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“JnanaSangama”, Belgaum -590014, Karnataka.



LAB REPORT on

Analysis and Design of Algorithms

Submitted by

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in partial fulfillment for the award of the degree of
BACHELOR OF ENGINEERING
in
COMPUTER SCIENCE AND ENGINEERING



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CERTIFICATE

This is to certify that the Lab work entitled “**Analysis and Design of Algorithms**” carried out by **VISHWANATHA HOSAGOUDRA (1BM22CS421)**, who is a 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 academic semester June-2023 to Sep-2023. The Lab report has been approved as it satisfies the academic requirements in respect of a **Analysis and Design of Algorithms (22CS4PCADA)** workprescribed for the said degree.

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Course Outcome

| | |
|-----|---|
| CO1 | Analyze time complexity of Recursive and Non-recursive algorithms using asymptotic notations. |
| CO2 | Apply various design techniques for the given problem. |
| CO3 | Apply the knowledge of complexity classes P, NP, and NP-Complete and prove certain problems are NP-Complete |
| CO4 | Design efficient algorithms and conduct practical experiments to solve problems. |

PROGRAM-1

Write program to do the following:

- a. Print all the nodes reachable from a given starting node in a digraph using BFS method.
- b. Check whether a given graph is connected or not using DFS method.

DFS

```
#include <stdio.h>

void DFS(int);
int isConnected();
int A[10][10], vis[10], n;
int main()
{
    printf("Enter the number of vertices: ");
    scanf("%d", &n);
    printf("Enter Adjacency Matrix\n");
    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            scanf("%d", &A[i][j]);
        }
    }
    printf("DFS Traversal\n");
    for (int i = 1; i <= n; i++)
    {
        vis[i] = 0;
    }
    DFS(1);
    if(isConnected()==1){
```

```

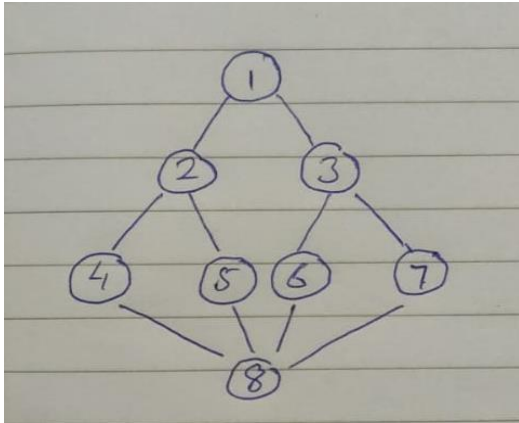
        printf("\nGraph is Conncted.");
    }
    else{
        printf("\nGraph is Not Conncted.");
    }
    return 0;
}

void DFS(int v)
{
    vis[v] = 1;
    printf("%d ", v);
    for (int i = 1; i <= n; i++)
    {
        if (A[v][i] == 1 && vis[i] == 0)
        {
            DFS(i);
        }
    }
}

int isConnected()
{
    for (int i = 1; i <= n; i++)
    {
        if (vis[i] == 0)
            return 0;
    }
    return 1;
}

```

GRAPH:



OUTPUT:

```
Enter the number of vertices: 8
```

```
Enter Adjacency Matrix
```

```
0 1 1 0 0 0 0 0
```

```
0 0 0 1 1 0 0 0
```

```
0 0 0 0 0 1 1 0
```

```
0 0 0 0 0 0 0 1
```

```
0 0 0 0 0 0 0 1
```

```
0 0 0 0 0 0 0 1
```

```
0 0 0 0 0 0 0 1
```

```
0 0 0 0 0 0 0 0
```

```
DFS Traversal:
```

```
>> 1 2 4 8 5 3 6 7
```

```
Graph is Conncted.
```

BFS

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

```
void BFS(int);
```

```
int Q[10],F=-1,R=-1;
```

```
int A[10][10],vis[10];
```

```
int n,m;
```

```
int main(){
```

```
    int v,u,st;
```

```
    printf("Enter the number of vertices\n");
```

```
    scanf("%d",&n);
```

```
    for(int i=1;i<=n;i++){
```

```
        for(int j=1;j<=n;j++){
```

```
            A[i][j]=0;
```

```
        }
```

```
    }
```

```
    printf("Enter the number of edges\n");
```

```
    scanf("%d",&m);
```

```
    printf("Enter the edges\n");
```

```
    for(int i=1;i<=m;i++){
```

```
        scanf("%d %d",&u,&v);
```

```
        A[u][v]=1;
```

```
    }
```

```
    for(int i=1;i<=n;i++){
```

```
        vis[i]=0;
```



```

    }

    printf("Enter the starting Node\n");
    scanf("%d",&st);
    printf("Nodes reachable from %d\n",st);

    BFS(st);
    return 0;
}

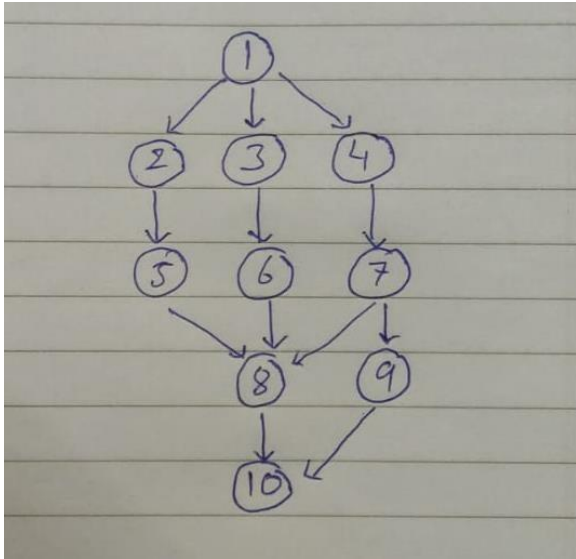
void BFS(int v){
    int u;
    vis[v]=1;
    Q[++R]=v;

    while(F<=R){
        u=Q[++F];
        printf("%d ",u);
        for(int i=1;i<=n;i++){
            if(A[u][i]==1 && vis[i]==0){

                Q[++R]=i;
                vis[i]=1;
            }
        }
    }
}

```

GRAPH:



OUTPUT:

```
Enter the number of vertices: 10
Enter the number of edges: 12
Enter the edges:
1 2
1 3
1 4
2 5
3 6
4 7
5 8
6 8
7 9
8 10
9 1
Enter the starting Node: 1

Nodes reachable from 1:
1 2 3 4 5 6 7 8 9 10
```

PROGRAM-2

Write program to obtain the Topological ordering of vertices in a given digraph.

```
#include <stdio.h>

void DFS(int);

int A[10][10], vis[10], EXP[10], J = 0;

int n, m;

int main()
{
    int v, u;
    printf("Enter the number of vertices\n");
    scanf("%d", &n);
    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            A[i][j] = 0;
        }
    }
    printf("Enter the number of edges\n");
    scanf("%d", &m);
    printf("Enter the edges\n");
    for (int i = 1; i <= m; i++)
    {
        scanf("%d %d", &u, &v);
        A[u][v] = 1;
    }
    for (int i = 1; i <= n; i++)
```

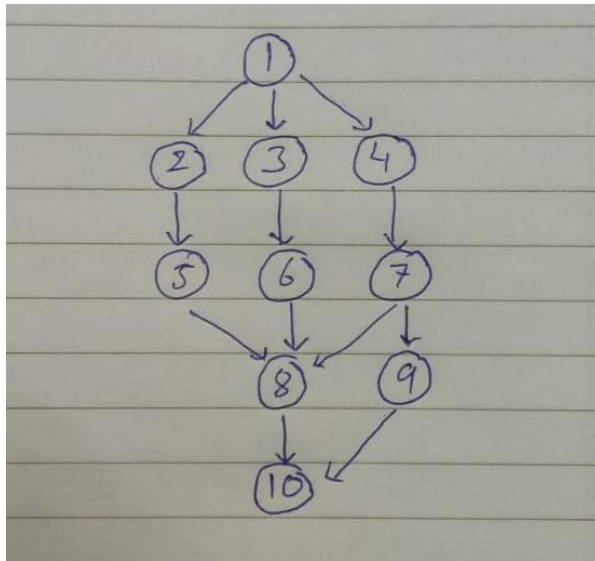
```

        vis[i] = 0;
    for (int i = 1; i <= n; i++)
    {
        if (vis[i] == 0)
        {
            DFS(i);
        }
    }
    printf("Topological traversal\n");
    for (int i = n - 1; i >= 0; i--)
    {
        printf("%d ", EXP[i]);
    }
}

void DFS(int v)
{
    int i;
    vis[v] = 1;
    for (int i = 1; i <= n; i++)
    {
        if (A[v][i] == 1 && vis[i] == 0)
        {
            DFS(i);
        }
    }
    EXP[J++] = v;
}

```

GRAPH:



OUTPUT:

```
Enter the number of vertices: 7
Enter the number of edges: 12
Enter the edges:
1 2
1 6
6 5
4 5
2 3
4 3
2 4
7 1
7 6
7 5
7 4
7 2
Topological traversal:
>> 7 1 6 2 4 5 3
```

PROGRAM-3

Implement Johnson Trotter algorithm to generate permutations.

```
#include <stdio.h>

#include <conio.h>

int LEFT_TO_RIGHT = 1;
int RIGHT_TO_LEFT = 0;

int searchArr(int a[], int n, int mobile)
{
    for (int i = 0; i < n; i++)
        if (a[i] == mobile)
            return i + 1;
}

int getMobile(int a[], int dir[], int n)
{
    int mobile_prev = 0, mobile = 0;
    for (int i = 0; i < n; i++)
    {

        if (dir[a[i] - 1] == RIGHT_TO_LEFT && i != 0)
        {
            if (a[i] > a[i - 1] && a[i] > mobile_prev)
            {
                mobile = a[i];
                mobile_prev = mobile;
            }
        }
    }
}
```

```

    }
    if (dir[a[i] - 1] == LEFT_TO_RIGHT && i != n - 1)
    {

        if (a[i] > a[i + 1] && a[i] > mobile_prev)
        {
            mobile = a[i];
            mobile_prev = mobile;
        }
    }
}

if (mobile == 0 && mobile_prev == 0)
    return 0;
else
    return mobile;
}

```

```

int printOnePerm(int a[], int dir[], int n)
{
    int mobile = getMobile(a, dir, n);
    int pos = searchArr(a, n, mobile);

    if (dir[a[pos - 1] - 1] == RIGHT_TO_LEFT)
    {
        printf("\n");
        int temp;
        temp = a[pos - 1];
    }
}

```

```

        a[pos - 1] = a[pos - 2];
        a[pos - 2] = temp;
    }

    else if (dir[a[pos - 1] - 1] == LEFT_TO_RIGHT)
    {
        printf("\n");
        int temp;
        temp = a[pos];
        a[pos] = a[pos - 1];
        a[pos - 1] = temp;
    }

    for (int i = 0; i < n; i++)
    {
        if (a[i] > mobile)
        {
            if (dir[a[i] - 1] == LEFT_TO_RIGHT)
                dir[a[i] - 1] = RIGHT_TO_LEFT;
            else if (dir[a[i] - 1] == RIGHT_TO_LEFT)
                dir[a[i] - 1] = LEFT_TO_RIGHT;
        }
    }

    for (int i = 0; i < n; i++)
        printf(" %d", a[i]);
}

```



```

int fact(int n)
{
    int res = 1;
    int i;
    for (i = 1; i <= n; i++)
        res = res * i;
    return res;
}

void printPermutation(int n)
{

    int a[n];
    int dir[n];

    for (int i = 0; i < n; i++)
    {
        a[i] = i + 1;
        printf(" %d", a[i]);
    }
    for (int i = 0; i < n; i++)
        dir[i] = RIGHT_TO_LEFT;
    for (int i = 1; i < fact(n); i++)
        printOnePerm(a, dir, n);
    printf("\n");
}

int main()

```

```
{  
    int n;  
    printf("\nEnter the value of n: ");  
    scanf("%d", &n);  
    printf("\n");  
    printPermutation(n);  
    printf("\n");  
    return 0;  
}
```

OUTPUT:

```
Enter the value of n: 4
```

```
1 2 3 4  
1 2 4 3  
1 4 2 3  
4 1 2 3  
4 1 3 2  
1 4 3 2  
1 3 4 2  
1 3 2 4  
3 1 2 4  
3 1 4 2  
3 4 1 2  
4 3 1 2  
4 3 2 1  
3 4 2 1  
3 2 4 1  
3 2 1 4  
2 3 1 4  
2 3 4 1  
2 4 3 1  
4 2 3 1  
4 2 1 3  
2 4 1 3  
2 1 4 3  
2 1 3 4
```

PROGRAM-4

Sort a given set of N integer elements using the Merge Sort technique and compute its time taken. Run the program for different values of N and record the time taken to sort.

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

void merge(int arr[], int l, int m, int r)
{
    int i, j, k;
    int n1 = m - l + 1;
    int n2 = r - m;

    int L[n1], R[n2];

    for (i = 0; i < n1; i++)
        L[i] = arr[l + i];
    for (j = 0; j < n2; j++)
        R[j] = arr[m + 1 + j];

    i = 0;
    j = 0;
    k = l;
    while (i < n1 && j < n2)
    {
        if (L[i] <= R[j])
        {
            arr[k] = L[i];
```

```

        i++;
    }
    else
    {
        arr[k] = R[j];
        j++;
    }
    k++;
}

while (i < n1)
{
    arr[k] = L[i];
    i++;
    k++;
}

while (j < n2)
{
    arr[k] = R[j];
    j++;
    k++;
}
}

void mergeSort(int arr[], int l, int r)
{
    if (l < r)

```

```

    {
        int m = 1 + (r - l) / 2;

        mergeSort(arr, l, m);
        mergeSort(arr, m + 1, r);
        merge(arr, l, m, r);
    }
}

int main()
{

    int ch;
    int n;
    int A[100];
    clock_t start_time, end_time;

    printf("\n1.For manual entry of N value and array elements\n2.For Random Values of
N\n3.Exit");

    while (1)
    {
        printf("\nEnter your choice: ");
        scanf("%d", &ch);
        switch (ch)
        {
            case 1:

                printf("\nEnter the number of elements: ");
                scanf("%d", &n);

```

```
printf("Enter array elements\n");
for (int i = 0; i < n; i++)
{
    scanf("%d", &A[i]);
}

printf("Array Elements: \n");
for (int i = 0; i < n; i++)
{
    printf("%d ", A[i]);
}

start_time = clock();

mergeSort(A, 0, n - 1);

end_time = clock();
double taken_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;

printf("\nSorted Array: \n");
for (int i = 0; i < n; i++)
{
    printf("%d ", A[i]);
}

printf("\nTime taken: %f seconds\n", taken_time);
break;
```

case 2:

```
srand(time(NULL));
```

```
int sizes[] = {10, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000, 100000};
```

```
int num_sizes = sizeof(sizes) / sizeof(sizes[0]);
```

```
for (int i = 0; i < num_sizes; i++)
```

```
{
```

```
    int N = sizes[i];
```

```
    int arr[N];
```

```
    for (int j = 0; j < N; j++)
```

```
    {
```

```
        arr[j] = rand() % 1000;
```

```
    }
```

```
    clock_t start = clock();
```

```
    mergeSort(arr, 0, N - 1);
```

```
    clock_t end = clock();
```

```
    double time_taken = ((double)(end - start)) / CLOCKS_PER_SEC;
```

```
    printf("Time taken to sort array of size %d: %lf seconds\n", N, time_taken);
```

```
}
```

```
break;
```

case 3:

```
printf("Exiting the program.\n");
```

```
        exit(0);

    default:
        printf("Invalid choice");
        break;
    }
}

return 0;
}
```


OUTPUT:

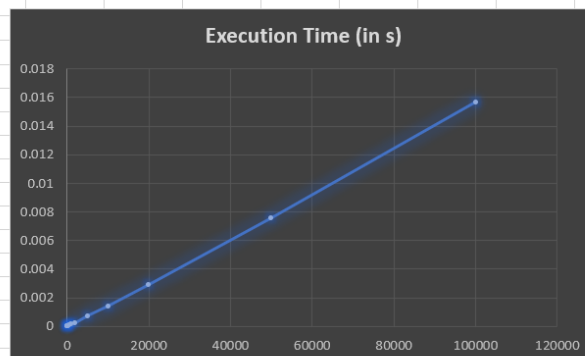
```
1. For manual entry of N value and array elements
2. For Random Values of N
3. Exit
Enter your choice: 1

Enter the number of elements: 6
Enter array elements
1 6 -8 4 2 -3
Array Elements:
1 6 -8 4 2 -3
Sorted Array:
-8 -3 1 2 4 6
Time taken: 0.000003 seconds

Enter your choice: 2
Time taken to sort array of size 10: 0.000003 seconds
Time taken to sort array of size 50: 0.000006 seconds
Time taken to sort array of size 100: 0.000012 seconds
Time taken to sort array of size 200: 0.000025 seconds
Time taken to sort array of size 500: 0.000067 seconds
Time taken to sort array of size 1000: 0.000128 seconds
Time taken to sort array of size 2000: 0.000259 seconds
Time taken to sort array of size 5000: 0.000713 seconds
Time taken to sort array of size 10000: 0.001422 seconds
Time taken to sort array of size 20000: 0.002932 seconds
Time taken to sort array of size 50000: 0.007578 seconds
Time taken to sort array of size 100000: 0.015673 seconds

Enter your choice: 3
Exiting the program.
```

| N | Execution Time (in s) |
|--------|-----------------------|
| 10 | 0.000003 |
| 50 | 0.000006 |
| 100 | 0.000012 |
| 200 | 0.000025 |
| 500 | 0.000067 |
| 1000 | 0.000128 |
| 2000 | 0.000259 |
| 5000 | 0.000713 |
| 10000 | 0.001422 |
| 20000 | 0.002932 |
| 50000 | 0.007578 |
| 100000 | 0.015673 |



PROGRAM-5

Sort a given set of N integer elements using the Quick Sort technique and compute its time taken.

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

int partition(int arr[], int low, int high)
{
    int pivot = arr[high];
    int i = (low - 1);

    for (int j = low; j <= high - 1; j++)
    {
        if (arr[j] < pivot)
        {
            i++;
            int temp = arr[i];
            arr[i] = arr[j];
            arr[j] = temp;
        }
    }

    int temp = arr[i + 1];
    arr[i + 1] = arr[high];
    arr[high] = temp;

    return (i + 1);
}
```

```

}

void quickSort(int arr[], int low, int high)
{
    if (low < high)
    {
        int pi = partition(arr, low, high);

        quickSort(arr, low, pi - 1);
        quickSort(arr, pi + 1, high);
    }
}

int main()
{
    int ch;
    int n;
    int A[100];
    clock_t start_time, end_time;

    printf("\n1.For manual entry of N value and array elements\n2.For Random Values of
N\n3.Exit");

    while (1)
    {
        printf("\nEnter your choice: ");
        scanf("%d", &ch);

        switch (ch)

```

```

{
case 1:

    printf("\nEnter the number of elements: ");
    scanf("%d", &n);
    printf("Enter array elements\n");
    for (int i = 0; i < n; i++)
    {
        scanf("%d", &A[i]);
    }

    printf("Array Elements: \n");
    for (int i = 0; i < n; i++)
    {
        printf("%d ", A[i]);
    }

    start_time = clock();
    quickSort(A, 0, n - 1);
    end_time = clock();

    printf("\nSorted Array: \n");
    for (int i = 0; i < n; i++)
    {
        printf("%d ", A[i]);
    }

    double taken_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;
    printf("\nTime taken: %f seconds\n", taken_time);

```

```

        break;

case 2:
    srand(time(NULL));

    int sizes[] = {10, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000, 100000};
    int num_sizes = sizeof(sizes) / sizeof(sizes[0]);

    for (int i = 0; i < num_sizes; i++)
    {
        int N = sizes[i];
        int arr[N];

        for (int j = 0; j < N; j++)
        {
            arr[j] = rand() % 1000;
        }

        clock_t start = clock();
        quickSort(arr, 0, N - 1);
        clock_t end = clock();

        printf("Time taken to sort array of size %d: %lf seconds\n", N, ((double)(end - start)) /
CLOCKS_PER_SEC);
    }
    break;

case 3:
    printf("Exiting the program.\n");

```

```
        exit(0);

    default:
        printf("Invalid choice\n");
        break;
    }
}

return 0;
}
```

OUTPUT:

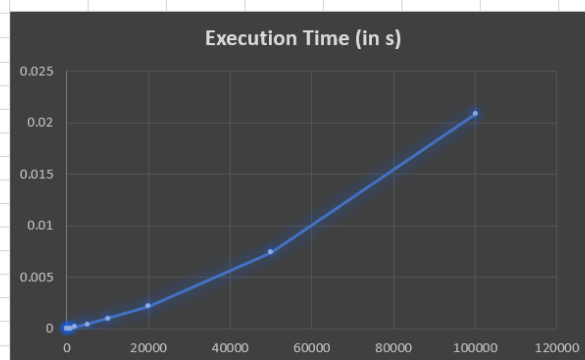
```
1.For manual entry of N value and array elements
2.For Random Values of N
3.Exit
Enter your choice: 1

Enter the number of elements: 7
Enter array elements
6 2 1 5 -4 3 4
Array Elements:
6 2 1 5 -4 3 4
Sorted Array:
-4 1 2 3 4 5 6
Time taken: 0.000001 seconds

Enter your choice: 2
Time taken to sort array of size 10: 0.000001 seconds
Time taken to sort array of size 50: 0.000004 seconds
Time taken to sort array of size 100: 0.000008 seconds
Time taken to sort array of size 200: 0.000015 seconds
Time taken to sort array of size 500: 0.000044 seconds
Time taken to sort array of size 1000: 0.000079 seconds
Time taken to sort array of size 2000: 0.000177 seconds
Time taken to sort array of size 5000: 0.000456 seconds
Time taken to sort array of size 10000: 0.000993 seconds
Time taken to sort array of size 20000: 0.002222 seconds
Time taken to sort array of size 50000: 0.007444 seconds
Time taken to sort array of size 100000: 0.020886 seconds

Enter your choice: 3
Exiting the program.
```

| N | Execution Time (in s) |
|--------|-----------------------|
| 10 | 0.000001 |
| 50 | 0.000004 |
| 100 | 0.000008 |
| 200 | 0.000015 |
| 500 | 0.000044 |
| 1000 | 0.000079 |
| 2000 | 0.000177 |
| 5000 | 0.000456 |
| 10000 | 0.000993 |
| 20000 | 0.002222 |
| 50000 | 0.007444 |
| 100000 | 0.020886 |



PROGRAM-6

Sort a given set of N integer elements using Heap Sort technique and compute its time taken.

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

void heapify(int arr[], int n, int i)
{
    int largest = i;
    int left = 2 * i + 1;
    int right = 2 * i + 2;

    if (left < n && arr[left] > arr[largest])
    {
        largest = left;
    }

    if (right < n && arr[right] > arr[largest])
    {
        largest = right;
    }

    if (largest != i)
    {
        // Swap arr[i] and arr[largest]
        int temp = arr[i];
        arr[i] = arr[largest];
```



```

        arr[largest] = temp;

        heapify(arr, n, largest);
    }
}

void heapSort(int arr[], int n)
{
    for (int i = n / 2 - 1; i >= 0; i--)
    {
        heapify(arr, n, i);
    }

    for (int i = n - 1; i >= 0; i--)
    {
        // Swap arr[0] and arr[i]
        int temp = arr[0];
        arr[0] = arr[i];
        arr[i] = temp;

        heapify(arr, i, 0);
    }
}

int main()
{
    int ch;
    int n;

```

```

int arr[100];
clock_t start_time, end_time;

printf("\n1.For manual entry of N value and array elements\n2.For Random Values of
N\n3.Exit");

while (1)
{
    printf("\nEnter your choice: ");
    scanf("%d", &ch);

    switch (ch)
    {
        case 1:

            printf("\nEnter the number of elements: ");
            scanf("%d", &n);

            printf("Enter array elements: ");
            for (int i = 0; i < n; i++)
            {
                scanf("%d", &arr[i]);
            }

            start_time = clock();
            heapSort(arr, n);
            end_time = clock();

            printf("\nSorted Array: \n");

```

```
for (int i = 0; i < n; i++)  
{  
    printf("%d ", arr[i]);  
}
```

```
double taken_time = (double)(end_time - start_time) / CLOCKS_PER_SEC;  
printf("\nTime taken: %f seconds\n", taken_time);  
break;
```

case 2:

```
srand(time(NULL));
```

```
int sizes[] = {10, 50, 100, 200, 500, 1000, 2000, 5000, 10000, 20000, 50000, 100000};  
int num_sizes = sizeof(sizes) / sizeof(sizes[0]);
```

```
for (int i = 0; i < num_sizes; i++)  
{  
    int N = sizes[i];  
    int arr[N];  
  
    for (int j = 0; j < N; j++)  
    {  
        arr[j] = rand() % 1000;  
    }  
}
```

```
clock_t start = clock();  
heapSort(arr, N);  
clock_t end = clock();
```

```
        printf("Time taken to sort array of size %d: %lf seconds\n", N, ((double)(end - start)) /  
CLOCKS_PER_SEC);  
    }  
    break;  
  
    case 3:  
        printf("Exiting the program.\n");  
        exit(0);  
  
    default:  
        printf("Invalid choice\n");  
        break;  
    }  
}  
  
return 0;  
}
```

OUTPUT:

```
1.For manual entry of N value and array elements
2.For Random Values of N
3.Exit
Enter your choice: 1

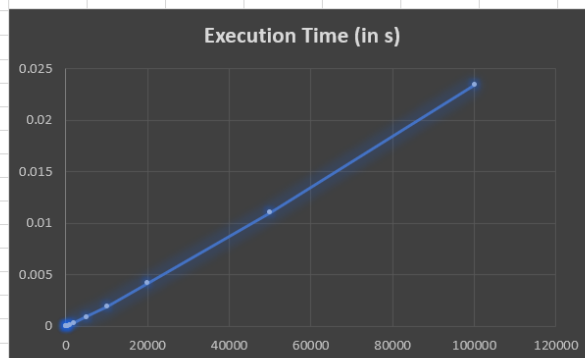
Enter the number of elements: 7
Enter array elements: 2 4 1 -2 5 3 6

Sorted Array:
-2 1 2 3 4 5 6
Time taken: 0.000002 seconds

Enter your choice: 2
Time taken to sort array of size 10: 0.000002 seconds
Time taken to sort array of size 50: 0.000006 seconds
Time taken to sort array of size 100: 0.000012 seconds
Time taken to sort array of size 200: 0.000028 seconds
Time taken to sort array of size 500: 0.000067 seconds
Time taken to sort array of size 1000: 0.000145 seconds
Time taken to sort array of size 2000: 0.000322 seconds
Time taken to sort array of size 5000: 0.000890 seconds
Time taken to sort array of size 10000: 0.001920 seconds
Time taken to sort array of size 20000: 0.004192 seconds
Time taken to sort array of size 50000: 0.011076 seconds
Time taken to sort array of size 100000: 0.023422 seconds

Enter your choice: 3
Exiting the program.
```

| N | Execution Time (in s) |
|--------|-----------------------|
| 10 | 0.000002 |
| 50 | 0.000006 |
| 100 | 0.000012 |
| 200 | 0.000028 |
| 500 | 0.000067 |
| 1000 | 0.000145 |
| 2000 | 0.000322 |
| 5000 | 0.00089 |
| 10000 | 0.00192 |
| 20000 | 0.004192 |
| 50000 | 0.011076 |
| 100000 | 0.023422 |



PROGRAM-7

Implement 0/1 Knapsack problem using dynamic programming.

```
#include <stdio.h>

#include <stdlib.h>

int V[100][100];

int max(int a, int b)
{
    return a > b ? a : b;
}

int knapsack(int W, int N, int val[], int wt[])
{
    for (int i = 0; i <= N; i++)
    {
        for (int j = 0; j <= W; j++)
        {
            if (i == 0 || j == 0)
            {
                V[i][j] = 0;
            }
            else if (wt[i - 1] > j)
            {
                V[i][j] = V[i - 1][j];
            }
            else
            {
                V[i][j] = max(V[i - 1][j], V[i - 1][j - wt[i - 1]] + val[i - 1]);
            }
        }
    }
}
```

```

    }
}
return V[N][W];
}
void object_selecetd(int N, int W, int wt[])
{
    int X[N + 1];
    for (int i = 1; i <= N; i++)
    {
        X[i] = 0;
    }
    int i = N;
    int j = W;
    while (i != 0 && j != 0)
    {
        if (V[i][j] != V[i - 1][j])
        {
            X[i] = 1;
            j = j - wt[i - 1];
        }
        i--;
    }

    printf("\n");

    for (int i = 1; i <= N; i++)
    {
        if (X[i] == 1)

```

```

        {
            printf("Object %d Selected\n", i);
        }
    }
}

int main()
{
    int W, N;

    printf("\nEnter number of items: ");
    scanf("%d", &N);
    printf("Enter the Capacity of bag: ");
    scanf("%d", &W);

    int val[W], wt[N];

    for (int i = 0; i < N; i++)
    {
        printf("Enter profit and weight of item %d: ", i + 1);
        scanf("%d%d", &val[i], &wt[i]);
    }

    int result = knapsack(W, N, val, wt);
    object_selectd(N, W, wt);
    printf("\nMaximum profit is: %d", result);
}

```


OUTPUT:

```
Enter number of items: 4
Enter the Capacity of bag: 5
Enter profit and weight of item 1: 12 2
Enter profit and weight of item 2: 10 1
Enter profit and weight of item 3: 20 3
Enter profit and weight of item 4: 15 2
```

```
Object 1 Selected
Object 2 Selected
Object 4 Selected
```

```
Maximum profit is: 37
```

PROGRAM-8

Implement All Pair Shortest paths problem using Floyd's algorithm.

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

```
int min(int, int);
```

```
void floyds(int p[10][10], int n)
```

```
{
```

```
    int i, j, k;
```

```
    for (k = 1; k <= n; k++)
```

```
        for (i = 1; i <= n; i++)
```

```
            for (j = 1; j <= n; j++)
```

```
                if (i == j)
```

```
                    p[i][j] = 0;
```

```
                else
```

```
                    p[i][j] = min(p[i][j], p[i][k] + p[k][j]);
```

```
}
```

```
int min(int a, int b)
```

```
{
```

```
    if (a < b)
```

```
        return (a);
```

```
    else
```

```
        return (b);
```

```
}
```

```
void main()
```

```
{
```

```

int p[10][10], w, n, e, u, v, i, j;

printf("\nEnter the number of vertices: ");
scanf("%d", &n);
printf("Enter the number of edges: ");
scanf("%d", &e);

for (i = 1; i <= n; i++)
{
    for (j = 1; j <= n; j++)
        p[i][j] = 999;
}

for (i = 1; i <= e; i++)
{
    printf("\nEnter the end vertices of edge %d: ", i);
    scanf("%d%d", &u, &v);
    printf("Enter Weight: ");
    scanf("%d",&w);
    p[u][v] = w;
}

printf("\nAdjacency Matrix: \n");
for (i = 1; i <= n; i++)
{
    for (j = 1; j <= n; j++)
        printf("%d\t", p[i][j]);
    printf("\n");
}

```

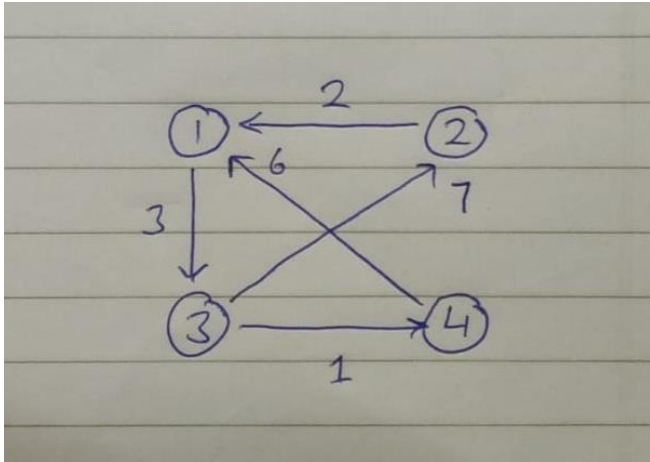
```
}

floyds(p, n);

printf("\nPath Matrix: \n");
for (i = 1; i <= n; i++)
{
    for (j = 1; j <= n; j++)
        printf("%d \t", p[i][j]);
    printf("\n");
}

}
```

GRAPH:



OUTPUT:

```
Enter the number of vertices: 4
Enter the number of edges: 5

Enter the end vertices of edge 1: 1 3
Enter Weight: 3

Enter the end vertices of edge 2: 2 1
Enter Weight: 2

Enter the end vertices of edge 3: 3 4
Enter Weight: 1

Enter the end vertices of edge 4: 3 2
Enter Weight: 7

Enter the end vertices of edge 5: 4 1
Enter Weight: 6
```

Adjacency Matrix:

| | | | |
|-----|-----|-----|-----|
| 999 | 999 | 3 | 999 |
| 2 | 999 | 999 | 999 |
| 999 | 7 | 999 | 1 |
| 6 | 999 | 999 | 999 |

Path Matrix:

| | | | |
|---|----|---|---|
| 0 | 10 | 3 | 4 |
| 2 | 0 | 5 | 6 |
| 7 | 7 | 0 | 1 |
| 6 | 16 | 9 | 0 |

PROGRAM-9

Find Minimum Cost Spanning Tree of a given undirected graph using Prim's and Kruskal's algorithm.

Prim's algorithm

```
#include <stdio.h>

int n, m, e = 0;

float sum = 0;

float costs[100][100];

int VT[100], ET[100][2], vis[20];

void prims()
{
    int u, v;
    int x = 1, j, K, min;
    VT[x] = 1;
    vis[x] = 1;
    for (int i = 1; i < n; i++)
    {
        j = x;
        min = 999;
        while (j > 0)
        {
            K = VT[j];
            for (int m = 2; m <= n; m++)
            {
                if (costs[K][m] < min && vis[m] == 0)
                {
```

```

        min = costs[K][m];
        u = K;
        v = m;
    }
}
j--;
}
VT[++x] = v;
ET[i][0] = u;
ET[i][1] = v;
e++;
vis[v] = 1;
sum += costs[u][v];
}
}

void main()
{
    printf("\n    Prim's Algorithm\n");
    printf("    .....");
    int u, v;
    float w;
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);

    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)

```

```

    {
        if (i == j)
            costs[i][j] = 0;
        else
            costs[i][j] = 999;
    }
}

printf("Enter the number of egdes: ");
scanf("%d", &m);

printf("Enter vertices of edge with its weight: \n");
for (int i = 1; i <= m; i++)
{
    scanf("%d%d%f", &u, &v, &w);
    costs[u][v] = costs[v][u] = w;
}

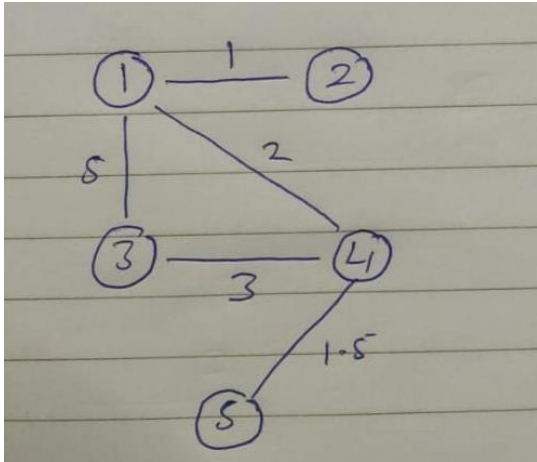
for (int i = 1; i <= n; i++)
{
    vis[i] = 0;
}

prims();

printf("\nMinimum Cost: %.2f\n", sum);
printf("\nEdges of Minimum spanning tree\n");
for (int i = 1; i <= e; i++)
{
    printf("%d-->%d\n", ET[i][0], ET[i][1]);
}
}

```


GRAPH:



OUTPUT:

```
Prim's Algorithm
-----
Enter the number of vertices: 5
Enter the number of egdes: 5
Enter vertices of edge with its weight:
1 2 1
1 3 5
1 4 2
3 4 3
4 5 1.5

Minimum Cost: 7.50

Edges of Minimum spanning tree
1-->2
1-->4
4-->5
4-->3
```

Kruskal's algorithm

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

int n, m, parent[100];
int count = 0;
int ET[100][2];
int cost[100][100];
int sum = 0;

void unionn(int a, int b)
{
    if (a < b)
        parent[b] = a;
    else
        parent[a] = b;
}

int find(int a)
{
    while (parent[a] != a)
    {
        a = parent[a];
    }
    return a;
}
```

```

void kruskal()
{
    int k = 0;
    for (int i = 1; i <= n; i++)
    {
        parent[i] = i;
    }
    while (count != n - 1)
    {
        int min = 999;
        int u, v;
        for (int i = 1; i <= n; i++)
        {
            for (int j = 1; j <= n; j++)
            {
                if (cost[i][j] < min && cost[i][j] != 0)
                {
                    min = cost[i][j];
                    u = i;
                    v = j;
                }
            }
        }

        int x = find(u);
        int y = find(v);

        if (x != y)

```

```

    {
        ET[k][0] = u;
        ET[k][1] = v;
        k++;
        count++;
        sum += cost[u][v];
        unionn(x, y);
    }

    cost[u][v] = cost[v][u] = 999;
}
}

int main()
{
    printf("\n    Kruskal's algorithm\n");
    printf("    .....");
    int u, v, w;
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);

    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            if (i == j)
                cost[i][j] = 0;
            else

```

```

        cost[i][j] = 999;
    }
}

printf("Enter the number of edges: ");
scanf("%d", &m);

printf("Enter the egde with its weight: \n");
for (int i = 1; i <= m; i++)
{
    scanf("%d%d%d", &u, &v, &w);
    cost[u][v] = cost[v][u] = w;
}

kruskal();

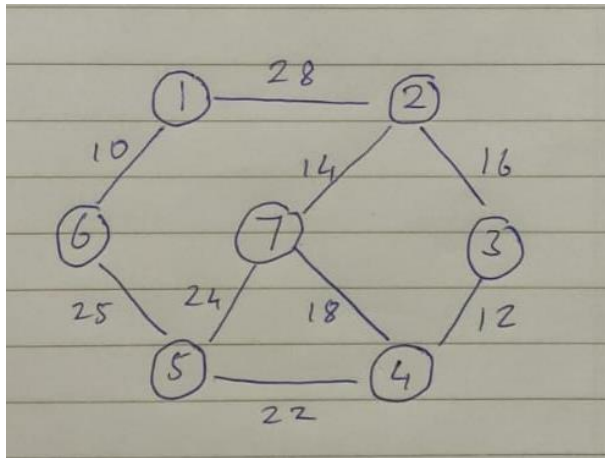
printf("\nMinimum cost = %d\n", sum);

printf("Minimum spanning tree:\n");
for (int i = 1; i < count; i++)
{
    printf("%d -> %d\n", ET[i][0], ET[i][1]);
}

return 0;
}

```

GRAPH:



OUTPUT:

Kruskal's algorithm

Enter the number of vertices: 7

Enter the number of edges: 9

Enter the edge with its weight:

1 2 28

1 6 10

2 7 14

2 3 16

3 4 12

4 7 18

4 5 22

5 7 24

5 6 25

Minimum cost = 99

Minimum spanning tree:

3 -> 4

2 -> 7

2 -> 3

4 -> 5

5 -> 6

PROGRAM-10

From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.

```
#include <stdio.h>

int dist[10], cost[100][100], n, vis[10], src;

void dijkstra()
{
    int count, min, u;
    for (int i = 1; i <= n; i++)
    {
        dist[i] = cost[src][i];
        vis[src] = 1;
    }
    count = 1;
    while (count < n)
    {
        min = 9999;
        for (int i = 1; i <= n; i++)
        {
            if (dist[i] < min && vis[i] == 0)
            {
                min = dist[i];
                u = i;
            }
        }
        vis[u] = 1;
        for (int i = 1; i <= n; i++)
        {
```

```

        if (dist[u] + cost[u][i] < dist[i] && vis[i] == 0)
        {
            dist[i] = dist[u] + cost[u][i];
        }
    }
    count++;
}
}

```

```

void main()
{
    int m, u, v, w;
    printf("\n    Dijkstra's Algorithm\n");
    printf("    .....");
    printf("\nEnter the number of vertices: ");
    scanf("%d", &n);
    for (int i = 1; i <= n; i++)
    {
        for (int j = 1; j <= n; j++)
        {
            if (i == j)
            {
                cost[i][j] = 0;
            }
            else
            {
                cost[i][j] = 9999;
            }
        }
    }
}

```



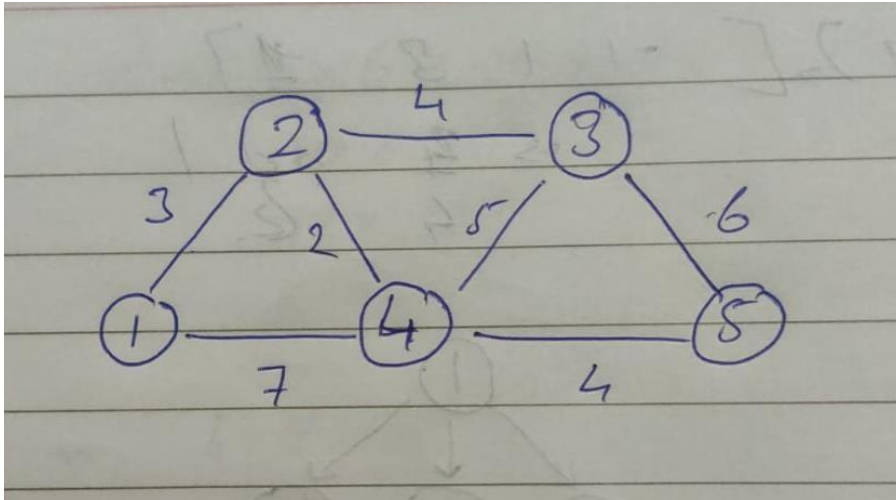
```

    }
}
printf("Enter the number of edges: ");
scanf("%d", &m);
printf("Enter the edge with its weight\n");
for (int i = 1; i <= m; i++)
{
    scanf("%d%d%d", &u, &v, &w);
    cost[v][u] = cost[u][v] = w;
}
printf("Enter the source\n");
scanf("%d", &src);
dijkstra();

printf("\n");
for (int i = 2; i <= n; i++)
    printf("The distance from %d --> %d is %d\n", src, i, dist[i]);
}

```

GRAPH:



OUTPUT:

```
Dijkstra's Algorithm
-----
Enter the number of vertices: 5
Enter the number of edges: 7
Enter the edge with its weight
1 2 3
1 4 7
2 3 4
2 4 2
3 4 5
3 5 6
4 5 4
Enter the source
1

The distance from 1 --> 2 is 3
The distance from 1 --> 3 is 7
The distance from 1 --> 4 is 5
The distance from 1 --> 5 is 9
```

PROGRAM-11

Implement “N-Queens Problem” using Backtracking.

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

```
int n, count=0;
```

```
int isSafe(char board[n][n], int row, int col)
```

```
{  
    for (int i = row - 1; i >= 0; i--)  
    {  
        if (board[i][col] == 'Q')  
        {  
            return 0;  
        }  
    }  
}
```

```
for (int i = row - 1, j = col - 1; i >= 0 && j >= 0; i--, j--)  
{  
    if (board[i][j] == 'Q')  
    {  
        return 0;  
    }  
}
```

```
for (int i = row - 1, j = col + 1; i >= 0 && j < n; i--, j++)  
{  
    if (board[i][j] == 'Q')
```

```

        {
            return 0;
        }
    }
    return 1;
}

void printBoard(char board[][n])
{
    printf("\n---Chess Board---\n");

    for (int i = 0; i < n; i++)
    {
        for (int j = 0; j < n; j++)
        {
            printf("%c ", board[i][j]);
        }
        printf("\n");
    }
}

void nQueens(char board[n][n], int row)
{
    if (row == n)
    {
        printBoard(board);
        count++;
        return;
    }
}

```

```

    }
    for (int j = 0; j < n; j++)
    {
        if (isSafe(board, row, j) == 1)
        {
            board[row][j] = 'Q';
            nQueens(board, row + 1);
            board[row][j] = 'X';
        }
    }
}

int main()
{
    printf("Enter the size of the board: ");
    scanf("%d", &n);
    char board[n][n];
    for (int i = 0; i < n; i++)
    {
        for (int j = 0; j < n; j++)
        {
            board[i][j] = 'X';
        }
    }
    nQueens(board, 0);
    printf("\nTotal Possible Solution: %d ",count);
}

```

OUTPUT:

```
Enter the size of the board: 4
```

```
---Chess Board---
```

```
X Q X X  
X X X Q  
Q X X X  
X X Q X
```

```
---Chess Board---
```

```
X X Q X  
Q X X X  
X X X Q  
X Q X X
```

```
Total Possible Solution: 2
```

LeetCode Problems

I.

The screenshot shows the LeetCode interface for the 'Set Matrix Zeroes' problem. The problem description on the left states: 'Given an $m \times n$ integer matrix `matrix`, if an element is 0, set its entire row and column to 0's. You must do it in place.' It includes an example with a 3x3 matrix transformation and the input/output arrays. The solution editor on the right contains the following Java code:

```
1 class Solution {
2     public void setZeroes(int[][] matrix) {
3         int row = matrix.length;
4         int col = matrix[0].length;
5         int[] dummyRow = new int[row];
6         int[] dummyCol = new int[col];
7         Arrays.fill(dummyRow, -1);
8         Arrays.fill(dummyCol, -1);
9         for(int i=0; i<row; i++){
10             for(int j=0; j<col; j++){
11                 if(matrix[i][j]==0){
12                     dummyRow[i] = 0;
13                     dummyCol[j] = 0;
14                 }
15             }
16         }
17         for(int i=0; i<row; i++){
18             for(int j=0; j<col; j++){
19                 if(dummyRow[i] == 0 || dummyCol[j] == 0 ){
20                     matrix[i][j]=0;
21                 }
22             }
23         }
24     }
25 }
```

The screenshot shows the LeetCode submission page for the 'Set Matrix Zeroes' problem. The submission table on the left shows a successful submission with the following details:

| Status | Language | Runtime | Memory | Time | Notes |
|----------|----------|---------|---------|--------------|-------|
| Accepted | Java | 1 ms | 44.9 MB | Jun 13, 2023 | |

The solution editor on the right contains the same Java code as in the previous screenshot:

```
1 class Solution {
2     public void setZeroes(int[][] matrix) {
3         int row = matrix.length;
4         int col = matrix[0].length;
5         int[] dummyRow = new int[row];
6         int[] dummyCol = new int[col];
7         Arrays.fill(dummyRow, -1);
8         Arrays.fill(dummyCol, -1);
9         for(int i=0; i<row; i++){
10             for(int j=0; j<col; j++){
11                 if(matrix[i][j]==0){
12                     dummyRow[i] = 0;
13                     dummyCol[j] = 0;
14                 }
15             }
16         }
17         for(int i=0; i<row; i++){
18             for(int j=0; j<col; j++){
19                 if(dummyRow[i] == 0 || dummyCol[j] == 0 ){
20                     matrix[i][j]=0;
21                 }
22             }
23         }
24     }
25 }
```

II.

Problem List

1971. Find if Path Exists in Graph

Easy

3.2K

155

☆

🔗

Companies

There is a **bi-directional** graph with n vertices, where each vertex is labeled from 0 to $n - 1$ (inclusive). The edges in the graph are represented as a 2D integer array `edges`, where each `edges[i] = [ui, vi]` denotes a bi-directional edge between vertex `ui` and vertex `vi`. Every vertex pair is connected by **at most one** edge, and no vertex has an edge to itself.

You want to determine if there is a **valid path** that exists from vertex `source` to vertex `destination`.

Given `edges` and the integers `n`, `source`, and `destination`, return `true` if there is a **valid path** from `source` to `destination`, or `false` otherwise.

Example 1:

Input: `n = 3`, `edges = [[0,1],[1,2],[2,0]]`, `source = 0`, `destination = 2`
Output: `true`
Explanation: There are two paths from vertex 0 to vertex 2:
 - `0 → 1 → 2`
 - `0 → 2`

Example 2:

```

1 class Solution {
2     public boolean validPath(int n, int[][] edges, int source, int destination) {
3         DS d = new DS(n);
4         for (int i = 0; i < edges.length; i++) {
5             d.union(edges[i][0], edges[i][1]);
6         }
7         return d.areTheyConnected(source, destination);
8     }
9 }
10
11 class DS {
12     int P[];
13
14     public DS(int n) {
15         P = new int[n];
16
17         for (int i = 0; i < n; i++) {
18             P[i] = i;
19         }
20     }
21
22     public boolean areTheyConnected(int u, int v) {
23         return find(u) == find(v);
24     }
25
26     private int find(int x) {
27         if (x == P[x]) {
28             return x;
29         } else {
30             return find(P[x]);
31         }
32     }
33
34     private void union(int x, int y) {
35         int X = find(x);
36         int Y = find(y);
37
38         if (X == Y) {
39             return;
40         } else {
41             P[Y] = X;
42         }
43     }
44 }

```

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← → ↺

leetcode.com/problems/find-if-path-exists-in-graph/submissions/

🔍 📄 ⭐ ⚙️ 👤

Problem List

Description

Editorial

Solutions (2K)

Submissions

Status ▾

Language ▾

Runtime

Memory

Time

Notes

⚙️

Accepted

Java

33 ms

100.2 MB

Jun 20, 2023

```

1 class Solution {
2     public boolean validPath(int n, int[][] edges, int source, int destination) {
3         DS d = new DS(n);
4         for (int i = 0; i < edges.length; i++) {
5             d.union(edges[i][0], edges[i][1]);
6         }
7         return d.areTheyConnected(source, destination);
8     }
9 }
10
11 class DS {
12     int P[];
13
14     public DS(int n) {
15         P = new int[n];
16
17         for (int i = 0; i < n; i++) {
18             P[i] = i;
19         }
20     }
21
22     public boolean areTheyConnected(int u, int v) {
23         return find(u) == find(v);
24     }
25
26     private int find(int x) {
27         if (x == P[x]) {
28             return x;
29         } else {
30             return find(P[x]);
31         }
32     }
33
34     private void union(int x, int y) {
35         int X = find(x);
36         int Y = find(y);
37
38         if (X == Y) {
39             return;
40         } else {
41             P[Y] = X;
42         }
43     }
44 }

```


III.

Problem List

112. Path Sum

Easy

8.9K

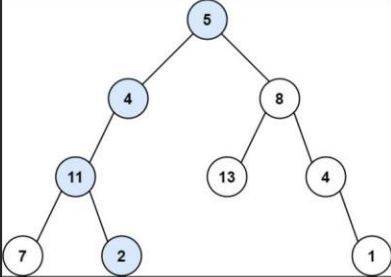
998

Companies

Given the `root` of a binary tree and an integer `targetSum`, return `true` if the tree has a **root-to-leaf** path such that adding up all the values along the path equals `targetSum`.

A **leaf** is a node with no children.

Example 1:



Input: `root = [5,4,8,11,null,13,4,7,2,null,null,null,1]`, `targetSum = 22`
Output: `true`
Explanation: The root-to-leaf path with the target sum is shown.

Console

Run

Submit

C

Auto

```
1
2
3
4
5
6 bool hasPathSum(struct TreeNode *root, int targetSum)
7 {
8     if(!root)
9         return 0;
10    targetSum -= root->val;
11    return (!targetSum && !root->right && !root->left) ||
12           hasPathSum(root->left, targetSum) || hasPathSum(root->right, targetSum);
13 }
```

Ln 13, Col 2

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← → ↺ leetcode.com/problems/path-sum/submissions/ 🔍 📄 ⚙️ 👤

Problem List

Submissions

Accepted

C

8 ms

8.1 MB

Jul 11, 2023

Console

Run

Submit

C

Auto

```
1
2
3
4
5
6 bool hasPathSum(struct TreeNode *root, int targetSum)
7 {
8     if(!root)
9         return 0;
10    targetSum -= root->val;
11    return (!targetSum && !root->right && !root->left) ||
12           hasPathSum(root->left, targetSum) || hasPathSum(root->right, targetSum);
13 }
```

Ln 13, Col 2

IV.

Problem List

221. Maximal Square

Medium

0.4K

198

Companies

Given an $m \times n$ binary matrix filled with 0's and 1's, find the largest square containing only 1's and return its area.

Example 1:

| | | | | |
|---|---|---|---|---|
| 1 | 0 | 1 | 0 | 0 |
| 1 | 0 | 1 | 1 | 1 |
| 1 | 1 | 1 | 1 | 1 |
| 1 | 0 | 0 | 1 | 0 |

Input: matrix = [[["1","0","1","0","0"],["1","0","1","1","1"],["1","1","1","1","1"],["1","0","0","1","0"]],
Output: 4

Example 2:

| | |
|---|---|
| 0 | 1 |
|---|---|

Console

Run Submit

Java

Auto

```

1 class Solution
2 {
3     public int maximalSquare(char[][] a) {
4         if (a == null || a.length == 0 || a[0].length == 0)
5             return 0;
6         int max = 0, n = a.length, m = a[0].length;
7         int[][] dp = new int[n + 1][m + 1];
8         for (int i = 1; i <= n; i++)
9         {
10             for (int j = 1; j <= m; j++)
11             {
12                 if (a[i - 1][j - 1] == '1')
13                 {
14                     dp[i][j] = Math.min(dp[i - 1][j - 1], Math.min(dp[i - 1][j], dp[i][j - 1])) + 1;
15                     max = Math.max(max, dp[i][j]);
16                 }
17             }
18         }
19         return max * max;
20     }
21 }

```

Ln 21, Col 2

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← → ↺

leetcode.com/problems/maximal-square/submissions/

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Problem List

Solutions (2.2K)

Submissions

| Status | Language | Runtime | Memory | Time | Notes |
|----------|----------|---------|---------|--------------|-------|
| Accepted | Java | 6 ms | 54.4 MB | Jul 25, 2023 | |

Console

Run Submit

Java

Auto

```

1 class Solution
2 {
3     public int maximalSquare(char[][] a) {
4         if (a == null || a.length == 0 || a[0].length == 0)
5             return 0;
6         int max = 0, n = a.length, m = a[0].length;
7         int[][] dp = new int[n + 1][m + 1];
8         for (int i = 1; i <= n; i++)
9         {
10             for (int j = 1; j <= m; j++)
11             {
12                 if (a[i - 1][j - 1] == '1')
13                 {
14                     dp[i][j] = Math.min(dp[i - 1][j - 1], Math.min(dp[i - 1][j], dp[i][j - 1])) + 1;
15                     max = Math.max(max, dp[i][j]);
16                 }
17             }
18         }
19         return max * max;
20     }
21 }

```

Ln 21, Col 2