf("%d ", frames[i]);
        } else {
            printf("- ");
        }
    }
    printf("\n");
```

```
}

// Function to implement FIFO page replacement
void fifoPageReplacement(int pages[], int numPages, int numFrames) {
    int frames[numFrames];
    int front = 0, pageFaults = 0;

    // Initialize frames
    for (int i = 0; i < numFrames; i++) {
        frames[i] = -1;
    }

    printf("FIFO Replacement\n");
    printf("Reference String\tFrames\n");
    for (int i = 0; i < numPages; i++) {
        printf("%d\t\t", pages[i]);

        if (!isPagePresent(frames, numFrames, pages[i])) {
            frames[front] = pages[i];
            front = (front + 1) % numFrames;
            pageFaults++;
        }
        printFrames(frames, numFrames);
    }

    printf("\nTotal Page Faults: %d\n\n", pageFaults);
}
```

```
// Function to find the page to replace using the Optimal page replacement algorithm
int findOptimalReplacementIndex(int pages[], int numPages, int frames[], int numFrames, int currentIndex) {
    int farthest = currentIndex;
    int index = -1;

    for (int i = 0; i < numFrames; i++) {
        int j;
        for (j = currentIndex; j < numPages; j++) {
            if (frames[i] == pages[j]) {
                if (j > farthest) {
                    farthest = j;
                    index = i;
                }
                break;
            }
        }
        // If the page is not found in future, return this index
        if (j == numPages) {
            return i;
        }
    }

    // If all pages are found in future, return the one with farthest future use
    return (index == -1) ? 0 : index;
}
```

```
// Function to implement Optimal page replacement
void optPageReplacement(int pages[], int numPages, int numFrames) {
    int frames[numFrames];
    int pageFaults = 0;

    // Initialize frames
    for (int i = 0; i < numFrames; i++) {
        frames[i] = -1;
    }

    printf("Optimal Replacement\n");
    printf("Reference String\tFrames\n");
    for (int i = 0; i < numPages; i++) {
        printf("%d\t\t", pages[i]);

        if (!isPagePresent(frames, numFrames, pages[i])) {
            if (isPagePresent(frames, numFrames, -1)) {
                for (int j = 0; j < numFrames; j++) {
                    if (frames[j] == -1) {
                        frames[j] = pages[i];
                        break;
                    }
                }
            } else {
                int index = findOptimalReplacementIndex(pages, numPages, frames, numFrames, i +
1);
```

```
                frames[index] = pages[i];
            }
            pageFaults++;
        }
        printFrames(frames, numFrames);
    }

    printf("\nTotal Page Faults: %d\n\n", pageFaults);
}

// Function to implement LRU page replacement
void lruPageReplacement(int pages[], int numPages, int numFrames) {
    int frames[numFrames];
    int pageFaults = 0;
    int timestamps[numFrames];

    // Initialize frames and timestamps
    for (int i = 0; i < numFrames; i++) {
        frames[i] = -1;
        timestamps[i] = -1;
    }

    printf("LRU Replacement\n");
    printf("Reference String\tFrames\n");
    for (int i = 0; i < numPages; i++) {
        printf("%d\t\t", pages[i]);
```

```
        if (!isPagePresent(frames, numFrames, pages[i])) {
            int lruIndex = 0;
            for (int j = 1; j < numFrames; j++) {
                if (timestamps[j] < timestamps[lruIndex]) {
                    lruIndex = j;
                }
            }
            frames[lruIndex] = pages[i];
            timestamps[lruIndex] = i;
            pageFaults++;
        } else {
            for (int j = 0; j < numFrames; j++) {
                if (frames[j] == pages[i]) {
                    timestamps[j] = i;
                    break;
                }
            }
        }
        printFrames(frames, numFrames);
    }

    printf("\nTotal Page Faults: %d\n\n", pageFaults);
}

int main() {
    int numFrames, numPages;
```

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

    printf("Enter the number of pages: ");
    scanf("%d", &numPages);

    int pages[numPages];

    printf("Enter the reference string: ");
    for (int i = 0; i < numPages; i++) {
        scanf("%d", &pages[i]);
    }

    fifoPageReplacement(pages, numPages, numFrames);
    optPageReplacement(pages, numPages, numFrames);
    lruPageReplacement(pages, numPages, numFrames);

    return 0;
}
```

Output:

Page Replacement (FIFO, OPTIMAL, LRU)

```
Enter the number of frames: 4
Enter the number of pages: 14
Enter the reference string: 7 0 1 2 0 3 0 4 2 3 0 3 2 3
FIFO Replacement
Reference String       Frames
7              7 - - -
0              7 0 - -
1              7 0 1 -
2              7 0 1 2
0              7 0 1 2
3              3 0 1 2
0              3 0 1 2
4              3 4 1 2
2              3 4 1 2
3              3 4 1 2
0              3 4 0 2
3              3 4 0 2
2              3 4 0 2
3              3 4 0 2

Total Page Faults: 7

Optimal Replacement
Reference String       Frames
7              7 - - -
0              7 0 - -
1              7 0 1 -
2              7 0 1 2
0              7 0 1 2
3              3 0 1 2
0              3 0 1 2
4              3 0 4 2
2              3 0 4 2
3              3 0 4 2
0              3 0 4 2
3              3 0 4 2
2              3 0 4 2
3              3 0 4 2

Total Page Faults: 6

LRU Replacement
Reference String       Frames
7              7 - - -
0              7 0 - -
1              7 0 1 -
2              7 0 1 2
0              7 0 1 2
3              3 0 1 2
0              3 0 1 2
4              3 0 4 2
2              3 0 4 2
3              3 0 4 2
0              3 0 4 2
3              3 0 4 2
2              3 0 4 2
3              3 0 4 2

Total Page Faults: 6
```