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LAB REPORT

on

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Submitted by

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CERTIFICATE

This is to certify that the Lab work entitled "OPERATING SYSTEMS – 23CS4PCOPS" carried out by SUPREETH AR (1BM23CS423), 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 The Lab report has been approved as it satisfies the academic requirements in respect of a .2024 .OPERATING SYSTEMS - (23CS4PCOPS) work prescribed for the said degree

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Course Outcome

CO1	Apply the different concepts and functionalities of Operating System
CO2	Analyse 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

Program -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#
} struct Process
int pid;        // Process ID
int burst_time; // Burst time
int arrival_time; // Arrival time
int waiting_time; // Waiting time
int turnaround_time; // Turnaround time
;{
} void findWaitingTime(struct Process proc[], int n)
;int service_time[n]
;service_time[0] = proc[0].arrival_time
;proc[0].waiting_time = 0

} for (int i = 1; i < n; i++)
;service_time[i] = service_time[i-1] + proc[i-1].burst_time
;proc[i].waiting_time = service_time[i] - proc[i].arrival_time
if (proc[i].waiting_time < 0)
;proc[i].waiting_time = 0
{
{
} void findTurnaroundTime(struct Process proc[], int n)
for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{
} void findAverageTime(struct Process proc[], int n)
;int total_waiting_time = 0, total_turnaround_time = 0
;findWaitingTime(proc, n)
;findTurnaroundTime(proc, n)
;printf("Processes  Burst time  Arrival time  Waiting time  Turnaround time\n")
} for (int i = 0; i < n; i++)
```

```
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("        %d    \t\t%d    \t\t%d    \t\t%d    \t\t%d\n",    proc[i].pid,    proc[i].burst_time,
;(proc[i].arrival_time, proc[i].waiting_time, proc[i].turnaround_time
{
;printf("Average waiting time = %.2f\n", (float)total_waiting_time / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / (float)n)
{

} ()int main
;{{2 ,8 ,3} ,{1 ,5 ,2} ,{0 ,10 ,1}} = []struct Process proc
;int n = sizeof(proc) / sizeof(proc[0])

;findAverageTime(proc, n)

;return 0
{
```

Output

```
Processes   Burst time   Arrival time   Waiting time   Turnaround time
   1            10              0              0               10
   2            5               1              9               14
   3            8               2              13              21
Average waiting time = 7.33
Average turnaround time = 15.00
```

SJF (pre-emptive) →

```
<include <stdio.h#
} struct Process
;int pid
;int burst_time
;int arrival_time
;int waiting_time
;int turnaround_time
;{
```

```
} void findWaitingTime(struct Process proc[], int n)
;int complete = 0, t = 0, minm = 10000
;int shortest = 0, finish_time
;int check = 0
;int rt[n]
for (int i = 0; i < n; i++)
;rt[i] = proc[i].burst_time

} while (complete != n)
} for (int j = 0; j < n; j++)
} if ((proc[j].arrival_time <= t) && (rt[j] < minm) && rt[j] > 0)
;minm = rt[j]
;shortest = j
;check = 1
{
{
} if (check == 0)
;++t
;continue
{
;--rt[shortest]
;minm = rt[shortest]
if (minm == 0)
;minm = 10000
} if (rt[shortest] == 0)
;++complete
;check = 0
;finish_time = t + 1
proc[shortest].waiting_time = finish_time - proc[shortest].burst_time -
;proc[shortest].arrival_time
if (proc[shortest].waiting_time < 0)
;proc[shortest].waiting_time = 0
{
;++t
{
```

```
{

} void findTurnaroundTime(struct Process proc[], int n)
for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{

} void findAverageTime(struct Process proc[], int n)
;int total_waiting_time = 0, total_turnaround_time = 0

;findWaitingTime(proc, n)
;findTurnaroundTime(proc, n)

;printf("Processes  Burst time  Arrival time  Waiting time  Turnaround time\n")

} for (int i = 0; i < n; i++)
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("        %d    \t\t%d    \t\t%d    \t\t%d    \t\t%d\n",    proc[i].pid,    proc[i].burst_time,
;(proc[i].arrival_time, proc[i].waiting_time, proc[i].turnaround_time
{

;printf("Average waiting time = %.2f\n", (float)total_waiting_time / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / (float)n)
{

} ()int main
;{{3 ,3 ,4} ,{2 ,7 ,3} ,{1 ,8 ,2} ,{0 ,6 ,1}} = []struct Process proc
;int n = sizeof(proc) / sizeof(proc[0])

;findAverageTime(proc, n)

;return 0
{
```

OUTPUT

```
Processes  Burst time  Arrival time  Waiting time  Turnaround time
   1           6           0             0              6
   2           8           1             15             23
   3           7           2             7              14
   4           3           3             3              6
Average waiting time = 6.25
Average turnaround time = 12.25
```

SJF (Non-preemptive) →

```
<include <stdio.h#
} struct Process
;int pid
;int burst_time
;int arrival_time
;int waiting_time
;int turnaround_time
;{
} void findWaitingTime(struct Process proc[], int n)
;int rt[n]
for (int i = 0; i < n; i++)
;rt[i] = proc[i].burst_time
;int complete = 0, t = 0, minm = 10000
;int shortest = 0, finish_time
;int check = 0
} while (complete != n)
} for (int j = 0; j < n; j++)
} if ((proc[j].arrival_time <= t) && (rt[j] < minm) && rt[j] > 0)
;minm = rt[j]
;shortest = j
;check = 1
```

```
{
{
} if (check == 0)
;++t
;continue
{
;--rt[shortest]
;minm = rt[shortest]
if (minm == 0)
;minm = 10000
} if (rt[shortest] == 0)
;++complete
;check = 0
;finish_time = t + 1
proc[shortest].waiting_time = finish_time - proc[shortest].burst_time -
;proc[shortest].arrival_time
if (proc[shortest].waiting_time < 0)
;proc[shortest].waiting_time = 0
{
;++t
{
{

} void findTurnaroundTime(struct Process proc[], int n)
for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{

} void findAverageTime(struct Process proc[], int n)
;int total_waiting_time = 0, total_turnaround_time = 0

;findWaitingTime(proc, n)
;findTurnaroundTime(proc, n)

;printf("Processes  Burst time  Arrival time  Waiting time  Turnaround time\n")
```

```
} for (int i = 0; i < n; i++)
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("          %d    \t\t%d    \t\t%d    \t\t%d    \t\t%d\n",    proc[i].pid,    proc[i].burst_time,
;(proc[i].arrival_time, proc[i].waiting_time, proc[i].turnaround_time
{

;printf("Average waiting time = %.2f\n", (float)total_waiting_time / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / (float)n)
{

} ()int main
;{{3 ,3 ,4} ,{2 ,7 ,3} ,{1 ,8 ,2} ,{0 ,6 ,1}} = []struct Process proc
;int n = sizeof(proc) / sizeof(proc[0])

;findAverageTime(proc, n)

;return 0
{
```

```
Processes  Burst time  Arrival time  Waiting time  Turnaround time
   1          6            0             0              6
   2          8            1             15             23
   3          7            2             7              14
   4          3            3             3              6
Average waiting time = 6.25
Average turnaround time = 12.25
```

Program-2

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

Priority (pre-emptive) →

```
<include <stdio.h#
} struct Process
;int pid
;int burst_time
;int arrival_time
;int priority
;int waiting_time
;int turnaround_time
;{

} void findWaitingTime(struct Process proc[], int n)
;int rt[n]
for (int i = 0; i < n; i++)
;rt[i] = proc[i].burst_time

;int complete = 0, t = 0, minm = 10000
;int shortest = 0, finish_time
;int check = 0

} while (complete != n)
} for (int j = 0; j < n; j++)
} if ((proc[j].arrival_time <= t) && (proc[j].priority < minm) && rt[j] > 0)
;minm = proc[j].priority
```

```
;shortest = j
;check = 1
{
{
} if (check == 0)
;++t
;continue
{
;--rt[shortest]
;minm = proc[shortest].priority
} if (rt[shortest] == 0)
;++complete
;check = 0
;finish_time = t + 1
proc[shortest].waiting_time = finish_time - proc[shortest].burst_time -
;proc[shortest].arrival_time
if (proc[shortest].waiting_time < 0)
;proc[shortest].waiting_time = 0
;minm = 10000
{
;++t
{
{

} void findTurnaroundTime(struct Process proc[], int n)
for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{

} void findAverageTime(struct Process proc[], int n)
;int total_waiting_time = 0, total_turnaround_time = 0

;findWaitingTime(proc, n)
;findTurnaroundTime(proc, n)
```

```
;printf("Processes  Burst time  Arrival time  Priority  Waiting time  Turnaround time\n")

} for (int i = 0; i < n; i++)
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("       %d   \t\t%d   \t\t%d   \t\t%d   \t\t%d   \t\t%d\n",   proc[i].pid,   proc[i].burst_time,
;(proc[i].arrival_time, proc[i].priority, proc[i].waiting_time, proc[i].turnaround_time
{

;printf("Average waiting time = %.2f\n", (float)total_waiting_time / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / (float)n)
{

} ()int main
;{{2 ,3 ,3 ,4} ,{3 ,2 ,7 ,3} ,{1 ,1 ,8 ,2} ,{2 ,0 ,6 ,1}} = []struct Process proc
;int n = sizeof(proc) / sizeof(proc[0])

;findAverageTime(proc, n)

;return 0
{
```

```
Processes  Burst time  Arrival time  Priority  Waiting time  Turnaround time
   1           6            0            2           8              14
   2           8            1            1           0              8
   3           7            2            3           15             22
   4           3            3            2           11             14
Average waiting time = 8.50
Average turnaround time = 14.50
```

Priority (Non-preemptive) →

```
<include <stdio.h#

} struct Process
;int pid
;int burst_time
;int arrival_time
;int priority
```

```
;int waiting_time
;int turnaround_time
;{

} void findWaitingTime(struct Process proc[], int n)
;int completed[n]
for (int i = 0; i < n; i++)
;completed[i] = 0

;int t = 0
;int completed_count = 0

} while (completed_count < n)
;int min_priority = 10000
;int idx = -1
} for (int i = 0; i < n; i++)
} if (proc[i].arrival_time <= t && !completed[i] && proc[i].priority < min_priority)
;min_priority = proc[i].priority
;idx = i
{
{

} if (idx != -1)
;t += proc[idx].burst_time
;proc[idx].waiting_time = t - proc[idx].burst_time - proc[idx].arrival_time
if (proc[idx].waiting_time < 0)
;proc[idx].waiting_time = 0
;completed[idx] = 1
;++completed_count
} else {
;++t
{
{
{
```

```
} void findTurnaroundTime(struct Process proc[], int n)
for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{

} void findAverageTime(struct Process proc[], int n)
;int total_waiting_time = 0, total_turnaround_time = 0

;findWaitingTime(proc, n)
;findTurnaroundTime(proc, n)

;printf("Processes  Burst time  Arrival time  Priority  Waiting time  Turnaround time\n")

} for (int i = 0; i < n; i++)
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("      %d  \t\t%d  \t\t%d  \t\t%d  \t\t%d  \t\t%d\n",  proc[i].pid,  proc[i].burst_time,
;(proc[i].arrival_time, proc[i].priority, proc[i].waiting_time, proc[i].turnaround_time
{

;printf("Average waiting time = %.2f\n", (float)total_waiting_time / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / (float)n)
{

} ()int main
;{{2 ,3 ,3 ,4} ,{3 ,2 ,7 ,3} ,{1 ,1 ,8 ,2} ,{2 ,0 ,6 ,1}} = []struct Process proc
;int n = sizeof(proc) / sizeof(proc[0])

;findAverageTime(proc, n)

;return 0
{
```

```
Processes  Burst time  Arrival time  Priority  Waiting time  Turnaround time
   1           6             0           2            0              6
   2           8             1           1            5              13
   3           7             2           3            15             22
   4           3             3           2            11             14
Average waiting time = 7.75
Average turnaround time = 13.75
```

Round Robin (Experiment with different quantum sizes for RR → (algorithm

```
<include <stdio.h#

} struct Process
;int pid
;int burst_time
;int arrival_time
;int priority
;int waiting_time
;int turnaround_time
;{

} void findWaitingTime(struct Process proc[], int n)
;int completed[n]
for (int i = 0; i < n; i++)
;completed[i] = 0

;int t = 0
;int completed_count = 0

} while (completed_count < n)
;int min_priority = 10000
;int idx = -1
} for (int i = 0; i < n; i++)
} if (proc[i].arrival_time <= t && !completed[i] && proc[i].priority < min_priority)
```

```
;min_priority = proc[i].priority
;idx = i
{
{

} if (idx != -1)
;t += proc[idx].burst_time
;proc[idx].waiting_time = t - proc[idx].burst_time - proc[idx].arrival_time
if (proc[idx].waiting_time < 0)
;proc[idx].waiting_time = 0
;completed[idx] = 1
;++completed_count
} else {
;++t
{
{
{

} void findTurnaroundTime(struct Process proc[], int n)
for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{

} void findAverageTime(struct Process proc[], int n)
;int total_waiting_time = 0, total_turnaround_time = 0

;findWaitingTime(proc, n)
;findTurnaroundTime(proc, n)

;printf("Processes  Burst time  Arrival time  Priority  Waiting time  Turnaround time\n")

} for (int i = 0; i < n; i++)
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("      %d  \t\t%d  \t\t%d  \t\t%d  \t\t%d  \t\t%d\n",  proc[i].pid,  proc[i].burst_time,
```

```
;(proc[i].arrival_time, proc[i].priority, proc[i].waiting_time, proc[i].turnaround_time
{

;printf("Average waiting time = %.2f\n", (float)total_waiting_time / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / (float)n)
{

} ()int main
;{{2 ,3 ,3 ,4} ,{3 ,2 ,7 ,3} ,{1 ,1 ,8 ,2} ,{2 ,0 ,6 ,1}} = []struct Process proc
;int n = sizeof(proc) / sizeof(proc[0])

;findAverageTime(proc, n)

;return 0
{
```

```
Processes  Burst time  Arrival time  Priority  Waiting time  Turnaround time
   1           6             0            2            0              6
   2           8             1            1            5             13
   3           7             2            3           15             22
   4           3             3            2           11             14
Average waiting time = 7.75
Average turnaround time = 13.75
```

Program 3

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

```
<include <stdio.h#
define MAX_PROCESSES 100#
} struct Process
;int pid
;int burst_time
;int arrival_time
;int waiting_time
;int turnaround_time
int is_system_process; // 1 for system process, 0 for user process
;{

} void sortProcessesByArrival(struct Process proc[], int n)
;struct Process temp
} for (int i = 0; i < n - 1; i++)
} for (int j = i + 1; j < n; j++)
} if (proc[i].arrival_time > proc[j].arrival_time)
;temp = proc[i]
;proc[i] = proc[j]
;proc[j] = temp
{
{
{
{

} void calculateWaitingTime(struct Process proc[], int n)
;int current_time = 0
```

```
} for (int i = 0; i < n; i++)
} if (current_time < proc[i].arrival_time)
;current_time = proc[i].arrival_time
{
;proc[i].waiting_time = current_time - proc[i].arrival_time
;current_time += proc[i].burst_time
{
{

} void calculateTurnaroundTime(struct Process proc[], int n)
} for (int i = 0; i < n; i++)
;proc[i].turnaround_time = proc[i].burst_time + proc[i].waiting_time
{
{

} void printProcesses(struct Process proc[], int n)
;int total_waiting_time = 0
;int total_turnaround_time = 0

;printf("Processes  Burst time  Arrival time  Waiting time  Turnaround time  Type\n")
} for (int i = 0; i < n; i++)
;total_waiting_time += proc[i].waiting_time
;total_turnaround_time += proc[i].turnaround_time
printf("      %d   \t\t%d   \t\t%d   \t\t%d   \t\t%d   \t\t%s\n",   proc[i].pid,   proc[i].burst_time,
proc[i].arrival_time, proc[i].waiting_time, proc[i].turnaround_time, proc[i].is_system_process ?
;("System" : "User"
{

;printf("Average waiting time = %.2f\n", (float)total_waiting_time / n)
;printf("Average turnaround time = %.2f\n", (float)total_turnaround_time / n)
{

} ()int main
;struct Process proc[MAX_PROCESSES]
;int n
```

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

} for (int i = 0; i < n; i++)
printf("Enter process ID, burst time, arrival time, and type (1 for system, 0 for user) for
;(process %d: ", i + 1
scanf("%d %d %d %d", &proc[i].pid, &proc[i].burst_time, &proc[i].arrival_time,
;(proc[i].is_system_process&
{

;struct Process system_queue[MAX_PROCESSES]
;struct Process user_queue[MAX_PROCESSES]
;int system_count = 0, user_count = 0

} for (int i = 0; i < n; i++)
} if (proc[i].is_system_process)
;system_queue[system_count++] = proc[i]
} else {
;user_queue[user_count++] = proc[i]
{
{

;sortProcessesByArrival(system_queue, system_count)
;sortProcessesByArrival(user_queue, user_count)

;printf("\nSystem Queue:\n")
;calculateWaitingTime(system_queue, system_count)
;calculateTurnaroundTime(system_queue, system_count)
;printProcesses(system_queue, system_count)

;printf("\nUser Queue:\n")
;calculateWaitingTime(user_queue, user_count)
;calculateTurnaroundTime(user_queue, user_count)
;printProcesses(user_queue, user_count)
```

```
;return 0
{
```

```
Enter the number of processes: 3
Enter process ID, burst time, arrival time, and type (1 for system, 0 for user) for process 1: 1 3 1 0
Enter process ID, burst time, arrival time, and type (1 for system, 0 for user) for process 2: 2 4 2 1
Enter process ID, burst time, arrival time, and type (1 for system, 0 for user) for process 3: 3 4 2 0

System Queue:
Processes  Burst time  Arrival time  Waiting time  Turnaround time  Type
   2           4            2              0              4              System
Average waiting time = 0.00
Average turnaround time = 4.00

User Queue:
Processes  Burst time  Arrival time  Waiting time  Turnaround time  Type
   1           3            1              0              3              User
   3           4            2              2              6              User
Average waiting time = 1.00
Average turnaround time = 4.50
```

Program 4
:Write a C program to simulate Real-Time CPU Scheduling algorithms
Rate- Monotonic →

```
<include <stdio.h#

} void findWaitingTime(int processes[], int n, int bt[], int wt[], int period[])
;0 = ]0[wt
} for (int i = 1; i < n; i++)
;wt[i] = bt[i - 1] + wt[i - 1]
{
{
} void findTurnAroundTime(int processes[], int n, int bt[], int wt[], int tat[])
} for (int i = 0; i < n; i++)
;tat[i] = bt[i] + wt[i]
{
{
} void findAvgTime(int processes[], int n, int bt[], int period[])
```

```
;int wt[n], tat[n]
;findWaitingTime(processes, n, bt, wt, period)
;findTurnAroundTime(processes, n, bt, wt, tat)

;printf("Processes   Burst time   Waiting time   Turnaround time   Period\n")
} for (int i = 0; i < n; i++)
;printf(" %d ", (i + 1))
;printf("          %d ", bt[i])
;printf("          %d ", wt[i])
;printf("          %d ", tat[i])
;printf("                 %d\n", period[i])
{
;int total_wt = 0, total_tat = 0
} for (int i = 0; i < n; i++)
;total_wt += wt[i]
;total_tat += tat[i]
{
;printf("Average waiting time = %.2f\n", (float)total_wt / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_tat / (float)n)
{
} void rateMonotonicScheduling(int processes[], int n, int bt[], int period[])
Sort by period //
} for (int i = 0; i < n - 1; i++)
} for (int j = 0; j < n - i - 1; j++)
} if (period[j] > period[j + 1])
;int temp = period[j]
;period[j] = period[j + 1]
;period[j + 1] = temp
;temp = bt[j]
;bt[j] = bt[j + 1]
;bt[j + 1] = temp
;temp = processes[j]
;processes[j] = processes[j + 1]
;processes[j + 1] = temp
{
{
{

;findAvgTime(processes, n, bt, period)
{

} ()int main
;{3 ,2 ,1} = []int processes
;int n = sizeof(processes) / sizeof(processes[0])
;{2 ,1 ,3} = []int burst_time
;{5 ,4 ,7} = []int period
```

```
;rateMonotonicScheduling(processes, n, burst_time, period)
;return 0
{
```

```
Processes    Burst time    Waiting time    Turnaround time    Period
 1            1             0              1                   4
 2            2             1              3                   5
 3            3             3              6                   7
Average waiting time = 1.33
Average turnaround time = 3.33
```

Earliest-deadline First →

```
<include <stdio.h#

} void findWaitingTime(int processes[], int n, int bt[], int wt[], int deadline[])
;0 = ]0[wt
} for (int i = 1; i < n; i++)
;wt[i] = bt[i - 1] + wt[i - 1]
{
{

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

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

;printf("Processes   Burst time   Waiting time   Turnaround time   Deadline\n")
} for (int i = 0; i < n; i++)
;printf(" %d ", (i + 1))
;printf("          %d ", bt[i])
;printf("          %d ", wt[i])
;printf("          %d ", tat[i])
;printf("              %d\n", deadline[i])
{

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

```
;printf("Average waiting time = %.2f\n", (float)total_wt / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_tat / (float)n)
{

} void earliestDeadlineFirstScheduling(int processes[], int n, int bt[], int deadline[])
Sort by deadline //
} for (int i = 0; i < n - 1; i++)
} for (int j = 0; j < n - i - 1; j++)
} if (deadline[j] > deadline[j + 1])
;int temp = deadline[j]
;deadline[j] = deadline[j + 1]
;deadline[j + 1] = temp
;temp = bt[j]
;bt[j] = bt[j + 1]
;bt[j + 1] = temp
;temp = processes[j]
;processes[j] = processes[j + 1]
;processes[j + 1] = temp
{
{
{

;findAvgTime(processes, n, bt, deadline)
{

} ()int main
;{3 ,2 ,1} = []int processes
;int n = sizeof(processes) / sizeof(processes[0])
;{2 ,1 ,3} = []int burst_time
;{5 ,4 ,7} = []int deadline

;earliestDeadlineFirstScheduling(processes, n, burst_time, deadline)
;return 0
{
```

```
Processes    Burst time   Waiting time   Turnaround time   Ratio
 1            3            0              3                 0.50
 2            2            3              5                 0.30
 3            1            5              6                 0.20
Average waiting time = 2.67
Average turnaround time = 4.67
```

Proportional scheduling →

```
<include <stdio.h#
```

```
} void findWaitingTime(int processes[], int n, int bt[], int wt[], float ratio[])
;0 = ]0[wt
} for (int i = 1; i < n; i++)
;wt[i] = bt[i - 1] + wt[i - 1]
{
{
} void findTurnAroundTime(int processes[], int n, int bt[], int wt[], int tat[])
} for (int i = 0; i < n; i++)
;tat[i] = bt[i] + wt[i]
{
{

} void findAvgTime(int processes[], int n, int bt[], float ratio[])
;int wt[n], tat[n]
;findWaitingTime(processes, n, bt, wt, ratio)
;findTurnAroundTime(processes, n, bt, wt, tat)

;printf("Processes   Burst time   Waiting time   Turnaround time   Ratio\n")
} for (int i = 0; i < n; i++)
;printf(" %d ", (i + 1))
;printf("          %d ", bt[i])
;printf("          %d ", wt[i])
;printf("          %d ", tat[i])
;printf("              %.2f\n", ratio[i])
{

;int total_wt = 0, total_tat = 0
} for (int i = 0; i < n; i++)
;total_wt += wt[i]
;total_tat += tat[i]
{
;printf("Average waiting time = %.2f\n", (float)total_wt / (float)n)
;printf("Average turnaround time = %.2f\n", (float)total_tat / (float)n)
{

} void proportionalScheduling(int processes[], int n, int bt[], float ratio[])
} for (int i = 0; i < n - 1; i++)
} for (int j = 0; j < n - i - 1; j++)
} if (ratio[j] < ratio[j + 1])
;float temp = ratio[j]
;ratio[j] = ratio[j + 1]
;ratio[j + 1] = temp
;int temp_bt = bt[j]
;bt[j] = bt[j + 1]
;bt[j + 1] = temp_bt
```

```
;int temp_proc = processes[j]
;processes[j] = processes[j + 1]
;processes[j + 1] = temp_proc
{
{
{
;findAvgTime(processes, n, bt, ratio)
{
} ()int main
;{3 ,2 ,1} = []int processes
;int n = sizeof(processes) / sizeof(processes[0])
;{2 ,1 ,3} = []int burst_time
float ratio[] = {0.5, 0.2, 0.3}; // Example ratios

;proportionalScheduling(processes, n, burst_time, ratio)
;return 0
{
```

```
 Processes    Burst time    Waiting time    Turnaround time    Ratio
  1            3             0               3                 0.50
  2            2             3               5                 0.30
  3            1             5               6                 0.20
 Average waiting time = 2.67
 Average turnaround time = 4.67
```

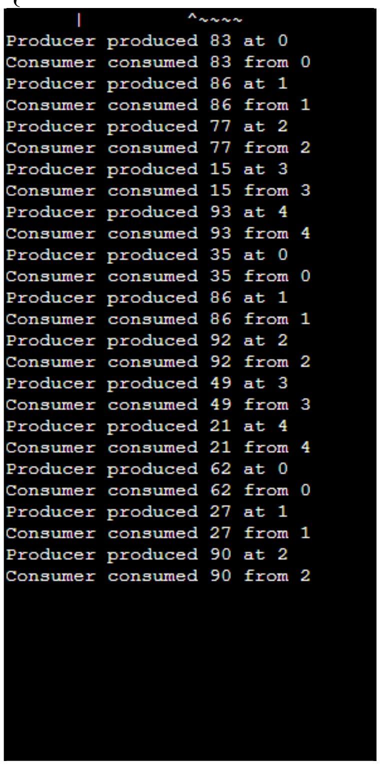
Program 5

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

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

define BUFFER_SIZE 5#
;int buffer[BUFFER_SIZE]
;int in = 0, out = 0

;sem_t empty
;sem_t full
;pthread_mutex_t mutex
```

```
} void *producer(void *param)
;int item
} (1) while
;100 % )(item = rand
 ;sem_wait(&empty)
;pthread_mutex_lock(&mutex)

;buffer[in] = item
;printf("Producer produced %d at %d\n", item, in)
;in = (in + 1) % BUFFER_SIZE

;pthread_mutex_unlock(&mutex)
 ;sem_post(&full)
 ;(1)sleep
{
{

} void *consumer(void *param)
;int item
} (1) while
 ;sem_wait(&full)
 ;pthread_mutex_lock(&mutex)

;item = buffer[out]
;printf("Consumer consumed %d from %d\n", item, out)
;out = (out + 1) % BUFFER_SIZE

 ;pthread_mutex_unlock(&mutex)
 ;sem_post(&empty)
 ;(1)sleep
{
{

} ()int main
;pthread_t tid1, tid2
;pthread_attr_t attr

;pthread_attr_init(&attr)
;pthread_mutex_init(&mutex, NULL)
;sem_init(&empty, 0, BUFFER_SIZE)
;sem_init(&full, 0, 0)

;pthread_create(&tid1, &attr, producer, NULL)
;pthread_create(&tid2, &attr, consumer, NULL)

;pthread_join(tid1, NULL)
```

```
;pthread_join(tid2, NULL)

;pthread_mutex_destroy(&mutex)
;sem_destroy(&empty)
;sem_destroy(&full)

;return 0
{
```



```
      |          ^~~~~
Producer produced 83 at 0
Consumer consumed 83 from 0
Producer produced 86 at 1
Consumer consumed 86 from 1
Producer produced 77 at 2
Consumer consumed 77 from 2
Producer produced 15 at 3
Consumer consumed 15 from 3
Producer produced 93 at 4
Consumer consumed 93 from 4
Producer produced 35 at 0
Consumer consumed 35 from 0
Producer produced 86 at 1
Consumer consumed 86 from 1
Producer produced 92 at 2
Consumer consumed 92 from 2
Producer produced 49 at 3
Consumer consumed 49 from 3
Producer produced 21 at 4
Consumer consumed 21 from 4
Producer produced 62 at 0
Consumer consumed 62 from 0
Producer produced 27 at 1
Consumer consumed 27 from 1
Producer produced 90 at 2
Consumer consumed 90 from 2
```

Program 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#

 define N#
;sem_t forks[N]
;sem_t mutex

} void *philosopher(void *num)
;int id = *(int *)num
} (1) while
;printf("Philosopher %d is thinking.\n", id)
```

```
 ;(1)sleep

 ;sem_wait(&mutex)
;sem_wait(&forks[id])
;sem_wait(&forks[(id + 1) % N])

;printf("Philosopher %d is eating.\n", id)
 ;(1)sleep

sem_post(&forks[id]); // Put down chopsticks
;sem_post(&forks[(id + 1) % N])
;sem_post(&mutex)

;printf("Philosopher %d is done eating and starts thinking again.\n", id)
 ;(1)sleep
{
{

} ()int main
;pthread_t tid[N]
;int ids[N]

 ;sem_init(&mutex, 0, 1)

} for (int i = 0; i < N; i++)
 ;sem_init(&forks[i], 0, 1)
;ids[i] = i
{

} for (int i = 0; i < N; i++)
;pthread_create(&tid[i], NULL, philosopher, &ids[i])
{

} for (int i = 0; i < N; i++)
;pthread_join(tid[i], NULL)
{

} for (int i = 0; i < N; i++)
;sem_destroy(&forks[i])
{
;sem_destroy(&mutex)

;return 0
{
```

```
Philosopher 0 is thinking.
Philosopher 1 is thinking.
Philosopher 2 is thinking.
Philosopher 3 is thinking.
Philosopher 4 is thinking.
Philosopher 0 is eating.
Philosopher 0 is done eating and starts thinking again.
Philosopher 1 is eating.
Philosopher 0 is thinking.
Philosopher 1 is done eating and starts thinking again.
Philosopher 2 is eating.
Philosopher 3 is eating.
Philosopher 2 is done eating and starts thinking again.
Philosopher 1 is thinking.
Philosopher 2 is thinking.
Philosopher 4 is eating.
Philosopher 3 is done eating and starts thinking again.
Philosopher 3 is thinking.
Philosopher 0 is eating.
Philosopher 4 is done eating and starts thinking again.
Philosopher 4 is thinking.
Philosopher 1 is eating.
Philosopher 0 is done eating and starts thinking again.
Philosopher 1 is done eating and starts thinking again.
Philosopher 2 is eating.
Philosopher 0 is thinking.
Philosopher 2 is done eating and starts thinking again.
Philosopher 1 is thinking.
Philosopher 3 is eating.
Philosopher 2 is thinking.
Philosopher 4 is eating.
Philosopher 3 is done eating and starts thinking again.
```

Program 7

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

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

define MAX_PROCESSES 5#
define MAX_RESOURCES 3#

} ()int main
;int n, m, i, j, k
```

```
 ;n = 5
 ;m = 3

,{ 0 ,1 ,0 { { = int alloc[MAX_PROCESSES][MAX_RESOURCES]
,{ 0 ,0 ,2 }
,{ 2 ,0 ,3 }
,{ 1 ,1 ,2 }
;{ { 2 ,0 ,0 }

,{ 3 ,5 ,7 { { = int max[MAX_PROCESSES][MAX_RESOURCES]
,{ 2 ,2 ,3 }
,{ 2 ,0 ,9 }
,{ 2 ,2 ,2 }
;{ { 3 ,3 ,4 }

 ;{ 2 ,3 ,3 } = int avail[MAX_RESOURCES]
;int f[MAX_PROCESSES], ans[MAX_PROCESSES], ind = 0
} for (k = 0; k < n; k++)
;f[k] = 0
{

;int need[MAX_PROCESSES][MAX_RESOURCES]
} for (i = 0; i < n; i++)
} for (j = 0; j < m; j++)
;need[i][j] = max[i][j] - alloc[i][j]
{
{
;printf("Need matrix:\n")
} for (i = 0; i < n; i++)
} for (j = 0; j < m; j++)
;printf("%d ", need[i][j])
{
;printf("\n")
{
;int y = 0
} for (k = 0; k < n; k++)
} for (i = 0; i < n; i++)
} if (f[i] == 0)
;bool flag = true
} for (j = 0; j < m; j++)
} if (need[i][j] > avail[j])
;flag = false
;break
{   {
} if (flag)
;ans[ind++] = i
```

```
} for (y = 0; y < m; y++)
;avail[y] += alloc[i][y]
{
;f[i] = 1
{
{
{
{
;printf("Following is the SAFE Sequence:\n")
} for (i = 0; i < n - 1; i++)
;printf(" P%d ->", ans[i])
{
;printf(" P%d\n", ans[n - 1])

;return 0
{
```

```
Need matrix:
7 4 3
1 2 2
6 0 0
0 1 1
4 3 1
Following is the SAFE Sequence:
 P1 -> P3 -> P4 -> P0 -> P2
```

Program 8
Write a C program to simulate deadlock detection

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

define MAX_PROCESSES 5#
define MAX_RESOURCES 3#

void printMatrices(int processes, int resources, int
alloc[MAX_PROCESSES][MAX_RESOURCES], int
max[MAX_PROCESSES][MAX_RESOURCES], int
} (need[MAX_PROCESSES][MAX_RESOURCES], int avail[MAX_RESOURCES]
;printf("Allocation Matrix:\n")
} for (int i = 0; i < processes; i++)
} for (int j = 0; j < resources; j++)
```

```
;printf("%d ", alloc[i][j])
{
;printf("\n")
{

;printf("\nMax Matrix:\n")
} for (int i = 0; i < processes; i++)
} for (int j = 0; j < resources; j++)
;printf("%d ", max[i][j])
{
;printf("\n")
{

;printf("\nNeed Matrix:\n")
} for (int i = 0; i < processes; i++)
} for (int j = 0; j < resources; j++)
;printf("%d ", need[i][j])
{
;printf("\n")
{

;printf("\nAvailable Resources:\n")
} for (int i = 0; i < resources; i++)
;printf("%d ", avail[i])
{
;printf("\n")
{

void deadlockDetection(int processes, int resources, int
alloc[MAX_PROCESSES][MAX_RESOURCES], int
} (max[MAX_PROCESSES][MAX_RESOURCES], int avail[MAX_RESOURCES]
;int need[MAX_PROCESSES][MAX_RESOURCES]
;int work[MAX_RESOURCES]
;bool finish[MAX_PROCESSES]

} for (int i = 0; i < processes; i++)
} for (int j = 0; j < resources; j++)
;need[i][j] = max[i][j] - alloc[i][j]
{
{

;printMatrices(processes, resources, alloc, max, need, avail)
} for (int i = 0; i < resources; i++)
;work[i] = avail[i]
{
} for (int i = 0; i < processes; i++)
```

```
;finish[i] = false
{
;bool found
} do
;found = false
} for (int i = 0; i < processes; i++)
} if (!finish[i])
;bool flag = true
} for (int j = 0; j < resources; j++)
} if (need[i][j] > work[j])
;flag = false
;break
{
{

} if (flag)
;printf("\nProcess %d can be satisfied and is now finishing.\n", i)
} for (int k = 0; k < resources; k++)
;work[k] += alloc[i][k]
{
;finish[i] = true
;found = true

;printf("New Available Resources:\n")
} for (int k = 0; k < resources; k++)
;printf("%d ", work[k])
{
;printf("\n")
{
{
{
;while (found( {
;bool deadlock = false
;printf("\nDeadlock Check:\n")
} for (int i = 0; i < processes; i++)
} if (!finish[i])
;deadlock = true
;printf("Process %d is in a deadlock.\n", i)
{
{
} if (!deadlock)
;printf("No deadlock detected.\n")
{
{
} ()int main
;int processes = 5
```

```
;int resources = 3

} = int alloc[MAX_PROCESSES][MAX_RESOURCES]
 ,{ 0 ,1 ,0 }
 ,{ 0 ,0 ,2 }
 ,{ 2 ,0 ,3 }
 ,{ 1 ,1 ,2 }
  { 2 ,0 ,0 }
;{
} = int max[MAX_PROCESSES][MAX_RESOURCES]
 ,{ 3 ,5 ,7 }
 ,{ 2 ,2 ,3 }
 ,{ 2 ,0 ,9 }
 ,{ 2 ,2 ,2 }
  { 3 ,3 ,4 }
;{
int avail[MAX_RESOURCES] = { 3, 3, 2 }; // Available resources
;deadlockDetection(processes, resources, alloc, max, avail)
 ;return 0
{
```

:OUTPUT

```
Allocation Matrix:
0 1 0
2 0 0
3 0 2
2 1 1
0 0 2

Max 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

Available Resources:
3 3 2
```

Program 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#

```
<include <stdlib.h#

define MAX 25#

} void firstFit(int nb, int nf, int b[], int f[])
;int allocation[MAX]
 ;{0} = int allocated[MAX]
} for (int i = 0; i < nf; i++)
 ;allocation[i] = -1
} for (int j = 0; j < nb; j++)
} if (allocated[j] == 0 && b[j] >= f[i])
;allocation[i] = j
;allocated[j] = 1
;break
{
{
{

;printf("\nFile_no:\tFile_size:\tBlock_no:\tBlock_size:")
} for (int i = 0; i < nf; i++)
if (allocation[i] != -1)
;printf("\n%d\t\t%d\t\t%d\t\t%d", i + 1, f[i], allocation[i] + 1, b[allocation[i]])
else
;printf("\n%d\t\t%d\t\t-\t\t-", i + 1, f[i])
{
{

} void bestFit(int nb, int nf, int b[], int f[])
;int allocation[MAX]
 ;{0} = int allocated[MAX]
} for (int i = 0; i < nf; i++)
;int bestIdx = -1
 ;allocation[i] = -1
} for (int j = 0; j < nb; j++)
} if (allocated[j] == 0 && b[j] >= f[i])
if (bestIdx == -1 || b[j] < b[bestIdx])
;bestIdx = j
{
{
} if (bestIdx != -1)
;allocation[i] = bestIdx
;allocated[bestIdx] = 1
{
{

;printf("\nFile_no:\tFile_size:\tBlock_no:\tBlock_size:")
```

```
} for (int i = 0; i < nf; i++)
if (allocation[i] != -1)
;printf("\n%d\t\t%d\t\t%d\t\t%d", i + 1, f[i], allocation[i] + 1, b[allocation[i]])
else
;printf("\n%d\t\t%d\t\t-\t\t-", i + 1, f[i])
{
{

} void worstFit(int nb, int nf, int b[], int f[])
;int allocation[MAX]
 ;{0} = int allocated[MAX]

} for (int i = 0; i < nf; i++)
;int worstIdx = -1
 ;allocation[i] = -1
} for (int j = 0; j < nb; j++)
} if (allocated[j] == 0 && b[j] >= f[i])
if (worstIdx == -1 || b[j] > b[worstIdx])
;worstIdx = j
{
{
} if (worstIdx != -1)
;allocation[i] = worstIdx
;allocated[worstIdx] = 1
{
{

;printf("\nFile_no:\tFile_size:\tBlock_no:\tBlock_size:")
} for (int i = 0; i < nf; i++)
if (allocation[i] != -1)
;printf("\n%d\t\t%d\t\t%d\t\t%d", i + 1, f[i], allocation[i] + 1, b[allocation[i]])
else
;printf("\n%d\t\t%d\t\t-\t\t-", i + 1, f[i])
{
{

} ()int main
;int nb, nf, choice

;printf("Memory Management Scheme")
;printf("\nEnter the number of blocks: ")
;scanf("%d", &nb)
;printf("Enter the number of files: ")
;scanf("%d", &nf)
;int b[nb], f[nf]
;printf("\nEnter the size of the blocks:\n")
```

```
} for (int i = 0; i < nb; i++)
;printf("Block %d: ", i + 1)
;scanf("%d", &b[i])
{
;printf("Enter the size of the files:\n")
} for (int i = 0; i < nf; i++)
;printf("File %d: ", i + 1)
;scanf("%d", &f[i])
{

} (1) while
;printf("\n1. First Fit\n2. Best Fit\n3. Worst Fit\n4. Exit\n")
;printf("Enter your choice: ")
;scanf("%d", &choice)
} switch (choice)
:case 1
;printf("\n\tMemory Management Scheme - First Fit\n")
;firstFit(nb, nf, b, f)
;break
:case 2
;printf("\n\tMemory Management Scheme - Best Fit\n")
;bestFit(nb, nf, b, f)
;break
:case 3
;printf("\n\tMemory Management Scheme - Worst Fit\n")
;worstFit(nb, nf, b, f)
;break
:case 4
;printf("\nExiting...\n")
;(0)exit
;break
:default
;printf("\nInvalid choice.\n")
;break
{
{

;return 0
{
```

:OUTPUT

```
Memory Management Scheme
Enter the number of blocks: 5
Enter the number of files: 4

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

```
1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 1

        Memory Management Scheme - First Fit

File_no:        File_size:      Block_no:       Block_size:
1               212             2               500
2               417             5               600
3               112             3               200
4               426             -               -
1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 2

        Memory Management Scheme - Best Fit

File_no:        File_size:      Block_no:       Block_size:
1               212             4               300
2               417             2               500
3               112             3               200
4               426             5               600
1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice: 3

        Memory Management Scheme - Worst Fit

File_no:        File_size:      Block_no:       Block_size:
1               212             5               600
2               417             2               500
3               112             4               300
4               426             -               -
1. First Fit
2. Best Fit
3. Worst Fit
4. Exit
Enter your choice:
```

Write a C program to simulate page replacement algorithms .10
a) FIFO

b) LRU
c) Optimal

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

define MAX_FRAMES 10#
define MAX_PAGES 25#

} void fifo(int pages[], int n, int capacity)
;int frame[MAX_FRAMES], frameCount = 0, pageFaults = 0, frameIndex = 0
;bool isPagePresent = false

} for (int i = 0; i < n; i++)
;isPagePresent = false
} for (int j = 0; j < frameCount; j++)
} if (frame[j] == pages[i])
;isPagePresent = true
;break
{
{

} if (isPagePresent == false)
} if (frameCount < capacity)
;frame[frameCount] = pages[i]
;++frameCount
} else {
;frame[frameIndex] = pages[i]
;++frameIndex
if (frameIndex >= capacity)
;frameIndex = 0
{
;++pageFaults
{
{
;printf("\nFIFO Page Replacement Algorithm:\n")
;printf("Total Page Faults: %d\n", pageFaults)
{

} void lru(int pages[], int n, int capacity)
;int frame[MAX_FRAMES], frameCount = 0, pageFaults = 0, counter[MAX_FRAMES]
;bool isPagePresent = false

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

```
;isPagePresent = false
} for (int j = 0; j < frameCount; j++)
} if (frame[j] == pages[i])
;isPagePresent = true
;counter[j] = i
;break
{
{

} if (isPagePresent == false)
} if (frameCount < capacity)
;frame[frameCount] = pages[i]
;counter[frameCount] = i
;++frameCount
} else {
;int lru = 0
} for (int j = 1; j < capacity; j++)
if (counter[j] < counter[lru])
;lru = j
{
;frame[lru] = pages[i]
;counter[lru] = i
{
;++pageFaults
{
{
;printf("\nLRU Page Replacement Algorithm:\n")
;printf("Total Page Faults: %d\n", pageFaults)
{

} void optimal(int pages[], int n, int capacity)
;int frame[MAX_FRAMES], frameCount = 0, pageFaults = 0
;bool isPagePresent = false

} for (int i = 0; i < n; i++)
;isPagePresent = false
} for (int j = 0; j < frameCount; j++)
} if (frame[j] == pages[i])
;isPagePresent = true
;break
{
{

} if (isPagePresent == false)
} if (frameCount < capacity)
;frame[frameCount] = pages[i]
```

```
;++frameCount
} else {
;{0} = int future[MAX_FRAMES]
} for (int j = 0; j < frameCount; j++)
;bool isFound = false
} for (int k = i + 1; k < n; k++)
} if (pages[k] == frame[j])
;future[j] = k
;isFound = true
;break
{
{
if (isFound == false)
;future[j] = n + 1
{
;int longest = 0
} for (int j = 1; j < frameCount; j++)
if (future[j] > future[longest])
;longest = j
{
;frame[longest] = pages[i]
{
;++pageFaults
{
{
;printf("\nOptimal Page Replacement Algorithm:\n")
;printf("Total Page Faults: %d\n", pageFaults)
{

} ()int main
;int pages[MAX_PAGES], n, capacity

;printf("Page Replacement Algorithms\n")
;printf("Enter the number of pages: ")
;scanf("%d", &n)
;printf("Enter the page reference string:\n")
} for (int i = 0; i < n; i++)
;printf("Page %d: ", i + 1)
;scanf("%d", &pages[i])
{
;printf("Enter the number of frames: ")
;scanf("%d", &capacity)

;fifo(pages, n, capacity)
;lru(pages, n, capacity)
;optimal(pages, n, capacity)
```

;return 0
{

```
Page Replacement Algorithms
Enter the number of pages: 10
Enter the page reference string:
Page 1: 1
Page 2: 2
Page 3: 1
Page 4: 4
Page 5: 6
Page 6: 4
Page 7: 2
Page 8: 1
Page 9: 56
Page 10: 3
Enter the number of frames: 3

FIFO Page Replacement Algorithm:
Total Page Faults: 7

LRU Page Replacement Algorithm:
Total Page Faults: 8

Optimal Page Replacement Algorithm:
Total Page Faults: 7
```