DELHI TECHNOLOGICAL UNIVERSITY

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DEPARTMENT OF COMPUTER SCIENCE AND ENGINEERING

OPERATING SYSTEM
LAB FILE

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EXPERIMENT-1

Aim:-

Introduction to Linux – Write a program to print Hello World

Theory:-

Linux is a Unix-like operating system that was initially created by Linus Torvalds and first released on September 17, 1991. It has since become one of the most prominent examples of open-source software development and free software, as its underlying source code is freely available to the public and can be modified, distributed, and used by anyone.

Some Linux Commands are:-

a) sudo: allows a user to execute a command with root/administrator privileges.
b) pwd: prints the current working directory.
c) cd: changes the current working directory.
d) ls: lists the files and directories in the current directory.
e) cat: displays the contents of a file on the terminal.
f) cp: copies a file or directory from one location to another.
g) mv: moves or renames a file or directory.
h) mkdir: creates a new directory.
i) rmdir: removes an empty directory.
j) rm: removes a file or directory (use with caution!).
k) touch: creates an empty file or updates the modification time of an existing file.
l) diff: compares two files and shows the differences.
m) tar: creates or extracts a compressed archive of files and directories.
n) find: searches for files and directories based on certain criteria.
o) grep: searches for a pattern or text string in a file or output.
p) df: displays the available disk space on the file system.
q) du: displays the disk usage of files and directories.
r) head: displays the first 10 lines of a file.
s) tail: displays the last 10 lines of a file.

Code:-

// To print "Hello World" in Linux, you can use the echo command in the terminal:

// Create a file named hello.sh and add the following code:

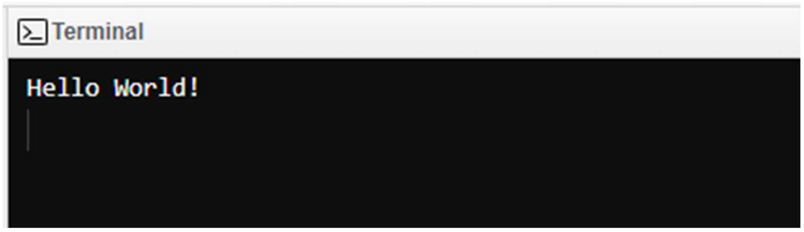
echo "Hello World"

// Save the file and give it execute permission

chmod +x hello.sh

```
//Run the script

./hello.sh
```

Output:-



EXPERIMENT-2

Aim:-

Write a program to implement Prims Algorithm using Disjoint Sets

Theory:-

Prim's algorithm is a greedy algorithm used to find the minimum spanning tree (MST) of a connected, undirected graph. The algorithm starts with an arbitrary node and grows the MST by adding the shortest edge that connects the tree to a vertex not yet in the tree. This process is repeated until all vertices are included in the MST. A disjoint set data structure is used to keep track of partitions or disjoint sets of elements. It provides two main operations:

- Union: Merge two sets.
- Find: Determine which set an element belongs to.

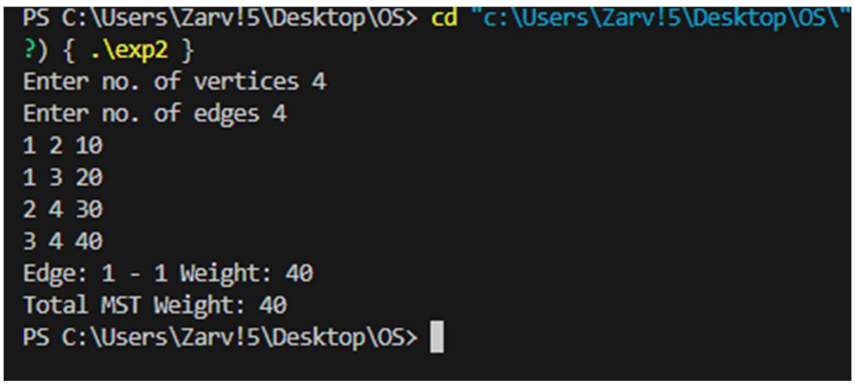
Code:-

```
#include <bits/stdc++.h>

using namespace std;

const int MAXN = 10;

int parent[MAXN], rank_arr[MAXN];

int find(int x) {

    if (parent[x] == x) return x;

    return parent[x] = find(parent[x]);

}
```

```
void union_sets(int x, int y) {
    x = find(x);
    y = find(y);
    if (x == y) return;
    if (rank_arr[x] < rank_arr[y]) swap(x, y);
    parent[y] = x;
    if (rank_arr[x] == rank_arr[y]) rank_arr[x]++;
}
int main() {
    int n, m;
    cout<<"Enter no. of vertices ";
    cin >>n;
    cout<<"Enter no. of edges ";
    cin>>m;
    for (int i = 1; i <= n; i++) {
        parent[i] = i;
        rank_arr[i] = 1;
    }
    int u, v, w;
    for (int i = 1; i <= m; i++) {
        cin >> u >> v >> w;
        union_sets(u, v);
    }
    int mst_weight = 0;
    for (int i = 1; i <= n; i++) {
        if (parent[i] == i) {
            mst_weight += w;
```

```
            cout << "Edge: " << i << " - " << parent[i] << " Weight: " << w << endl;
        }
    }
    cout << "Total MST Weight: " << mst_weight << endl;
    return 0;
}
```

Output:-



```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\"
?) { .\exp2 }
Enter no. of vertices 4
Enter no. of edges 4
1 2 10
1 3 20
2 4 30
3 4 40
Edge: 1 - 1 Weight: 40
Total MST Weight: 40
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-3

Aim:-

Write a program to implement Shortest Job First (SJF) job scheduling algorithm.

Theory:-

The Shortest Job First (SJF) scheduling algorithm is a non-preemptive, preemptive, or priority scheduling algorithm where the process with the smallest execution time is selected for execution next. The main idea behind SJF scheduling is to minimize the average waiting time of processes. In SJF, once a process starts executing, it runs to completion. Processes are sorted based on their burst times (execution times). The process with the shortest burst time is selected for execution first.

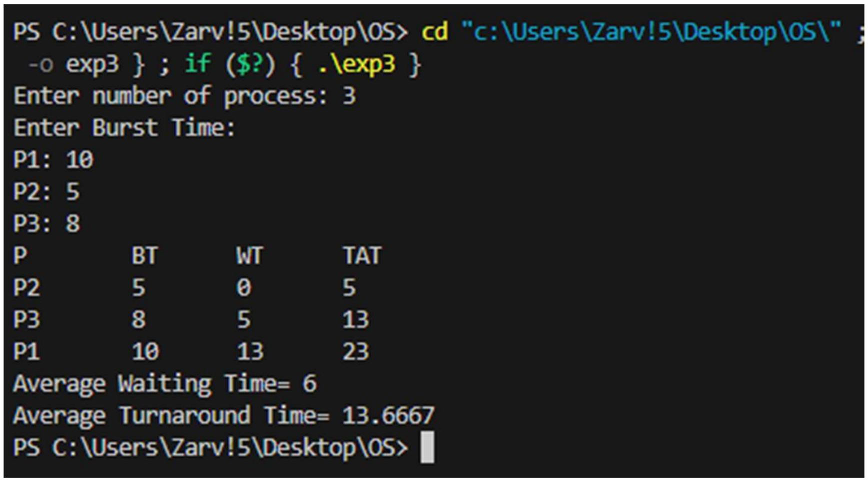
Code:-

```
#include <iostream>
using namespace std;

int main() {
```

```
// Matrix for storing Process Id, Burst Time, Average Waiting Time & Average Turn
Around Time.
int A[100][4];
int i, j, n, total = 0, index, temp;
float avg_wt, avg_tat;

cout << "Enter number of process: ";
cin >> n;

cout << "Enter Burst Time:" << endl;


for (i = 0; i < n; i++) {
        cout << "P" << i + 1 << ": ";
        cin >> A[i][1];
        A[i][0] = i + 1;
}
for (i = 0; i < n; i++) {
        index = i;
        for (j = i + 1; j < n; j++)
                if (A[j][1] < A[index][1])
                        index = j;
        temp = A[i][1];
        A[i][1] = A[index][1];
        A[index][1] = temp;

        temp = A[i][0];
        A[i][0] = A[index][0];
        A[index][0] = temp;
}

A[0][2] = 0;
for (i = 1; i < n; i++) {
        A[i][2] = 0;
        for (j = 0; j < i; j++)
                A[i][2] += A[j][1];
        total += A[i][2];
}

avg_wt = (float)total / n;
total = 0;
cout << "P       BT      WT     TAT" << endl;

for (i = 0; i < n; i++) {
        A[i][3] = A[i][1] + A[i][2];
        total += A[i][3];
        cout << "P" << A[i][0] << "    " << A[i][1] << "        " << A[i][2] << "        "
<< A[i][3] << endl;
}
```

```
        avg_tat = (float)total / n;
        cout << "Average Waiting Time= " << avg_wt << endl;
        cout << "Average Turnaround Time= " << avg_tat << endl;
}
```

OUTPUT:



```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ;
 -o exp3 } ; if ($?) { .\exp3 }
Enter number of process: 3
Enter Burst Time:
P1: 10
P2: 5
P3: 8
P       BT      WT      TAT
P2      5       0       5
P3      8       5       13
P1      10      13      23
Average Waiting Time= 6
Average Turnaround Time= 13.6667
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-4

Aim:-

Write a program to implement Shortest Remaining Time First (SRTF) job scheduling algorithm

Theory :

The Shortest Remaining Time First (SRTF) scheduling algorithm is a preemptive version of the Shortest Job First (SJF) scheduling algorithm. In SRTF, the process with the shortest remaining burst time is selected for execution. If a new process arrives with a shorter burst time than the currently executing process, the currently executing process is preempted. The scheduler selects the process with the shortest remaining burst time.The currently executing process can be preempted by a new arriving process with a shorter remaining burst time. Processes are sorted based on their remaining burst times.

Code:-

```
#include <bits/stdc++.h>

using namespace std;

struct Process {

        int pid;

        int bt;

        int art;
```

```
};
void findWaitingTime(Process proc[], int n,int wt[])
{
    int rt[n];
    for (int i = 0; i < n; i++)
        rt[i] = proc[i].bt;
    int complete = 0, t = 0, minm = INT_MAX;
    int shortest = 0, finish_time;
    bool check = false;
    while (complete != n) {
        for (int j = 0; j < n; j++) {
            if ((proc[j].art <= t) &&
            (rt[j] < minm) && rt[j] > 0) {
                minm = rt[j];
                shortest = j;
                check = true;
            }
        }
        if (check == false) {
            t++;
            continue;
        }
        rt[shortest]--;
        minm = rt[shortest];
        if (minm == 0)
            minm = INT_MAX;
        if (rt[shortest] == 0) {
            complete++;
            check = false;
```

```
                finish_time = t + 1;
                wt[shortest] = finish_time -proc[shortest].bt - proc[shortest].art;
                if (wt[shortest] < 0)
                    wt[shortest] = 0;
            }
            t++;
        }
}
void findTurnAroundTime(Process proc[], int n,int wt[], int tat[])
{
        for (int i = 0; i < n; i++)
            tat[i] = proc[i].bt + wt[i];
}
void findavgTime(Process proc[], int n)
{
        int wt[n], tat[n], total_wt = 0,total_tat = 0;
        findWaitingTime(proc, n, wt);
        findTurnAroundTime(proc, n, wt, tat);
        cout << " P\t\t"
            << "BT\t\t"
            << "WT\t\t"
            << "TAT\t\t\n";
        for (int i = 0; i < n; i++) {
            total_wt = total_wt + wt[i];
            total_tat = total_tat + tat[i];
            cout << " " << proc[i].pid << "\t\t"
                << proc[i].bt << "\t\t " << wt[i]
                << "\t\t " << tat[i] << endl;
        }
```

```
        cout << "\nAverage waiting time = "
                << (float)total_wt / (float)n;
        cout << "\nAverage turn around time = "
                << (float)total_tat / (float)n;
}
int main()
{
        Process proc[] = { { 1, 6, 2 }, { 2, 2, 5 },{ 3, 8, 1 }, { 4, 3, 0}, {5, 4, 4} };
        int n = sizeof(proc) / sizeof(proc[0]);
        findavgTime(proc, n);
        return 0;
}
```

Output:-

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ;
 -o exp4 } ; if ($?) { .\exp4 }
 P              BT              WT              TAT
 1              6               7               13
 2              2               0               2
 3              8               14              22
 4              3               0               3
 5              4               2               6

Average waiting time = 4.6
Average turn around time = 9.2
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-5

Aim:-

Write a program to implement First Come First Serve (FCFS) job scheduling algorithm

Theory:-

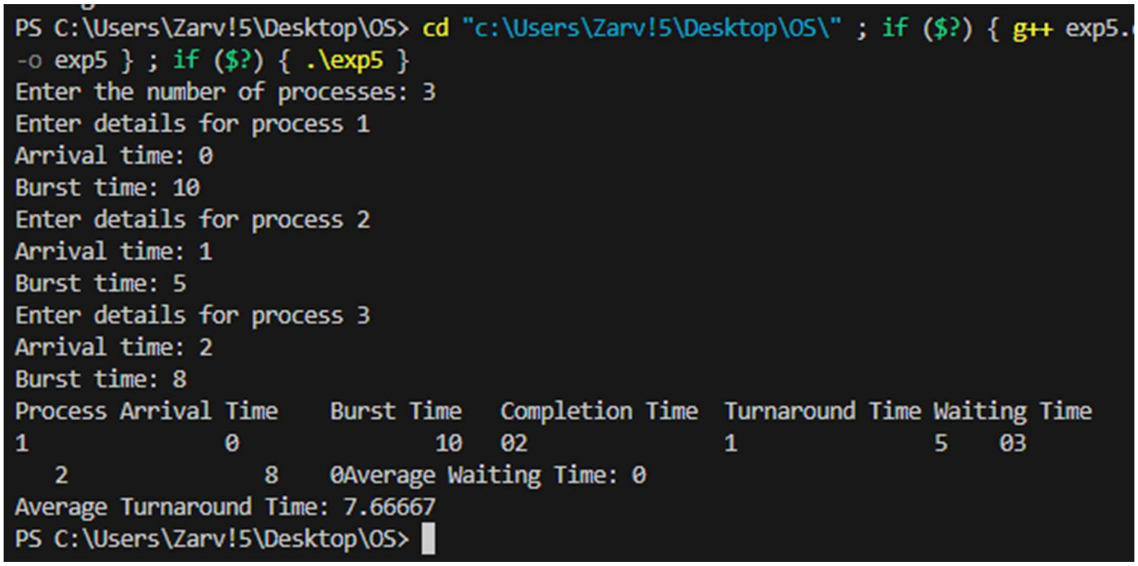
The First Come First Serve (FCFS) scheduling algorithm is a non-preemptive scheduling algorithm where processes are executed in the order they arrive. In FCFS, the process that arrives first gets executed first, and other processes wait in a queue. Once a process starts executing, it runs to completion. Processes are executed in the order they arrive, without considering their burst times.

Code:-

```
#include <iostream>
#include <vector>

using namespace std;

struct Process {
   int id, arrival_time, burst_time, completion_time, turnaround_time, waiting_time;
};

void fcfs(vector<Process> processes, int n) {
   int time = 0, count = 0;
   vector<int> completion_time(n), turnaround_time(n), waiting_time(n);

   while (count < n) {
      if (processes[count].arrival_time == time) {
         time += processes[count].burst_time;
         completion_time[count] = time;
         count++;
      } else {
         time++;
      }
   }

   time = 0;
   for (int i = 0; i < n; i++) {
      turnaround_time[i] = completion_time[i] - processes[i].arrival_time;
      waiting_time[i] = turnaround_time[i] - processes[i].burst_time;
      time += processes[i].burst_time;
   }

   cout << "Process\tArrival Time\tBurst Time\tCompletion Time\tTurnaround Time\tWaiting
Time" << endl;
   for (int i = 0; i < n; i++) {
      cout << i + 1 << "\t\t" << processes[i].arrival_time << "\t\t" << processes[i].burst_time
<< "\t\t" << processes[i].completion_time << "\t\t" << processes[i].turnaround_time << "\t\t"
<< processes[i].waiting_time << endl;
   }

   float avg_waiting_time = 0, avg_turnaround_time = 0;
   for (int i = 0; i < n; i++) {
      avg_waiting_time += waiting_time[i];
      avg_turnaround_time += turnaround_time[i];
```

```
    }

    cout << "Average Waiting Time: " << avg_waiting_time / n << endl;
    cout << "Average Turnaround Time: " << avg_turnaround_time / n << endl;
}

int main() {
    int n;
    cout << "Enter the number of processes: ";
    cin >> n;

    vector<Process> processes(n);
    for (int i = 0; i < n; i++) {
        cout << "Enter details for process " << i + 1 << endl;
        cout << "Arrival time: ";
        cin >> processes[i].arrival_time;
        cout << "Burst time: ";
        cin >> processes[i].burst_time;
        processes[i].id = i + 1;
        processes[i].completion_time = 0;
        processes[i].turnaround_time = 0;
        processes[i].waiting_time = 0;
    }

    fcfs(processes, n);

    return 0;
}
```

OUTPUT:



```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ; if ($?) { g++ exp5.
-o exp5 } ; if ($?) { .\exp5 }
Enter the number of processes: 3
Enter details for process 1
Arrival time: 0
Burst time: 10
Enter details for process 2
Arrival time: 1
Burst time: 5
Enter details for process 3
Arrival time: 2
Burst time: 8
Process Arrival Time    Burst Time    Completion Time    Turnaround Time Waiting Time
1               0               10    02               1               5    03
   2               8    0Average Waiting Time: 0
Average Turnaround Time: 7.66667
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-6

Aim:-

Write a program to implement Round Robin Scheduling Algorithm

Theory:-

The Round Robin (RR) scheduling algorithm is a preemptive scheduling algorithm where each process is assigned a fixed time quantum or time slice. Processes are executed in a circular manner, and if a process does not complete within its time quantum, it is moved to the end of the queue.Each process is executed for a fixed time quantum. If a process completes before its time quantum expires, it is removed from the queue. If a process does not complete within its time quantum, it is moved to the end of the queue. Processes are executed in a circular manner until all processes are completed.

Code:-

```
#include<iostream>

using namespace std;

void findWaitingTime(int processes[], int n, int bt[], int wt[], int quantum)

{

        int rem_bt[n];

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

                rem_bt[i] = bt[i];
```

```
        int t = 0;
        while (1)
        {
                bool done = true;
                for (int i = 0 ; i < n; i++)
                {
                        if (rem_bt[i] > 0)
                        {
                                done = false;

                                if (rem_bt[i] > quantum)
                                {
                                        t += quantum;
                                        rem_bt[i] -= quantum;
                                }
                                else
                                {
                                        t = t + rem_bt[i];
                                        wt[i] = t - bt[i];
                                        rem_bt[i] = 0;
                                }
                        }
                }
                if (done == true)
                break;
        }
}
void findTurnAroundTime(int processes[], int n, int bt[], int wt[], int tat[])
{
```

```
    // bt[i] + wt[i]
    for (int i = 0; i < n ; i++)
        tat[i] = bt[i] + wt[i];
}
void findavgTime(int processes[], int n, int bt[],int quantum)
{
    int wt[n], tat[n], total_wt = 0, total_tat = 0;
    findWaitingTime(processes, n, bt, wt, quantum);
    findTurnAroundTime(processes, n, bt, wt, tat);
    cout << "PN\t "<< " \tBT "<< " WT " << " \tTAT\n";
    for (int i=0; i<n; i++)
    {
        total_wt = total_wt + wt[i];
        total_tat = total_tat + tat[i];
        cout << " " << i+1 << "\t\t" << bt[i] <<"\t "
            << wt[i] <<"\t\t " << tat[i] <<endl;
    }
    cout << "Average waiting time = "
        << (float)total_wt / (float)n;
    cout << "\nAverage turn around time = "
        << (float)total_tat / (float)n;
}
int main()
{
    int processes[] = { 1, 2, 3};
    int n = sizeof processes / sizeof processes[0];
    int burst_time[] = {10, 5, 8};
    int quantum = 2;
    findavgTime(processes, n, burst_time, quantum);
```

```
	return 0;

}
```

Output:-

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ;
erFile.cpp -o tempCodeRunnerFile } ; if ($?) { .\tempCodeRunnerFi
PN              BT   WT          TAT
 1              10       13           23
 2              5        10           15
 3              8        13           21
Average waiting time = 12
Average turn around time = 19.6667
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-7

Aim:-

Write a program to implement priority scheduling algorithm.

Theory:-

The Priority Scheduling algorithm is a non-preemptive scheduling algorithm where each process is assigned a priority. The process with the highest priority is executed first. If two processes have the same priority, then they are scheduled in a First Come First Serve (FCFS) manner.Once a process starts executing, it runs to completion.Processes are sorted based on their priorities. The process with the highest priority is selected for execution first. Priority scheduling can lead to starvation of lower priority processes if higher priority processes continuously arrive.

Code:-

```
#include <bits/stdc++.h>

using namespace std;

struct Process {

	int pid;

	int bt;

	int priority;

};

bool comparison(Process a, Process b)

{
```

```
	return (a.priority > b.priority);
}
void findWaitingTime(Process proc[], int n, int wt[])
{
	wt[0] = 0;
	for (int i = 1; i < n; i++)
		wt[i] = proc[i - 1].bt + wt[i - 1];
}
void findTurnAroundTime(Process proc[], int n, int wt[],int tat[])
{
	for (int i = 0; i < n; i++)
		tat[i] = proc[i].bt + wt[i];
}
void findavgTime(Process proc[], int n)
{
	int wt[n], tat[n], total_wt = 0, total_tat = 0;
	findWaitingTime(proc, n, wt);
	findTurnAroundTime(proc, n, wt, tat);
	cout << "\nProcesses " << " Burst time "<< " Waiting time "<< " Turn around time\n";
	for (int i = 0; i < n; i++) {
		total_wt = total_wt + wt[i];
		total_tat = total_tat + tat[i];
		cout << " " << proc[i].pid << "\t\t" << proc[i].bt
			<< "\t " << wt[i] << "\t\t " << tat[i]
			<< endl;
	}
	cout << "\nAverage waiting time = "<< (float)total_wt / (float)n;
	cout << "\nAverage turn around time = "<< (float)total_tat / (float)n;
}
```

```
void priorityScheduling(Process proc[], int n)
{
        sort(proc, proc + n, comparison);
        cout << "Order in which processes gets executed \n";
        for (int i = 0; i < n; i++)
                cout << proc[i].pid << " ";

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

Output:-

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ; if ($?) {
exp7 } ; if ($?) { .\exp7 }
Order in which processes gets executed
1 3 2
Processes  Burst time  Waiting time  Turn around time
 1              10       0               10
 3              8        10              18
 2              5        18              23

Average waiting time = 9.33333
Average turn around time = 17
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-8

Aim:-

Write a program to create a child process using fork() system call.

Theory:-

In Unix-like operating systems such as Linux, the `fork()` system call is used to create a new process, which is called a child process. The `fork()` system call creates a new process by duplicating the existing process. After the `fork()` call, both the parent and the child processes continue execution from the next instruction following the `fork()` call. The `fork()` system call is specific to Unix-like operating systems and may not work on Windows. The `fork()` system call is a basic building block for creating new processes in Unix-like operating systems, and it is used extensively in process management and multitasking.

Code:-

```
#include <iostream>

#include <unistd.h>

#include <sys/wait.h>

int main() {

    pid_t pid = fork();

    if (pid < 0) {

        std::cerr << "Error: Fork failed" << std::endl;

        return 1;

    } else if (pid == 0) {

        std::cout << "Child process: My PID is " << getpid() << std::endl;

        std::cout << "Child process: My parent's PID is " << getppid() << std::endl;

       return 0;

    } else {

        std::cout << "Parent process: I have a child with PID " << pid << std::endl;

        std::cout << "Parent process: My PID is " << getpid() << std::endl;

        int status;

        waitpid(pid, &status, 0);

    }

    return 0;

}
```

Output:-

```
/tmp/x9UAqjOGwE.o
Parent process: I have a child with PID 18593
Parent process: My PID is 18592
Child process: My PID is 18593
Child process: My parent's PID is 18592
```

EXPERIMENT-8

Aim:-

Write a program to implement Banker’s algorithm.

Theory:-

The Banker's Algorithm is a resource allocation and deadlock avoidance algorithm used in operating systems to ensure that the system can allocate resources to processes in a safe manner without causing deadlocks. The algorithm works by simulating the resource allocation process and checking for safety before granting the resources to a process. Each process declares the maximum number of resources of each type it may need. The system maintains the number of available resources of each type. The system also maintains the number of resources allocated to each process. The algorithm checks if granting the requested resources to a process can lead to a safe state or not. A state is considered safe if there exists a sequence of processes such that each process can obtain its maximum resources and terminate, allowing the next process to complete. The Banker's Algorithm is a practical algorithm used in real-world operating systems to prevent deadlocks and ensure safe resource allocation.

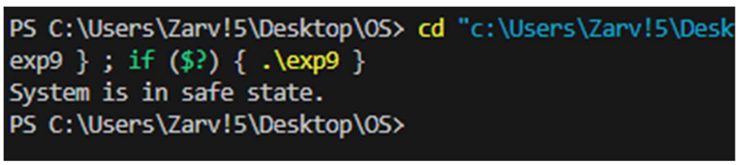
Code:-

```
#include <iostream>

using namespace std;

#define N 5

#define M 3

bool isSafe(int allocation[N][M], int max[N][M], int need[N][M], int available[M]) {

    int work[M], finish[N];

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

        work[i] = available[i];

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

        finish[i] = 0;

    int count = 0;

    while (count < N) {
```

```
        bool found = false;
        for (int i = 0; i < N; i++) {
            if (finish[i] == 0) {
                int j;
                found = true;
                for (j = 0; j < M; j++)
                    if (need[i][j] > work[j])
                        break;
                if (j == M) {
                    for (j = 0; j < M; j++)
                        work[j] += allocation[i][j];
                    finish[i] = 1;
                    count++;
                }
            }
        }
        if (!found)
            return false;
    }
    return true;
}
int main() {
    int allocation[N][M] = { { 0, 1, 0 }, { 2, 0, 0 }, { 3, 0, 2 }, { 2, 1, 1 }, { 0, 0, 2 } };
    int max[N][M] = { { 0, 2, 2 }, { 3, 0, 2 }, { 4, 0, 3 }, { 3, 2, 2 }, { 2, 0, 2 } };
    int need[N][M];
    int available[M] = { 2, 2, 2 };
    for (int i = 0; i < N; i++)
        for (int j = 0; j < M; j++)
            need[i][j] = max[i][j] - allocation[i][j];
```

```
    if (isSafe(allocation, max, need, available))
        cout << "System is in safe state.\n";
    else
        cout << "System is in unsafe state.\n";
    return 0;
}
```

Output:-



EXPERIMENT-10

Aim:-

Write a program to implement Dekker’s algorithm using Semaphore

Theory:-

Dekker's Algorithm is one of the earliest known solutions to the mutual exclusion problem in concurrent programming. It allows two processes to share a single resource without conflict. Dekker's Algorithm ensures mutual exclusion by using two flags (one for each process) and a turn variable to control access to the critical section.

Code:-

```
#include <iostream>
using namespace std;
int main()
{
int incomingStream[] = {7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1};
int pageFaults = 0;
int frames = 3;
int m, n, s, pages;
pages = sizeof(incomingStream)/sizeof(incomingStream[0]);
printf("Incoming \t Frame 1 \t Frame 2 \t Frame 3");
```

```
int temp[frames];
for(m = 0; m < frames; m++)
{
temp[m] = -1;
}
for(m = 0; m < pages; m++)
{
s = 0;
for(n = 0; n < frames; n++)
{
if(incomingStream[m] == temp[n])
{
    s++;
pageFaults--;
}
}
pageFaults++;
if((pageFaults <= frames) && (s == 0))
{
temp[m] = incomingStream[m];
}
else if(s == 0)
{
temp[(pageFaults - 1) % frames] =
incomingStream[m];
}
cout << "\n";
cout << incomingStream[m] << "\t\t\t";
for(n = 0; n < frames; n++)
```

```
{
if(temp[n] != -1)
cout << temp[n] << "\t\t\t";
else
cout << "- \t\t\t";
}
}
cout << "\n\nTotal Page Faults:\t" << pageFaults;
cout << "\nTotal Hits :\t" << pages - pageFaults;
return 0;
}
```

Output:-

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ; if ($?) { g++ e
 exp10 } ; if ($?) { .\exp10 }
Incoming         Frame 1         Frame 2         Frame 3
7                       7                       -                       -
0                       7                       0                       -
1                       7                       0                       1
2                       2                       0                       1
0                       2                       0                       1
3                       2                       3                       1
0                       2                       3                       0
4                       4                       3                       0
2                       4                       2                       0
3                       4                       2                       3
0                       0                       2                       3
3                       0                       2                       3
2                       0                       2                       3
1                       0                       1                       3

Total Page Faults:      11
Total Hits :    3
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-11

Aim:-

Write a program to implement Reader and Writer Problem using Semaphore

Theory:

The Reader-Writer Problem is a classical synchronization problem in concurrent programming. The problem involves multiple readers and writers accessing a shared resource. The constraints are as follows:

1. Multiple readers can read the shared resource simultaneously.

2. Only one writer can write to the shared resource at a time.

3. Readers and writers cannot access the shared resource simultaneously.

To implement the Reader-Writer Problem using semaphores, we can use two semaphores:

- \`mutex\`: A binary semaphore to control access to the \`read_count\` variable and ensure mutual exclusion.
- \`write\`: A binary semaphore to control access to the shared resource and ensure that only one writer can write at a time.

- The \`read\` method simulates the behavior of a reader. It acquires the \`mutex\` to increment \`read_count\`, reads from the shared resource, and then releases the \`mutex\` after decrementing \`read_count\`.
- The \`write\` method simulates the behavior of a writer. It acquires the \`write\` semaphore to block other writers and readers, writes to the shared resource, and then releases the \`write\` semaphore.
- Multiple reader and writer threads are created and started to simulate concurrent access to the shared resource.

Code:-

```
#include <iostream>

#include <thread>

#include <mutex>

#include <semaphore>

class ReadersWriters {

private:

    std::mutex mutex;

    sem_t write_mutex;

    int readers_count;

public:

    ReadersWriters() : readers_count(0) {

        sem_init(&write_mutex, 0, 1);
```

```
    }
    void start_read() {
        mutex.lock();
        readers_count++;
        if (readers_count == 1) {
            sem_wait(&write_mutex);
        }
        mutex.unlock();
        std::cout << "Reader is reading" << std::endl;
        mutex.lock();
        readers_count--;
        if (readers_count == 0) {
            sem_post(&write_mutex);
        }
        mutex.unlock();
    }
    void start_write() {
        sem_wait(&write_mutex);
        std::cout << "Writer is writing" << std::endl;
        sem_post(&write_mutex);
    }
};
void reader_thread(ReadersWriters& rw, int id) {
    while (true) {
        rw.start_read();
        std::this_thread::sleep_for(std::chrono::milliseconds(1000));
    }
}
void writer_thread(ReadersWriters& rw, int id) {
```

```
    while (true) {
        rw.start_write();
        std::this_thread::sleep_for(std::chrono::milliseconds(2000));
    }
}
int main() {
    ReadersWriters rw;
    std::thread readers[5];
    for (int i = 0; i < 5; ++i) {
        readers[i] = std::thread(reader_thread, std::ref(rw), i);
    }
    std::thread writers[2];
    for (int i = 0; i < 2; ++i) {
        writers[i] = std::thread(writer_thread, std::ref(rw), i);
    }
    for (int i = 0; i < 5; ++i) {
        readers[i].join();
    }
    for (int i = 0; i < 2; ++i) {
        writers[i].join();
    }
    return 0;
}
```

EXPERIMENT-12

Aim:-

Write a program to implement Optimal page replacement algorithm.

Theory:-

The Optimal Page Replacement Algorithm, also known as the Belady's Algorithm, is an algorithm used in virtual memory management. This algorithm replaces the page that will not be used for the longest period of time in the future. When a page needs to be replaced, the algorithm selects the page that will not be used for the longest period of time in the future. It requires future knowledge of the pages that will be accessed, which is not practical in a real system. Optimal page replacement is used as a theoretical benchmark to evaluate other page replacement algorithms. The Optimal Page Replacement Algorithm is a theoretical algorithm used to evaluate the performance of other page replacement algorithms.

Code:-

```
#include <iostream>

using namespace std;

int search(int key, int frame_items[], int frame_occupied)

{

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

        if (frame_items[i] == key)

            return 1;

    return 0;

}

void printOuterStructure(int max_frames)

{

    printf("Stream ");

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

        printf("Frame%d ", i + 1);

}

void printCurrFrames(int item, int frame_items[], int frame_occupied, int max_frames)

{

    printf("\n%d \t\t", item);

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

    {

        if (i < frame_occupied)

            printf("%d \t\t", frame_items[i]);

        else
```

```
            printf("- \t\t");
        }
    }
    int predict(int ref_str[], int frame_items[], int refStrLen, int index, int frame_occupied)
    {
        int result = -1, farthest = index;
        for (int i = 0; i < frame_occupied; i++)
        {
            int j;
            for (j = index; j < refStrLen; j++)
            {
                if (frame_items[i] == ref_str[j])
                {
                    if (j > farthest)
                    {
                        farthest = j;
                        result = i;
                    }
                    break;
                }
            }
            if (j == refStrLen)
                return i;
        }
        return (result == -1) ? 0 : result;
    }
    void optimalPage(int ref_str[], int refStrLen, int frame_items[], int max_frames)
    {
        int frame_occupied = 0;
```

```
    printOuterStructure(max_frames);
    int hits = 0;
    for (int i = 0; i < refStrLen; i++)
    {
        if (search(ref_str[i], frame_items, frame_occupied))
        {
            hits++;
            printCurrFrames(ref_str[i], frame_items, frame_occupied, max_frames);
            continue;
        }
        if (frame_occupied < max_frames)
        {
            frame_items[frame_occupied] = ref_str[i];
            frame_occupied++;
            printCurrFrames(ref_str[i], frame_items, frame_occupied, max_frames);
        }
        else
        {
            int pos = predict(ref_str, frame_items, refStrLen, i + 1, frame_occupied);
            frame_items[pos] = ref_str[i];
            printCurrFrames(ref_str[i], frame_items, frame_occupied, max_frames);
        }
    }
    printf("\n\nHits: %d\n", hits);
    printf("Misses: %d", refStrLen - hits);
}
int main()
{
    int ref_str[] = {7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2, 1, 2, 0, 1, 7, 0, 1};
```

```
    int refStrLen = sizeof(ref_str) / sizeof(ref_str[0]);
    int max_frames = 3;
    int frame_items[max_frames];
    optimalPage(ref_str, refStrLen, frame_items, max_frames);
    return 0;
}
```

Output:-

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ; if ($?) {
 exp12 } ; if ($?) { .\exp12 }
Stream Frame1 Frame2 Frame3
7       7       -       -
0       7       0       -
1       7       0       1
2       2       0       1
0       2       0       1
3       2       0       3
0       2       0       3
4       2       4       3
2       2       4       3
3       2       4       3
0       2       0       3
3       2       0       3
2       2       0       3
1       2       0       1
2       2       0       1
0       2       0       1
1       2       0       1
7       7       0       1
0       7       0       1
1       7       0       1

Hits: 11
Misses: 9
```

EXPERIMENT-13

Aim:-

Write a program to implement Least Recently Used (LRU) page replacement algorithm.

Theory:-

The Least Recently Used (LRU) Page Replacement Algorithm is a commonly used algorithm in virtual memory management. It replaces the least recently used page when a new page needs to be brought into memory. The algorithm replaces the page that has not been accessed for the longest period of time. It uses a data structure like a queue or a doubly linked list to keep track of the order in which pages are accessed. When a page is accessed, it is moved to the front of the queue or the head of the linked list. When a page needs to be replaced, the page at the end of the queue or the tail of the linked list (which is the least recently used page) is replaced.

Code:-

```
#include <iostream>

#include <unordered_map>

#include <list>


using namespace std;

class LRUCache {

public:

    LRUCache(int capacity) : _capacity(capacity) {}

    int get(int key) {

        auto it = _cache.find(key);

        if (it == _cache.end()) return -1;

        _lru.splice(_lru.begin(), _lru, it->second);

        return it->second->second;

    }

    void put(int key, int value) {

        auto it = _cache.find(key);

        if (it != _cache.end()) {

            it->second->second = value;

            _lru.splice(_lru.begin(), _lru, it->second);

            return;

        }

        if (_cache.size() >= _capacity) {

            int lruKey = _lru.back().first;

            _cache.erase(lruKey);

            _lru.pop_back();
```

```
        }
        _lru.emplace_front(key, value);
        _cache[key] = _lru.begin();
    }
private:
    int _capacity;
    list<pair<int, int>> _lru;
    unordered_map<int, list<pair<int, int>>::iterator> _cache;
};
int main() {
    LRUCache cache(2);
    cache.put(1, 1);
    cache.put(2, 2);
    cout << cache.get(1) << endl; // Returns 1
    cache.put(3, 3); // Evicts key 2
    cout << cache.get(2) << endl; // Returns -1 (not found)
    cache.put(4, 4); // Evicts key 1
    cout << cache.get(1) << endl; // Returns -1 (not found)
    cout << cache.get(3) << endl; // Returns 3
    cout << cache.get(4) << endl; // Returns 4
    return 0;
}
```

<u>Output:-</u>

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\
 exp13 } ; if ($?) { .\exp13 }
1
-1
-1
3
4
PS C:\Users\Zarv!5\Desktop\OS>
```

EXPERIMENT-14

Aim:-

Write a program to implement First In First Out (FIFO) page replacement algorithm.

Theory:-

The First In First Out (FIFO) Page Replacement Algorithm is one of the simplest page replacement algorithms. It replaces the oldest page in the memory when a new page needs to be brought in. The algorithm maintains a queue to keep track of the order in which pages are loaded into memory. When a page needs to be replaced, the page at the front of the queue (the oldest page) is replaced. New pages are added to the end of the queue. This algorithm does not consider the frequency of page usage. The FIFO Page Replacement Algorithm is a simple and commonly used algorithm in virtual memory management.

Code:-

```
#include<bits/stdc++.h>
using namespace std;

int pageFaults(int pages[], int n, int capacity)
{
        unordered_set<int> s;
        queue<int> indexes;
        int page_faults = 0;
        for (int i=0; i<n; i++)
        {
                if (s.size() < capacity)
                {
                        if (s.find(pages[i])==s.end())
                        {
                                s.insert(pages[i]);
                                page_faults++;
                                indexes.push(pages[i]);
                        }
                }
                else
                {
                        if (s.find(pages[i]) == s.end())
                        {
                                int val = indexes.front();
                                indexes.pop();
                                s.erase(val);
                                s.insert(pages[i]);
                                indexes.push(pages[i]);
                                page_faults++;
                        }
                }
```

```
        }

        return page_faults;
}
int main()
{
        int pages[] = {7, 0, 1, 2, 0, 3, 0, 4, 2, 3, 0, 3, 2};
        int n = sizeof(pages)/sizeof(pages[0]);
        int capacity = 4;
        cout << pageFaults(pages, n, capacity);
        return 0;
}
```

Output:-

```
PS C:\Users\Zarv!5\Desktop\OS> cd "c:\Users\Zarv!5\Desktop\OS\" ; if
 exp14 } ; if ($?) { .\exp14 }
7
PS C:\Users\Zarv!5\Desktop\OS>
```