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1BM23CS412

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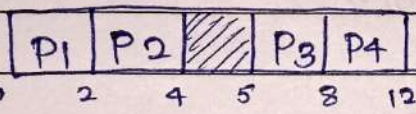
* Scheduling Algorithms

1) FCFS - First Come First Serve Scheduling

1.

Process ID	Arrival Time(ms)	Burst Time(ms)	Completion Time(ms)	Turn Around Time	Waiting Time (ms)
P1	0	2	2	2	0
P2	1	2	4	3	1
P3	5	3	8	3	0
P4	6	4	12	6	2

→ Gantt Chart



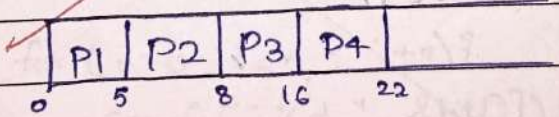
Average Turn Around Time = (2+3+3+6)/4 = 3.5 ms

Average Waiting Time = (0+1+0+2)/4 = 0.7 ms

2.

PID	AT	BT	CT	TAT	WT
P1	0	5	5	5	0
P2	1	3	8	7	4
P3	2	8	16	14	6
P4	3	6	22	19	13

→ Gantt chart



Average TAT = 11.25

Average WT = 5.75

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* Code:

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

void fcfs(int n, int at[], int bt[]){
    int ct[MAX];
    int tat[MAX];
    int wt[MAX];

    int total_wt = 0;
    int total_tat = 0;
    int current_time = 0;

    for (int i=0; i<n; i++){
        ct[i] = -1;
    }

    for (int i=0; i<n; i++){
        if (current_time < at[i]){
            current_time = at[i];
        }
        ct[i] = current_time + bt[i];
        current_time = ct[i];
    }

    for (int i=0; i<n; i++){
        tat[i] = ct[i] - at[i];
        total_tat += tat[i];
    }

    for (int i=0; i<n; i++){
        wt[i] = tat[i] - bt[i];
        total_wt += wt[i];
    }
```

```
    printf("\nProcess \t Arrival Time \t Burst Time \t Completion Time \t Turn Around Time \t Waiting Time");
    for (int i=0; i<n; i++){
        printf("%d \t %d \t\t %d \t\t %d \t\t %d \t\t %d\n",
            i+1, at[i], bt[i], ct[i], tat[i], wt[i]);
    }
    printf("\nAverage waiting time : %.2f",
                (float) total_wt/n);
    printf("\nAverage turnaround time: %.2f",
                (float) total_tat/n);
}

int main(){
    int n, i;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    int at[n], bt[n];
    printf("Enter the arrival time:\n");
    for(i=0; i<n; i++){
        scanf("%d", &at[i]);
    }
    printf("Enter the Burst time:\n");
    for(i=0; i<n; i++){
        scanf("%d", &bt[i]);
    }

    fcfs(n, at, bt);
    return 0;
}
```

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* Output:

Enter the number of processes: 4

Enter the arrival times:

0

1

5

6

Enter the burst times:

2

2

3

4

Process	Arrival Time	Burst Time	Completion Time	Turnaround Time	Waiting Time
1	0	2	2	2	0
2	1	2	4	3	1
3	5	3	8	3	0
4	6	4	12	6	2

Average waiting time: 0.75

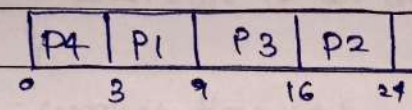
Average turnaround time: 3.50

2) SJF - Shortest Job First Scheduling

1.

PID	AT	BT	CT	TAT	WT
P1	0	6	9	9	3
P2	0	8	24	24	16
P3	6	7	16	16	9
P4	0	3	3	3	0

→ Gantt chart



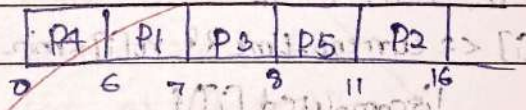
Average Turn around Time = 13

Average Waiting Time = 7

2.

PID	AT	BT	CT	TAT	WT
P1	2	1	7	5	4
P2	1	5	16	15	10
P3	4	1	8	4	3
P4	6	6	6	6	0
P5	2	3	11	9	6

→ Gantt Chart



Average Turn Around Time = 7.8

Average Waiting Time = 4.6

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* Code:

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

void sjf(int n, int at[], int bt[]){
    int ct[MAX];
    int tat[MAX];
    int wt[MAX];
    int rt[MAX];
    int total_wt = 0;
    int total_tat = 0;
    int completed = 0;
    int current_time = 0;
    int shortest_job = 0;
    int min_bt = 9999;
    int is_completed[MAX] = {0};

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

    while (completed < n){
      for (int i = 0; i<n; i++){
        if (at[i] <= current_time && rt[i]<min_bt &&
                !is_completed[i]){
          shortest_job = i;
          min_bt = rt[i];
        }
      }

      rt[shortest_job]--;

      if (rt[shortest_job] == 0){
        completed++;
```

```
        min_bt = 9999;
        is_completed[shortest_job] = 1;
        ct[shortest_job] = current_time + 1;
        tat[shortest_job] = ct[shortest_job] - at[shortest_job];
        total_tat += tat[shortest_job];
        wt[shortest_job] = tat[shortest_job] - bt[shortest_job];
        if (wt[shortest_job] < 0) wt[shortest_job] = 0;
        total_wt += wt[shortest_job];
    }
    current_time++;
}

printf("\nProcess\t Arrival Time\t Burst Time\t Completion
    Time\t TurnAround Time\t Waiting Time\n");
for (int i = 0; i < n; i++){
    printf("%d\t %d\t\t %d\t\t %d\t\t %d\n", i+1, at[i],
        bt[i], ct[i], tat[i], wt[i]);
}
}

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

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* Output:

Enter the number of processes: 4

Enter the arrival time:

0

0

0

0

Enter the burst time:

6

8

7

3

Process	AT	BT	CT	TAT	WT
1	0	6	9	9	3
2	0	8	24	24	16
3	0	7	16	16	9
4	0	3	3	3	0

Average waiting Time: 7.00

Average Turn around Time: 13.00

2) SJF - Shortest Job First - Preemptive Scheduling.

* Code:

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

int find_min(int arr[], int n){
    int min = arr[0];
    int index=0;
    for (int i=1; i<n; i++){
        if arr[i] <min){
            min = arr[i];
            index = i;
        }
    }
    return index;
}

void sjf_preemptive(int n, int at[], int bt[]){
    int ct[MAX] = {0};
    int tat[MAX]={0};
    int wt[MAX] = {0};
    int rt[MAX];

    int total_wt=0;
    int total_tat=0;

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

    int current_time=0;
    int completed_processes=0;
```

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```
while(completed_processes<n){
    int available_processes[MAX];
    int available_count=0;
    for(int i=0; i<n; i++){
        if(at[i]<=current_time && rt[i]>0){
            available_processes[available_count]=i;
            available_count++;
        }
    }
    if(available_count==0){
        current_time++;
        continue;
    }
    int sj_index=available_processes[find_min(rt,
                                available_count)];
    rt[shortest_job_index]--;
    current_time++;
    if(rt[sj_index]==0){
        completed_processes++;
        ct[shortest_job_index]=current_time;
        tat[shortest_job_index]=tat[sj_index]-at[sj_index];
        wt[sj_index]=tat[sj_index]-bt[sj_index];
        total_wt+=wt[sj_index];
        total_tat+=tat[sj_index];
    }
}
printf("\nProcess\tArrival Time\tBurst Time\t
    Completion Time\tTurnaround Time\t Waiting Time\n");
for(int i=0; i<n; i++){
    printf("%d\t%d\t%d\t%d\t%d\t%d\n",i+1,
        at[i], bt[i], ct[i], tat[i], wt[i]);
}
```

```
    printf("\nAverage waiting time: %.2f",
                                (float) total_wt / n);
    printf("\nAverage turnaroundtime : %.2f",
                                (float) total_tat / n);
}

int main(){
    int n;
    printf("Enter the number of processes: ");
    scanf("%d", &n);
    int at[MAX], bt[MAX];
    printf("Enter the arrival time:\n");
    for (int i=0; i<n; i++){
        scanf("%d", &at[i]);
    }

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

    sjf_preemptive(n, at, bt);
    return 0;
}
```

* Output:

```
Enter the number of processes:5
Enter the arrival time:
2 1 4 0 2
Enter the burst time:
1 5 1 6 3
```

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Process	AT	BT	CT	TAT	WT
1	2	1	3	1	0
2	1	5	7	6	1
3	4	1	8	4	3
4	0	6	13	13	7
5	2	3	16	14	11

Average waiting time: 4.40

Average turnaround time: 7.60

3) Priority Scheduling Preemptive and Non-preemptive

```
#include <stdio.h>

typedef struct {
    int id;
    int at;
    int bt;
    int priority;
    int rt;
} Proc;

void swap(Proc *a, Proc *b){
    Proc temp = *a;
    *a = *b;
    *b = temp;
}

void sort_by_priority(Proc p[], int n){
  for (int i = 0; i < n-1; i++){
    for (int j=0; j < n-i-1; j++){
      if (p[j].priority > p[j+1].priority){
        swap(&p[j], &p[j+1]);
      }
    }
  }
}

void priority_preemptive(Proc p[], int n){
    int wt[n], tat[n];
    int total_time = 0;
    int completed = 0;
    while (completed < n){
        int highest_priority_index = -1;
```

```
int highest_priority = -1;
for (int i=0; i<n; i++){
    if (p[i].at <= total_time && p[i].priority >
        highest_priority && p[i].rt >0){
        highest_priority_index = i;
        highest_priority = p[i].priority;
    }
}
if (highest_priority_index == -1){
    total_time++;
    continue;
}

p[highest_priority_index].rt--;
if (p[highest_priority_index].rt ==0){
    completed++;
    wt[highest_priority_index] = total_time + 1 -
    p[highest_priority_index].at - p[highest_priority_index].bt;
    if (wt[highest_priority_index] <0){
        wt[highestpriority_index] = 0;
    }
    tat[highest_priority_index] = wt[highest_priority_index]
    + p[highest_priority_index].bt;
}
total_time++;
}

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

```
printf("\nPreemptive Priority scheduling:\n");
printf("ID \t Arrival Time \t Burst Time \t Priority \t
    Waiting Time \t Turnaround Time \n");
for (int i=0; i<n; i++){
    printf("%d \t %d \t %d \t \t %d \t \t %d \n",
    p[i].id, p[i].at, p[i].bt, p[i].priority, wt[i],
                                    tat[i]);
}
printf("Avg waiting time: %.2f\n", avg_wt);
printf("Avg Turnaround time: %.2f \n", avg_tat);
}

void priority_non_preemptive (Proc p[], int n) {
    int wt[n], tat[n];
    sort_by_priority (p, n);
    int total_time = p[0].at;
    for (int i=0; i<n; i++){
        wt[i] = total_time - p[i].at;
        if (wt[i]<0){
            wt[i] = 0;
            total_time = p[i].at;
        }
        tat[i] = wt[i] + p[i].bt;
        total_time += p[i].bt;
    }
    float avg_wt = 0, avg_tat = 0;
    for (int i=0; i<n; i++){
        avg_wt += wt[i];
        avg_tat += tat[i];
    }
    avg_wt /= n;
    avg_tat /= n;
    printf("\n Non-preemptive Priority Scheduling:\n");
    printf("ID \t Arrival Time \t Burst time \t Priority \t
        Waiting Time \t Turnaround Time \n");
```

```
for (int i=0; i<n; i++){
  printf ("%d\t %d\t %d\t\t %d\t\t %d\n",
    p[i].id, p[i].at, p[i].bt, p[i].priority, wt[i],
    tat[i]);
}
printf("Avg Waiting Time: %.2f\n", avg_wt);
printf("Avg Turnaround Time: %.2f\n", avg_tat);
}

int main(){
  int n;
  printf("Enter the number of processes: ");
  scanf("%d", &n);
  Proc p[n];
  printf("Enter arrival time, burst time, and priority
      for each process:\n");
  for (int i=0; i<n; i++){
    printf("Process %d:\n", i+1);
    p[i].id = i+1;
    printf("Process Arrival Time: ");
    scanf("%d", &p[i].at);
    printf("Burst Time: ");
    scanf("%d", &p[i].bt);
    printf("Priority: ");
    scanf("%d", &p[i].priority);
    p[i].rt = p[i].bt;
  }
  priority_non_preemptive(p,n);
  priority_preemptive(p,n);

  return 0;
}
```

Output:

Enter the number of processes: 4

Enter arrival time, burst time, and priority for each processes:

Process 1:

Arrival Time : 0

Burst Time: 5

Priority: 10

Process 2:

Arrival Time: 1

Burst Time: 4

Priority: 20

Process 3:

Arrival Time: 2

Burst Time: 2

Priority: 30

Process 4:

Arrival Time: 4

Burst Time: 1

Priority: 40

- Non-Preemptive Priority scheduling:

ID	Arrival Time	BT	Priority	WT	TAT
1	0	5	10	0	5
2	1	4	20	4	8
3	2	2	30	7	9
4	4	1	40	7	8

Avg. waiting time : 4.50

Avg Turnaround Time: 7.50

- Preemptive Priority Scheduling:

ID	Arrival Time	BT	Priority	WT	TAT
1	0	5	10	7	12
2	1	4	20	3	7
3	2	2	30	0	2
4	4	1	40	0	1

Avg WT : 2.50 Avg TAT : 5.50

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4) Round Robin Scheduling

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

struct queue {
  int pid;
  struct queue * next;
};

struct queue * rq = NULL;
struct queue * create (int p){
   struct queue * nn = malloc (sizeof (struct queue));
   nn -> pid = p;
   nn -> next = NULL;
   return nn;
}

void enqueue (int p){
   struct queue* nn = create (p);
   if (rq == NULL)
      rq = nn;
   else {
      struct queue * temp = rq;
      while (temp -> next != NULL)
         temp = temp -> next;
      temp -> next = nn;
   }
}

int dequeue (){
   int x = 0;
   if (rq == NULL)
      return x;
   else{
```

```
    struct queue* temp = rq;
    x = temp -> pid;
    rq = rq -> next;
    free (temp);
  }
  return x;
}

void printq(){
  struct queue* temp = rq;
  while (temp != NULL){
    printf ("%d\t", temp -> pid);
    temp = temp -> next;
  }
  printf ("\n");
}

void swap (int *a, int *b){
  *a = *a + *b;
  *b = *a - *b;
  *a = *a - *b;
}

void sort (int *pid, int *at, int *bt, int n){
  for (int i=0; i<n; i++){
    for (int j=0; j<n; j++){
      if (at[i]<at[j]){
        swap (&at[i], &at[j]);
        swap (&bt[i], &bt[j]);
        swap (&pid[i], &pid[j]);
      }
    }
  }
}
```

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```
int main(){
  int n, t, x=1;
  printf("Enter the number of processes: ");
  scanf("%d", &n);
  printf("Enter the time quantum: ");
  scanf("%d", &t);
  int pid[n], at[n], bt1[n], ct[n], tat[n], wt[n], bt2[n], rt[n];
  for (int i=0; i<n; i++){
    printf("Enter arrival time and burst time: ");
    scanf("%d%d", &at[i], &bt1[i]);
    pid[i] = i+1;
  }
  sort(pid, at, bt1, n);
  enqueue(pid[0]);
  for (int i=0; i<n; i++){
    bt2[i] = bt1[i];
    rt[i] = -1;
  }
  int count = 0;
  int ctvar = at[0];
  while (count != n){
    int curp = rq->pid;
    int curi = 0;
    for (int i=0; i<n; i++){
      if (pid[i] == curp){
        curi = i;
        break;
      }
    }
    if (rt[curi] == -1){
      rt[curi] = ctvar - at[curi];
    }
    if (bt2[curi] <= t){
```

```
        ctvar += bt2[curi];
        bt2[curi] = 0;
    }
    else{
        ctvar += t;
        bt2[curi] -= t;
    }
    while(at[x] <= ctvar && x<n){
        enqueue(pid[x]);
        x += 1;
    }
    if(bt2[curi] > 0)
        enqueue(pid[curi]);
    if(bt2[curi] == 0){
        count += 1;
        ct[curi] = ctvar;
    }
    dequeue();
}
for(int i=0; i<n; i++){
    tat[i] = ct[i] - at[i];
    wt[i] = tat[i] - bt1[i];
}
float avg_tat = 0;
float avg_wt = 0;
for(int i=0; i<n; i++){
    avg_tat += tat[i];
    avg_wt += wt[i];
}
printf("pid\tat\tbt\tct\ttat\twt\trt\n\n");
for(int i=0; i<n; i++){
    printf("%d\t%d\t%d\t%d\t%d\t%d\t%d", pid[i], at[i],
        bt1[i], ct[i], tat[i], wt[i], rt[i]);
    printf("\n");
}
```

printf ("\nAverage Turn around Time: %.f", avg-tat);
printf ("\nAverage waiting time : %.f", avg-wt);
return 0;
}

* Output:

Enter the number of processes : 5
Enter the time quantum: 2
Enter arrival time and burst time: 0 5
_____ : 1 3
_____ : 2 1
_____ : 3 2
_____ : 4 3

pid	at	bt	ct	tat	wt	rt
1	0	5	13	13	8	0
2	1	3	12	11	8	1
3	2	1	5	3	2	2
4	3	2	9	6	4	4
5	4	3	14	10	7	5

Average TAT: 8.600000
Average WT: 5.800000

25/6/24 Lab-3

5) Multilevel Scheduling.

```
#include <stdio.h>

void sort(int proc_id[], int at[], int bt[], int n){
    int min, temp;
    for (int i=0; i<n-1; i++){
        for (int j=i+1; j<n; j++){
            if (at[j] < at[i]){
                temp = at[i];
                at[i] = at[j];
                at[j] = temp;
                temp = bt[i];
                bt[i] = bt[j];
                bt[j] = temp;
                temp = proc_id[i];
                proc_id[i] = proc_id[j];
                proc_id[j] = temp;
            }
        }
    }
}

void simulateFCFS(int proc_id[], int at[], int bt[], int n,
    int start_time){
    int c = start_time, ct[n], tat[n], wt[n];
    double ttat = 0.0, twt = 0.0;
    for (int i=0; i<n; i++){
        if (c >= at[i])
            c += bt[i];
        else
            c = at[i] + bt[i];
        ct[i] = c;
    }
```

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```
for (int i=0; i<n; i++)
    tat[i] = ct[i]-at[i];

for (int i= 0; i<n; i++)
    wt[i] = tat[i]- bt[i];

printf ("PID\tAT\t BT\tCT\t TAT \t tWT\n");
for (int i=0; i<n; i++){
    printf ("%d\t %d\t %d\t %d\t %d\t %d\n", proc_id[i],
        at[i], ct[i], bt[i], tat[i], wt[i]);
    ttat += tat[i];
    twt += wt[i];
}

printf ("Average Turnaround Time: %.2lfms\n",
        ttat/n);
printf ("Average Waiting Time: %.2lfms\n", twt/n);
}

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

    int proc_id[n], at[n], bt[n], type[n];
    int sys_proc_id[n], sys_at[n], sys_bt[n], user_proc_id[n],
        user_at[n], user_bt[n];
    int sys_count=0, user_count=0;

    for (int i=0; i<n; i++){
        proc_id[i] = i+1;
        printf("Enter arrival time, burst time and
            type(0 for system, 1 for user) for proces
```

```
%d: ", i+1);
scanf ("%d %d %d", &at[i], &bt[i], &type[i]);

if (type[i]==0){
    sys_proc_id[sys_count] = proc_id[i];
    sys_at[sys_count] = at[i];
    sys_bt[sys_count] = bt[i];
    sys_count++;
} else{
    user_proc_id[user_count] = proc_id[i];
    user_at[user_count] = at[i];
    user_bt[user_count] = bt[i];
    user_count++;
}
}

sort(sys_proc_id, sys_at, sys_bt, sys_count);
sort(user_proc_id, user_at, user_bt, user_count);

printf("System Processes Scheduling:\n");
simulateFCFS(sys_proc_id, sys_at, sys_bt, sys_count, 0);
int system_end_time = 0;
if (sys_count > 0){
    system_end_time = sys_at[sys_count-1] +
                      sys_bt[sys_count-1];
    for (int i=0; i<sys_count-1; i++){
        if (sys_at[i+1] > system_end_time){
            system_end_time = sys_at[i+1];
        }
        system_end_time += sys_bt[i];
    }
}
printf("\n User Processes Scheduling:\n");
simulateFCFS(user_proc_id, user_at, user_bt, user_count,
system_end_time);
}
```

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* Output:

Enter number of processes: 4

Enter arrival time, burst time and type (0 for system, 1 for user) for process 1 : 0 2 0

——"—— process 2 : 0 1 1

——"—— process 3 : 0 5 0

——"—— process 4 : 0 3 1

System Processes Scheduling:

PID	AT	BT	CT	TAT	WT
1	0	2	2	2	0
3	0	5	7	7	2

Average Turnaround Time: 4.50 ms

Average Waiting Time: 1.00 ms

User Processes Scheduling:

PID	AT	BT	CT	TAT	WT
2	0	1	8	8	7
4	0	3	11	11	8

Average Turnaround Time: 9.50 ms

Average Waiting Time: 7.50 ms

5/6/24 Lab-4 a)

6) Rate Monotonic Scheduling

```
#include <stdio.h>
#include <stdlib.h>
#define MAX_TASKS 10

typedef struct {
    int Ti;
    int Ci;
    int deadline;
    int RT;
    int id;
} Task;

void Input (Task tasks[], int *n_tasks) {
    printf ("Enter number of tasks: ");
    scanf ("%d", n_tasks);
    for (int i=0; i<*n_tasks; i++) {
        tasks[i].id = i+1;
        printf ("Enter Ti of task %d: ", i+1);
        scanf ("%d", &tasks[i].Ti);
        printf ("Enter execution time of task %d:", i+1);
        scanf ("%d", &tasks[i].Ci);
        tasks[i].deadline = tasks[i].Ti;
        tasks[i].RT = tasks[i].Ci;
    }
}

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

void RMS (Task tasks[], int n_tasks, int time_frame) {
    qsort (tasks, n_tasks, sizeof (Task), compare_by_period);
```

```
printf("\n Rate Monotonic Scheduling:\n");
for (int time=0; time<time_frame; time++){
    int s_task = -1;
    for (int i=0; i<n_tasks; i++){
        if (time % tasks[i].T; == 0){
            tasks[i].RT = tasks[i].C;
        }
        if (tasks[i].RT>0 && (s_task == -1 || tasks[i].T<
                              tasks[s_task].T;)){
            s_task = i;
        }
    }
    if (s_task != -1){
        printf("Time %d: Task %d \n", time, tasks[s_task]
        tasks[s_task].RT--;
    }else{
        printf("Time %d: Idle \n", time);
    }
}
}

int main(){
    Task tasks[MAX_TASKS];
    int n_tasks;
    int time_frame;
    Input(tasks, &n_tasks);
    printf("Enter time frame for simulation:");
    scanf("%d", &time_frame);
    RMS(tasks, n_tasks, time_frame);
    return 0;
}
```

* Output:

Enter number of tasks: 3
Enter Ti of task 1: 20
Enter execution time of task 1: 3
Enter Ti of task 2: 5
Enter execution time of task 2: 2
Enter Ti of task 3: 10
Enter execution time of task 3: 2
Enter time frame for simulation: 20

Rate Monotonic Scheduling-
Time 0: Task 2
Time 1: Task 2
Time 2: Task 3
Time 3: Task 3
Time 4: Task 1
Time 5: Task 2
Time 6: Task 2
Time 7: Task 1
Time 8: Task 1
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

5/6/24 Lab-4 b)

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7) Earliest Deadline Scheduling

```
#include <stdio.h>
#include <stdlib.h>
#define MAX_TASKS 10

typedef struct{
  int Ti;
  int Ci;
  int deadline;
  int RT;
  int n_deadline;
  int id;
}Task;

void Input (Task tasks[], int *n_tasks){
  printf("Enter number of tasks: ");
  scanf("%d", n_tasks);
  for (int i=0; i<*n_tasks; i++){
    tasks[i].id= i+1;
    printf("Enter Ti of task %d: ", i+1);
    scanf("%d", &tasks[i].Ti);
    printf("Enter execution time of task %d: ", i+1);
    scanf("%d", &tasks[i].Ci);
    printf("Enter deadline of task %d: ", i+1);
    scanf("%d", &tasks[i].deadline);
    tasks[i].RT= tasks[i].Ci;
    tasks[i].n_deadline = tasks[i].deadline;
  }
}

void EDF (Task tasks[], int n_tasks, int time_frame){
  printf("\nEarliest-Deadline First Scheduling:\n");
  for (int time =0; time< time_frame; time++){
```

```
    int s_task = -1;
    for (int i=0; i<n_tasks; i++) {
        if (time % tasks[i].T == 0) {
            tasks[i].RT = tasks[i].C;
            tasks[i].n_deadline = time + tasks[i].deadline;
        }
    }

    for (int i=0; i<n_tasks; i++) {
        if (tasks[i].RT > 0 && (s_task == -1 || tasks[i].n_dead
                < tasks[s_task].n_deadline)) {
            s_task = i;
        }
    }

    if (s_task != -1) {
        printf("Time %d: Task %d\n", time, tasks[s_task].i
        tasks[s_task].RT--;
    } else {
        printf("Time %d: Idle\n", time);
    }
  }
}

int main() {
    Task tasks[MAX_TASKS];
    int n_tasks;
    int time_frame;
    Input(tasks, &n_tasks);
    printf("Enter time frame for simulation: ");
    scanf("%d", &time_frame);
    EDF(tasks, n_tasks, time_frame);
    return 0;
}
```

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* Output:

Enter Ti of task 3:10

Enter number of tasks:3

Enter Ti of task 1:20

Enter execution time of task 1:3

Enter deadline of task 1: 7

Enter Ti of task 2: 5

Enter ET of task 2: 2

Enter deadline of task 2:4

Enter Ti of task 3:10

Enter ET of task 3: 2

Enter deadline 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

5/6/24 Lab - 4 c)

8) Proportional Scheduling

```
#include <stdio.h>
#include <stdlib.h>
#include <time.h>
#define MAX_TASKS 10
#define MAX_TICKETS 100
#define TIME_UNIT_DURATION_MS 100

struct Task {
    int tid;
    int tickets;
};

void schedule(struct Task tasks[], int num_tasks, int
    * time_span_ms){
    int total_tickets = 0;
    for (int i=0; i<num_tasks; i++){
        total_tickets += tasks[i].tickets;
    }
    srand(time(NULL));
    int current_time = 0;
    int completed_tasks = 0;
    printf("process scheduling :\n");
    while (completed_tasks < num_tasks){
        int winning_ticket = rand() % total_tickets;
        int cumulative_tickets = 0;
        for (int i=0; i<num_tasks; i++){
            cumulative_tickets += tasks[i].tickets;
            if (winning_ticket < cumulative_tickets){
                printf(" Time %d - %d : Task %d is running\n
                    current_time, current_time+1, tasks
                    [i].tid);
                current_time++;
                break;
            }
        }
    }
```

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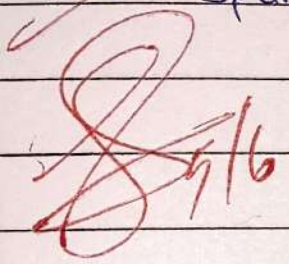
```
        completed_tasks++;
    }
    *time_span_ms = current_time * TIME_UNIT_DURATION_MS;
}

int main(){
    struct Task tasks[MAX_TASKS];
    int num_tasks;
    int time_span_ms;
    printf("Enter the number of tasks: ");
    scanf("%d", &num_tasks);
    if (num_tasks <= 0 || num_tasks > MAX_TASKS){
        printf("Invalid number of tasks. Please enter a
            number between 1 and %d.\n", MAX_TASKS);
    }
    printf("Enter number of tickets for each task:\n");
    for (int i=0 ; i< num_tasks ; i++){
        tasks[i].tid = i+1;
        printf("Task %d tickets: ", tasks[i].tid);
        scanf("%d", &tasks[i].tickets);
    }
    printf("\nRunning tasks:\n");
    schedule(tasks, num_tasks, &time_span_ms);
    printf("\nTime span of the Gantt Chart : %d
        milliseconds\n", time_span_ms);
    return 0;
}
```

* Output:

Enter the number of tasks: 3
Enter number of tickets for each task:
Task 1 tickets: 10
Task 2 tickets: 20
Task 3 tickets: 30

Running tasks:
Process scheduling:
Time 0-1: Task 2 is running
Time 1-2: Task 2 is running
Time 2-3: Task 3 is running
Time span of the Gantt chart: 300 millisconds.



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

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

int mutex=1, full=0, empty=5, x=0;

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

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

void producer(){
    mutex = wait(mutex);
    full = signal(full);
    empty = wait(empty);
    x++;
    printf("\nProducer produces the item %d", x);
    mutex = signal(mutex);
}

void consumer(){
    mutex = wait(mutex);
    full = wait(full);
    empty = signal(empty);
    printf("\n Consumer consumes item %d", x);
    x--;
    mutex = signal(mutex);
}
```

```
int main(){
  int n;
  void producer();
  void consumer();
  int wait(int);
  int signal(int);

  printf("\n1.Producer\n2.Consumer \n3.Exit");
  while(1){
    printf("\nEnter your choice: ");
    scanf("%d", &n);
    switch (n){
      case 1:
        if ((mutex ==1) && (empty != 0))
          producer();
        else
          printf("Buffer is full!!");
        break;
      case 2:
        if ((mutex==1) && (full !=0))
          Consumer();
        else
          printf("Buffer is empty!!");
        break;
      case 3:
        exit(0);
        break;
    }
  }
  return 0;
}
```

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* Output:

1. Producer
2. Consumer
3. Exit

Enter your choice: 1
Producer produces the item 1

Enter your choice: 1
Producer produces the item 2

Enter your choice: 1
Producer produces the item 3

Enter your choice: 2
Consumer consumes the item 3

Enter your choice: 2
Consumer consumes the item 2

Producer - 2 → 3 → 4 → 5

Enter your choice: 1
Buffer is full!!

Enter Consumer - 5 → 4 → 3 → 2 → 1

Enter your choice: 2
Buffer is empty!!

Enter your choice: 3

19/6/24 Lab-6

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

```
#include <stdio.h>
#include <stdlib.h>
#define MAX_PHILOSOPHERS 10

typedef enum {THINKING, HUNGRY, EATING} state_t;
state_t states[MAX_PHILOSOPHERS];
int num_philosophers;
int num_hungry;
int hungry_philosophers[MAX_PHILOSOPHERS];
int forks[MAX_PHILOSOPHERS];

void print_state(){
    printf("\n");
    for (int i=0; i<num_philosophers; ++i){
        if (states[i] == THINKING) printf("P %d is thinking\n", i+1);
        else if (states[i] == HUNGRY) printf("P %d is waiting\n", i+1);
        else if (states[i]== EATING) printf("P %d is eating\n", i+1);
    }
}

int can_eat(int philosophers_id){
    int left_fork = philosopher_id;
    int right_fork = (philosopher_id + 1) % num_philosophers;
    if (forks[left_fork] ==0 && forks[right_fork] ==0){
        forks[left_fork] = forks[right_fork] =1;
        return 1;
    };
    return 0;
}
```

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```
void simulate(int allow_two){
    int eating_count = 0;
    for (int i=0; i<num_hungry; ++i){
        int philosopher_id = hungry_philosophers[i];
        if (states[philosopher_id] == HUNGRY){
            if (can_eat(philosopher_id)){
                states[philosopher_id] = EATING;
                eating_count++;
                printf("p %d is granted to eat \n",
                    philosopher_id + 1);
                if (!allow_two && eating_count == 1) break;
                if (allow_two && eating_count == 2) break;
            }
        }
    }

    for (int i=0; i<num_hungry; i++){
        int philosopher_id = hungry_philosophers[i];
        if (states[philosopher_id] == EATING){
            int left_fork = philosopher_id;
            int right_fork = (philosopher_id + 1) % num_philosop
            forks[left_fork] = forks[right_fork] = 0;
            states[philosopher_id] = THINKING;
        }
    }
}

int main(){
    printf("Enter the total number of philosophers
        (max %d): ", MAX_PHILOSOPHERS);
    scanf("%d", &num_philosophers);
    if (num_philosophers < 2 || num_philosophers >
        MAX_PHILOSOPHERS){
```

```
printf ("Invalid number of philosophers. Exiting\n");
return 1;
}

printf ("How many are hungry: ");
scanf ("%d", &num_hungry);
for (int i=0; i<num_hungry; i++) {
    printf ("Enter philosopher %d position: ", i+1);
    int position;
    scanf ("%d", &position);
    hungry_philosophers [i] = position - 1;
    states [hungry_philosophers [i]] = HUNGRY;
}
for (int i=0; i< num_philosophers ; i++){
    forks [i]=0;
}

int choice;
do {
    print_state ();
    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);
    switch (choice) {
        case 1:
            simulate (0);
            break;
        case 2:
            simulate (1);
            break;
```

```
        case 3:
            printf("Exiting\n");
            break;
        case 4:
            printf("
        default:
            printf("Invalid choice. Please try again.\n");
            break;
    }
} while (choice != 3);
return 0;
}
```

*Output:

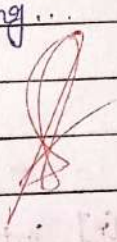
```
Enter the total number of philosophers (max 10): 5
How many are hungry: 3
Enter philosopher 1 position: 1
Enter philosopher 2 position: 3
Enter philosopher 3 position: 5

P1 is waiting
P2 is waiting
P3 is waiting
P4 is waiting
P5 is waiting

1. One can eat at a time
2. Two can eat at a time
3. Exit
Enter your choice: 1
P1 is granted to eat

P1 is thinking
```

P2 is thinking
P3 is waiting.
P4 is thinking
P5 is waiting

1. One can eat at a time
2. Two can eat at a time
3. Exit
Enter your choice: 1
P3 is granted to eat

P1 is thinking
P2 is thinking
P3 is thinking
P4 is thinking
P5 is waiting.

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



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Lab-7

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

```
#include <stdio.h>
int p, r;
void avai(int all[p][r], int tot[r], int avail[r]){
    for (int j=0; j<r; j++){
        avail[j]=0;
        for (int k=0; k<p; k++){
            avail[j] += all[k][j];
        }
    }
    for (int j=0; j<r; j++){
        avail[j] = tot[j] - avail[j];
    }
}

void need(int all[p][r], int max[p][r], int needmat[p][r]){
    for (int i=0; i<p; i++){
        for (int j=0; j<r; j++){
            needmat[i][j] = max[i][j] - all[i][j];
        }
    }
}

void safety(int p, int r, int all[p][r], int avail[r], int needmat[p][r], int seq[p]){
    for (int i=0; i<p; i++){
        f[i]=0;
    }
    while (count<p && h<p){
        for (int i=0; i<p; i++){
            if (f[i]==0){
```

```
c=0)
for (int j=0; j<r ; j++){
  if (need mat [i] [j] <= avail[j]){
    c++;
  }
}
if (c==r){
  printf("P%d is visited (Tt", i);
  for (int k=0; k<r; k++){
    avail[k] += all [i] [k];
    printf ("%d", avail [k]);
    printf ("\t");
  }
  printf("\n");
  f[i]=1;
  count++;
  seq [h]=i;
  h++;
 }
}
}
}
}
int main(){
printf ("Enter the number of processes : ");
scanf ("%d", &p);
printf (" Enter the number of resources : ");
scanf ("%d", &r);
int tot[r], need mat [p] [r], avail [r], seq [p];
printf ("Enter the total instances of each
  resource : ");
for (int i=0 ; i<r; i++){
```

```
    scanf ("%d ", &tot[r]);
}

int all [p][r], max [p][r];
printf ("Enter the details of each process
    (Allocation matrix) : \n");
for (int i=0; i<p; i++){
    for (int j=0; j<r; j++){
        scanf ("%d", &all [i][j]);
    }
}

printf ("Enter the maximum matrix : \n");
for (int i=0; i<p; i++){
    for (int j=0; j<r; j++){
        scanf ("%d ", &max [i][j]);
    }
}

avail (all, tot, avail);
needi (all, max, needmat);

printf ("Need matrix : \n");
for (int i=0; i<p; i++){
    for (int j=0; j<r; j++){
        printf ("%d \t", needmat [i][j]);
    }
    printf ("\n");
}

safety (p, r, all, avail, needmat, seq);
printf ("Safe sequence is: ");
for (int i=0; i<p; i++){
```

```
        printf("P%d", seq[i]);
    }
    return 0;
}
```

* Output :

```
Enter the number of processes: 5
Enter the number of resources: 3
Enter the total instances of each resource: 10 5 7
Enter the details of each process (allocation matrix):
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2
Enter the maximum matrix:
7 5 3
3 2 2
9 0 2
2 2 2
4 3 3
Need matrix:
7 4 3
1 2 2
6 0 0
0 1 1
4 3 1
P1 is visted (5 3 2)
P3 is visited (7 4 3)
P4 is visited (7 4 5)
P0 is visited (7 5 5)
P2 is visited (10 5 7)
Safe sequence is: P1 P3 P4 P0 P2
```

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12) Write a C program to simulate deadlock detection

```
#include <stdio.h>
void main(){
  int n, m, i, j;
  printf("Enter the number of processes and number
      of types of resources:\n");
  scanf("%d %d",&n,&m);
  int max[n][m], need[n][m], all[n][m], ava[m],
  flag=1, finish[n], dead[n], c=0;
  printf("Enter the request number of each type of
      resource needed by each process:\n");
  for(i=0; i<n; i++){
    for(j=0; j<m; j++){
      scanf("%d", &request[i][j]);
    }
  }
  for(i=0; i<n; i++){
    finish[i]=0;
  }
  printf("Enter the number of allocated of each type
   of resource needed by each process:\n");
  for(i=0; i<n; i++){
    for(j=0; j<m; j++){
      scanf("%d", &all[i][j]);
    }
  }
  while(flag){
    flag=0;
    for(i=0; i<n; i++){
      c=0;
      for(j=0; j<m; j++){
        if(finish[i]==0 && request[i][j]<=ava[j]){
          c++;
```

```
if (c==m){
  for (j=0;j<m;j++){
    ava[j] -= request[i][j];
    ava[j]+ = all[i][j];
    Finish[i] = 1;
    flag = 1;
  }
  if (Finish[i]==1){
    i=n;
  }
 }
}
}
}
j=0;
flag=0;
for (i=0; i<n; i++){
  if (Finish[i]==0){
    dead[j] = i;
    j++;
    flag = 1;
  }
}
if (flag==1){
  printf("Deadlock has occured: \n");
  printf("The deadlock processes are: \n");
  for (i=0; i<j; i++){
    printf("P%d", dead[i]);
  }
}
else
  printf("\nNo deadlock has occured!\n");
}
```

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Output:

Enter the number of processes and number of types of resources: 4 3

Enter the allocated number of each type of resource needed by each process:

1 0 2

2 1 1

1 0 3

1 2 2

Enter the available number of each type of resource:

0 0 0

Enter the request number of each type of resource needed by each process:

0 0 1

1 0 2

0 0 0

3 3 0

Deadlock has occured!

The deadlock processes are:

P3.

3/7/24 Lab-9

10) Write a C program to simulate the following CMA techniques a) Worst-fit Best-fit First-fit.

```
#include <stdio.h>
struct Block{
    int block_no;
    int block_size;
    int is_free;
};

struct File{
    int file_no;
    int file_size;
};

void firstFit (struct Block blocks[], int n_blocks,
    struct File files[], int n_files){
    printf("Memory Management Scheme-First Fit\n");
    printf("File no:\tFile_size:\tBlock_no:\tBlock_size:
        \tFragment\n");
    for (int i=0; i<n_files; i++){
      for (int j=0; j<n_blocks; j++){
        if (blocks[j].is_free && blocks[j].block_size>=
            files[i].file_size){
          blocks[j].is_free =0;
          printf("%d\t\t%d\t\t%d\t\t%d\t\t%d\n",
            files[i].file_no, files[i].file_size, blocks[j].
            block_no, blocks[j].block_size);
          break;
        }
      }
    }
}
```

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```
void worstFit(struct Block blocks[], int n_blocks,
    struct File files[], int n_files){
  printf("Memory Management scheme - Worst Fit\n");
  printf("File no : \tFile_size : \t Block_no.\t Block
    size :\t Fragment\n");
  for (int i=0; i<n_files; ++i){
    int worst_fit_block = -1;
    int max_fragment = -1;
    for (int j=0; j<n_blocks; j++){
      if (blocks[j].is_free && blocks[j].block_size>=
          files[i].file_size){
        int fragment = blocks[j].block_size -
            files[i].filesize;
        if (fragment > max_fragment){
          max_fragment = fragment;
          worst_fit_block = j;
        }
      }
    }
    if (worst_fit_block != -1){
      blocks[worst_fit_block].is_free = 0;
      printf("%d\t\t %d\t\t %d\t\t\n", files[i].file
          files[i].filesize, blocks[worst_fit_block].block
          blocks[worst_fit_block].blocksize);
    }
  }
}

void bestFit(struct Block blocks[], int n_blocks,
    struct File files[], int n_files){
  printf("Memory Management scheme - BestFit\n");
  printf("File_no :\tFile_Size:\t Block_no :\t BlockSize
      :\tFragment\n");
```

```
for (int i=0; i<n_files; i++){
    int best_fit_block = -1;
    int min_fragment = 10000;
    for (int j=0; j<n_blocks; j++){
        if (blocks[j].is_free && blocks[j].block_size
            >= files[i].file_size){
            int fragment = fragment;
            best_fit_block = j;
        }
    }
}
if (best_fit_block != -1){
    blocks [best_fit_block]. is_free = 0;
    printf("%d \t\t %d \t\t %d \t\t %d \n",
    files[i].file_no; files[i]. file_size, blocks [
    best_fitblock].block_no, blocks [best_fit_block].
    block_size);
}
}
}

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

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

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

worstFit(blocks, n_blocks, files, n_files);
printf("\n");

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

bestFit(blocks, n_blocks, files, n_files);

return 0;
}
```

Output:

```
Enter the number of blocks: 5
Enter the number of files: 4
Enter the size of block 1: 400
Enter the size of block 2: 700
Enter the size of block 3: 200
Enter the size of block 4: 800
Enter the size of block 5: 600
```

Enter the size of file 1: 212
Enter the size of file 2: 517
Enter the size of file 3: 312
Enter the size of file 4: 526

Memory Management Scheme - First-Fit

File_no:	File_size:	Block_no:	Block_size:	Fragment
1	212	1	400	188
2	517	2	700	183
3	312	5	600	288

Memory Management Scheme - Worst-Fit

File_no:	File_Size:	Block_no:	Block_size:	Fragment
1	212	2	700	488
2	517	5	600	83
3	312	1	400	88

Memory Management Scheme - Best-Fit

File_no:	File_Size:	Block_no:	Block_size:	Fragment
1	212	4	300	88
2	517	5	600	83
3	312	1	400	88
4	526	2	700	174

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10/7/24 Lab-10

14) Write a C program to simulate paging technique of memory management.

```
#include <stdio.h>
#include <limits.h>
#include<stdlib.h>
void print_frames(int frame[], int capacity, int page_faults){
  for (int i=0; i<capacity; i++){
    if (frame[i] == -1)
      printf("- ");
    else
      printf("%d ", frame[i]); }
  if (page_faults>0)
    printf("PF No. %d", page_faults);
  printf("\n");
}
void fifo(int pages[], int n, int capacity){
  int frame[capacity], index=0, page_faults=0;
  for (int i=0; i<capacity; i++)
    frame[i]=-1;
  printf("FIFO Page Replacement Process:\n");
  for (int i=0; i<n; i++){
    int found=0;
    for (int j=0; j<capacity; j++){
      if (frame[j]==pages[i]){
        found=1;
        break; } }
    if (!found){
      frame[index]=pages[i];
      index=(index+1)%capacity;
      page_faults++; }
    print_frames(frame, capacity, found?0:page_faults); }
  printf("Total Page Faults using FIFO: %d\n\n",
  page_faults); }
```

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```
void lru (int pages[], int n, int capacity) {
    int frame[capacity], counter[capacity], time=0,
        page-faults=0;
    for (int i=0 ; ; i<capacity ; i++){
        frame [i]=-1;
        counter [i]=0; }
    printf ("LRU . Page Replacement Process:\n");
    for (int i=0 ; i<n; i++){
        int found =0;
        for (int j=0; j<capacity ; j++){
            if (frame [j] == pages [i]){
                found =1;
                counter [j] =time++;
                break; } }
        if (!found){
            int min = INT_MAX, min_index =-1;
            for (int j=0 ; j<capacity ; j++){
                if (counter [j] <min){
                    min = counter [j];
                    min_index =j; } }
            frame [min_index] = pages [i];
            counter [min_index] = time++;
            page_faults ++; }
        print_frames(frame, capacity, found ? 0 : page_faults); }
    printf ("Total Page Faults using LRU: %d\n\n", page_faults);
void optimal (int pages[], int n, int capacity){
    int frame [capacity], page-faults =0;
    for (int i=0; i<capacity ; i++)
        frame[i]=-1;
    printf ("Optimal Page Replacement Process :\n");
    for (int i=0; i<n; i++){
        int found=0;
        for (int j=0; j<capacity ; j++) {
            if (frame[j] == pages [i]){
```

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```
        found=1;
        break; } }
    if (!found){
        int farthest=i+1, index=-1;
        for (int j=0; j<capacity; j++){
            int k; for (k=i+1; k<n; k++){
                if (frame[j]==pages[k])
                    break; } if (k>farthest){
                        farthest=k; index=j; } }
        if (index==-1){
            for (int j=0; j<capacity; j++){ if (frame[j]==-1)
                {index=j; break; } } }
        frame[index]=pages[i]; page_faults++; }
    print_frames(frame, capacity, found ? 0 : page_faults); }
    printf("Total Page faults using Optimal: %d\n\n", page_faults);}
int main(){
    int n, capacity;
    printf("Enter the number of pages: ");
    scanf("%d", &n);
    int *pages=(int*) malloc(n*sizeof(int));
    printf("Enter the pages: ");
    for (int i=0; i<n; i++) scanf("%d", &pages[i]);
    printf("Enter the frame capacity: ");
    scanf("%d", &capacity);
    printf("\n Pages: ");
    for (int i=0; i<n; i++){
        printf("%d", pages[i]);
    printf("\n\n");
    fifo(pages, n, capacity);
    lru(pages, n, capacity);
    Optimal(pages, n, capacity);
    free(pages);
    return 0;
}
```

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Output:

Enter the no. of pages : 20
Enter the pages : 0 9 0 1 8 1 8 7 8 7 1 2 8 2 7 8 2 3 8 3
Enter the frame capacity : 3
Pages : 0 9 0 1 2 1 8 7 8 7 1 2 8 2 7 8 2 3 8 3

FIFO page Replacement Process :
0 - - PF No. 1
0 9 - PF No. 2
0 9 1 PF No. 3
8 9 1 PF No. 4
8 7 1 PF No. 5
8 7 2 PF No. 6
3 7 2 PF No 7
3 8 2 PF No. 8
Total Page Faults using FIFO : 8

LRU page Replacement Process :
0 - - PF No. 1
9 - - PF No. 2
9 0 - PF No. 3
9 0 1 - PF No. 4
8 0 1 PF No. 5
8 7 1 PF No. 6
2 7 1 PF No. 7
2 8 1 PF No. 8
2 8 7 PF No. 9
2 8 3 PF No. 10
Total Page Faults using LRU : 10.

Optimal Page Replacement Process :
0 - - PF No. 1
0 9 - PF No. 2
1 9 - PF No. 3
1 8 - PF No. 4

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1 8 7 PF No. 5

2 8 7 PF No. 6

3 8 7 PF No. 7

Total Page Faults using Optimal : 7