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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



B.M.S. COLLEGE OF ENGINEERING
(Autonomous Institution under VTU)
BENGALURU-560019
April-2024 to August-2024

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Department of Computer Science and Engineering



CERTIFICATE

This is to certify that the Lab work entitled “**Analysis and Design of Algorithms**” carried out by **Pratham Ganapathy(1BM22CS206)**, 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 academic semester April-2024 to August-2024. The Lab report has been approved as it satisfies the academic requirements in respect of an **Analysis and Design of Algorithms (23CS4PCADA)** work prescribed for the said degree.

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10	<ul style="list-style-type: none"> □ Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm. □ From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm. □ Implement Fractional Knapsack using Greedy technique. 	38
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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.

Lab 1

LeetCode: Repeated Substring Pattern

```
char* substring(char *s, int start, int end) {
    char *res = (char*)malloc((end - start + 1) * sizeof(char));
    int j = 0;

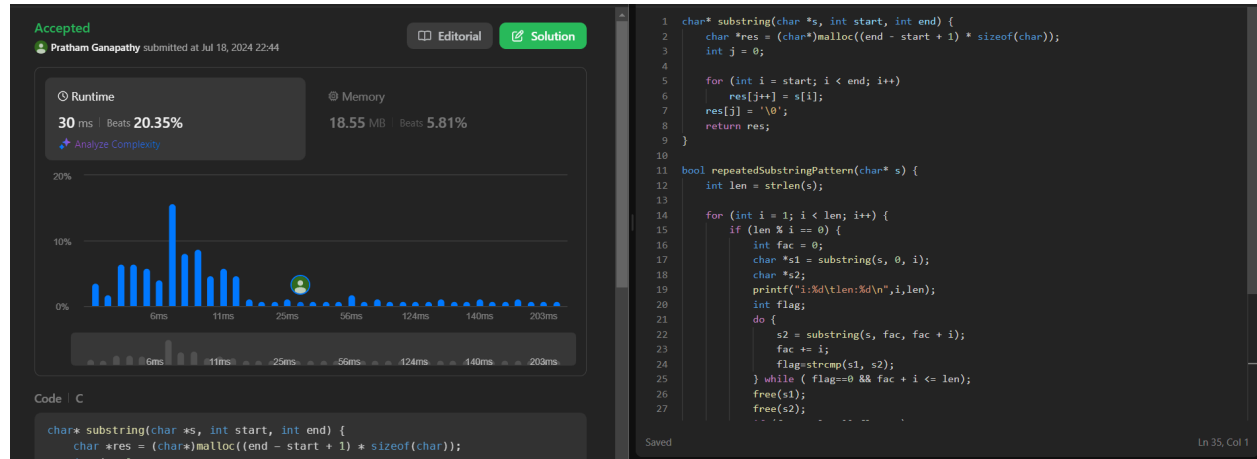
    for (int i = start; i < end; i++)
        res[j++] = s[i];
    res[j] = '\0';
    return res;
}

bool repeatedSubstringPattern(char* s) {
    int len = strlen(s);

    for (int i = 1; i < len; i++) {
        if (len % i == 0) {
            int fac = 0;
            char *s1 = substring(s, 0, i);
            char *s2;
            printf("i:%d\tlen:%d\n", i, len);
            int flag;
            do {
                s2 = substring(s, fac, fac + i);
                fac += i;
                flag = strcmp(s1, s2);
            } while (flag == 0 && fac + i <= len);
            free(s1);
            free(s2);
            if (fac == len && flag == 0)
                return true;
        }
    }

    return false;
}
```

Output



Lab 2

LeetCode: Kth Largest Sum in a Binary Tree

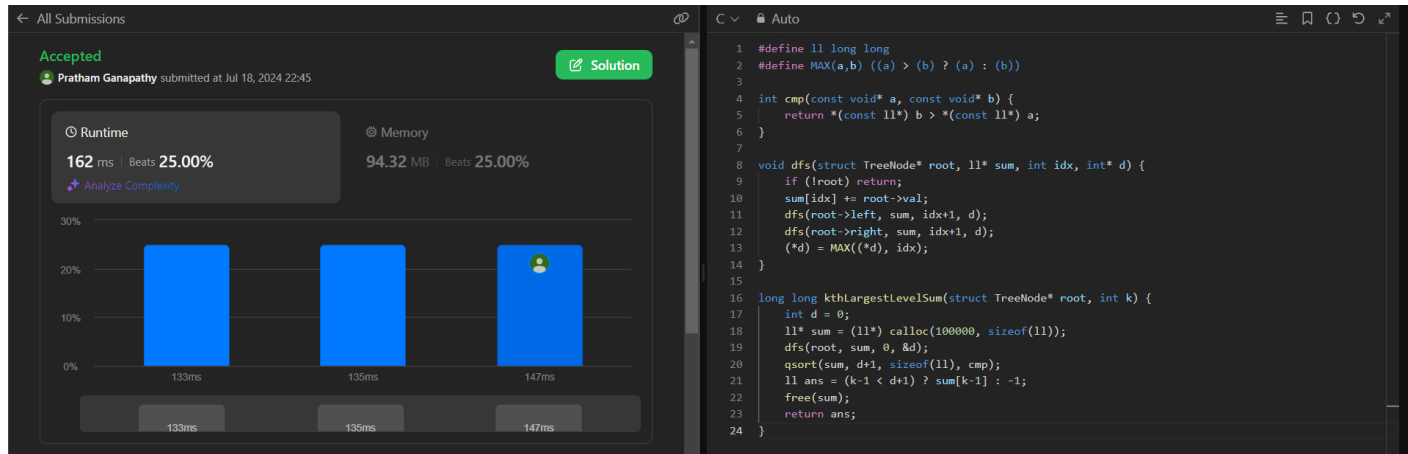
```
#define ll long long
#define MAX(a,b) ((a) > (b) ? (a) : (b))

int cmp(const void* a, const void* b) {
    return *(const ll*) b > *(const ll*) a;
}

void dfs(struct TreeNode* root, ll* sum, int idx, int* d) {
    if (!root) return;
    sum[idx] += root->val;
    dfs(root->left, sum, idx+1, d);
    dfs(root->right, sum, idx+1, d);
    (*d) = MAX(*d, idx);
}

long long kthLargestLevelSum(struct TreeNode* root, int k) {
    int d = 0;
    ll* sum = (ll*) calloc(100000, sizeof(ll));
    dfs(root, sum, 0, &d);
    qsort(sum, d+1, sizeof(ll), cmp);
    ll ans = (k-1 < d+1) ? sum[k-1] : -1;
    free(sum);
    return ans;
}
```

Output



Lab 3

LeetCode: Increasing Order Search Tree

```
/**
 * Definition for a binary tree node.
 * struct TreeNode {
 *     int val;
 *     struct TreeNode *left;
 *     struct TreeNode *right;
 * };
 */

struct TreeNode* increasingBST(struct TreeNode* root) {
    if (!root) {
        return NULL;
    }

    struct TreeNode* left = increasingBST(root->left);
    struct TreeNode* right = increasingBST(root->right);

    root->left = NULL;
    root->right = right;

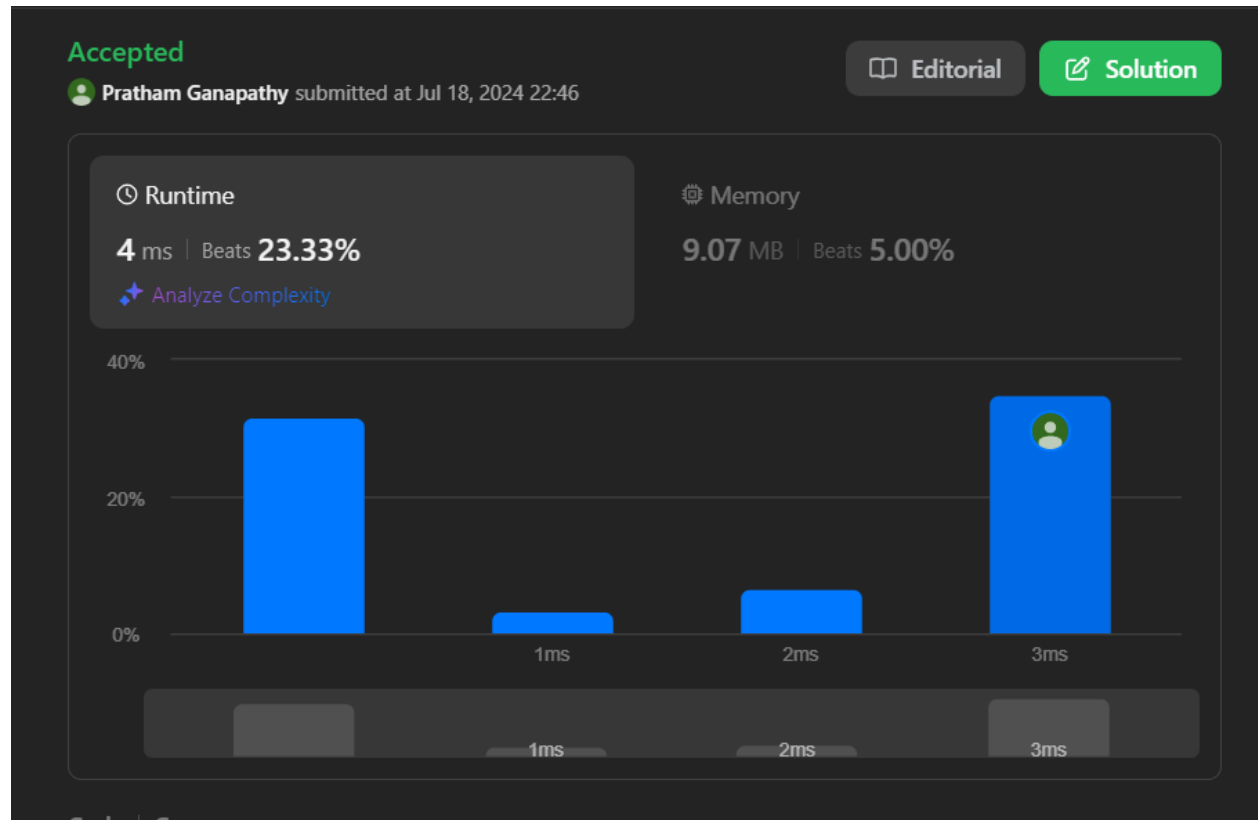
    if (!left) {
        return root;
    }

    struct TreeNode* iter = left;
    while (iter && iter->right) {
        iter = iter->right;
    }

    iter->right = root;

    return left;
}
```

Output



Lab 4

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

DFS

```
#include <stdio.h>

int s[100];
int res[100];
int m=0;

void dfs(int u, int n, int a[n][n]);
void dfs_tp(int n, int a[n][n]);

void dfs_tp(int n, int a[n][n]){

    for(int i=0;i<n;i++)
        s[i]=0;

    for(int u=0; u<n; u++){
        if(s[u]==0)
            dfs(u,n,a);
    }
}

void dfs(int u, int n, int a[n][n]){

    s[u]=1;
    res[m]=u;
    m++;

    for(int v=0; v<n; v++){
        if(a[u][v]==1 && s[v]==0)
            dfs(v,n,a);
    }
}
```

```

int main()
{
    int i,n;
    n=6;

    int a[6][6] = {

        {0, 0, 0, 0, 0, 0}, // Node 0
        {0, 0, 0, 1, 0, 0}, // Node 1
        {0, 0, 0, 1, 0, 0}, // Node 2
        {0, 0, 0, 0, 0, 0}, // Node 3
        {1, 1, 0, 0, 0, 0}, // Node 4
        {1, 0, 1, 0, 0, 0} // Node 5

    };

    dfs_tp(n,a);

    printf("DFS Traversal order:\n");
    for(int i=n-1;i>0;i--)
        printf("%d\t",res[i]);

    return 0;
}

```

Output

```

DFS Traversal order:
5      4      2      3      1

```

Source Removal

```

#include <stdio.h>
#define v 100
int top = -1;

void indegree(int a_matrix[v][v], int n, int in[v])
{
    for (int i = 0; i < n; i++)

```

```

    {
        for (int j = 0; j < n; j++)
        {
            if (a_matrix[i][j])
            {
                in[j]++;
            }
        }
    }
}

```

```

void toposort(int a_matrix[v][v], int n)
{

```

```

    int in[v] = {0};
    int topo[v];
    int k = 0;
    int s[v] = {0};

```

```

    indegree(a_matrix, n, in);

```

```

    for (int i = 0; i < n; i++)
    {
        if (in[i] == 0)
        {
            top++;
            s[top] = i;
        }
    }

```

```

    while (top != -1)
    {

```

```

        int vertex = s[top];
        top--;
        topo[k++] = vertex;

```

```

        for (int i = 0; i < n; i++)
        {
            if (a_matrix[vertex][i])
            {
                in[i]--;
                if (in[i] == 0)
                {
                    top++;

```

```

        s[top] = i;
    }
}

}

if (k != n)
{
    printf("cycle exists");
}
else
{
    printf("the topological sort: ");
    for (int i = 0; i < n; i++)
    {
        printf("%d ", topo[i] + 1);
    }
}
}

int main()
{
    int a_matrix[v][v] = {
        {0, 1, 0, 0, 0, 1},
        {0, 0, 1, 1, 0, 0},
        {0, 0, 0, 0, 0, 0},
        {0, 0, 0, 0, 0, 1},
        {1, 0, 0, 0, 0, 0},
        {0, 0, 0, 0, 0, 0}
    };
    int n = 6;

    toposort(a_matrix, n);
    return 0;
}

```

Output

```
the topological sort: 5 1 2 4 6 3
```

Lab 5

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

Merge Sort

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

void merge(int a[],int l,int m,int high)
{
    int i,h;h=l;i=0;
    int j=m+1;int b[high-l+1];
    while(h<=m && j<=high)
    {
        if(a[h]<=a[j])
        {
            b[i]=a[h];
            h++;
        }
        else
        {
            b[i]=a[j];
            j++;
        }i++;
    }
    if(h<=m)
        for(int k=h;k<=m;k++)
        {
            b[i++]=a[k];
        }
    if(j<=high)
        for(int k=j;k<=high;k++)
        {
            b[i++]=a[k];
        }
}
```

```

        for(int k=0,j=1;k<=high;k++,j++)
        {
            a[j]=b[k];
        }
    }

void mergesort(int a[],int l,int h)
{
    int m;
    if(l<h)
    {
        m=(l+h)/2;
        mergesort(a,l,m);
        mergesort(a,m+1,h);
        merge(a,l,m,h);
    }
}

int main()
{
    clock_t start,end;
    int n;
    printf("Enter the number of array elements:");
    scanf("%d",&n);
    int arr[n];
    srand(time(NULL));
    for (int i=0;i<n;i++)
        arr[i]=rand();
    start=clock();
    mergesort(arr,0,n-1);
    end=clock();
    printf("\nTime taken:%f",((double)(end - start)) / CLOCKS_PER_SEC);
    return 0;
}

```

Output


```

1: For manual entry of N value and array elements
2: To display time taken for sorting number of elements N in the range 500 to 15000 to 100000
3: To exit
Enter your choice: 1

Enter the number of elements: 6

Enter array elements: 3 5 1 2 6 4

Sorted array is: 1      2      3      4      5      6

```

Selection Sort

```

#include<stdio.h>
#include<time.h>
#include<stdlib.h> /* To recognise exit function when compiling with gcc*/

void selsort(int n,int a[]);

void main(){
    int a[15000],n,i,j,ch,temp;
    clock_t start,end;

    while(1){
        printf("\n1:For manual entry of N value and array elements");
        printf("\n2:To display time taken for sorting number of elements N in
the range 500 to 14500");
        printf("\n3:To exit");
        printf("\nEnter your choice:");
        scanf("%d", &ch);
        switch(ch){
            case 1:
                printf("\nEnter the number of elements: ");
                scanf("%d",&n);
                printf("\nEnter array elements: ");
                for(i=0;i<n;i++){
                    scanf("%d",&a[i]);
                }
                start=clock();
                selsort(n,a);
                end=clock();

```

```

        printf("\nSorted array is: ");
        for(i=0;i<n;i++)
            printf("%d\t",a[i]);
        printf("\n Time taken to sort %d numbers is %f Secs",n,
(((double)(end-start))/CLOCKS_PER_SEC));
        break;
    case 2:
        n=500;
        while(n<=14500) {
        for(i=0;i<n;i++){
            //a[i]=random(1000);
            a[i]=n-i;
        }
        start=clock();
        selsort(n,a);
        //Dummy loop to create delay
        for(j=0;j<500000;j++){
            temp=38/600;
        }
        end=clock();
        printf("\n Time taken to sort %d numbers is %f Secs",n,
(((double)(end-start))/CLOCKS_PER_SEC));
        n=n+1000;
        }
        break;
    case 3:
        exit(0);
    }
    getchar();
}
}

```

```

void selsort(int n,int a[]){
    int i,j,t,small,pos;
    for(i=0;i<n-1;i++)
    {
        pos=i;
        small=a[i];
        for(j=i+1;j<n;j++)
        {
            if(a[j]<small)
            {

```

```

        small=a[j];
        pos=j;
    }
}
t=a[i];
a[i]=a[pos];
a[pos]=t;
}
}

```

Output

```

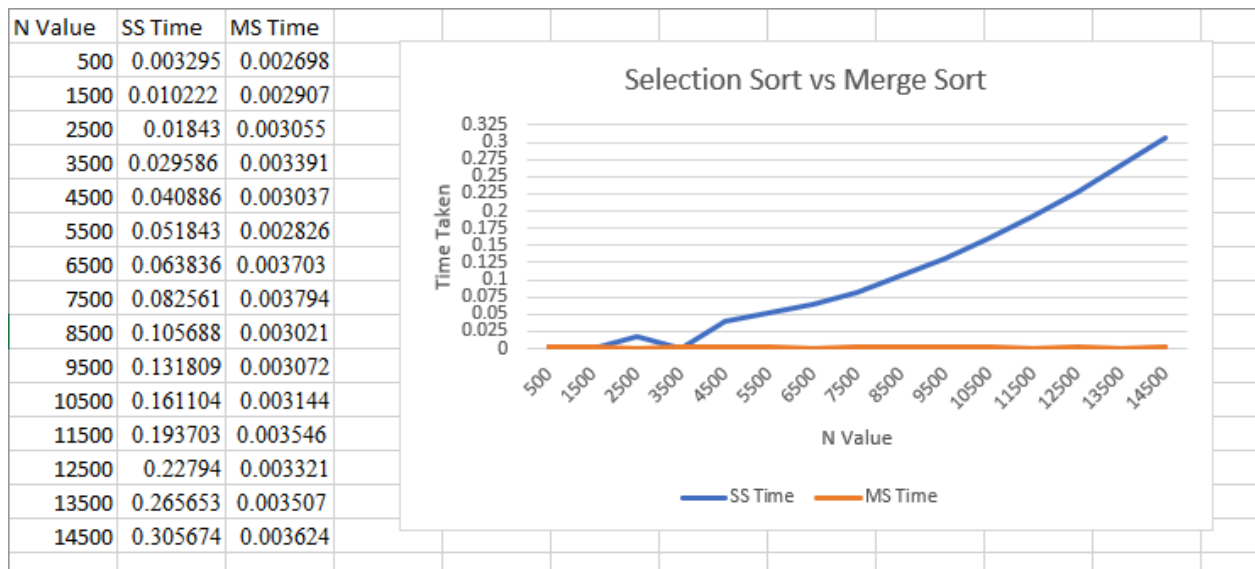
1:For manual entry of N value and array elements
2:To display time taken for sorting number of elements N in the range 500 to 14500
3:To exit
Enter your choice:1

Enter the number of elements: 6

Enter array elements: 4 1 2 6 3 5

Sorted array is: 1      2      3      4      5      6

```



Lab 6

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

```
#include<stdio.h>
#include<time.h>
#include<stdlib.h> /* To recognise exit function when compiling with gcc*/
void swap(int* a, int* b);
int partition(int arr[],int low, int high);
void quicksort(int arr[], int low, int high);
void main()
{
    int i,j,ch, temp;
    clock_t start,end;
    int a[110000], n;

    while(1)
    {
        printf("\n1:For manual entry of N value and array elements");
        printf("\n2:To display time taken for sorting number of elements N in the
range 7500 to 25000");
        printf("\n3:To exit");
        printf("\nEnter your choice:");
        scanf("%d", &ch);
        switch(ch)
        {
            case 1: printf("\nEnter the number of elements: ");
                    scanf("%d",&n);
                    printf("\nEnter array elements: ");
                    for(i=0;i<n;i++)
                    {
                        scanf("%d",&a[i]);
                    }
                }
```

```

    }
    start=clock();
    quicksort(a,0,n-1);
    end=clock();
    printf("\nSorted array is: ");
    for(i=0;i<n;i++)
        printf("%d\t",a[i]);
    printf("\n Time taken to sort %d numbers is %f Secs",n,
    (((double)(end-start))/CLOCKS_PER_SEC));
    break;
case 2:
    n=7500;
    while(n<=25500) {
        for(i=0;i<n;i++)
        {
            //a[i]=random(1000);
            a[i]=n-i;
        }
        start=clock();
        quicksort(a,0,n-1);
        //Dummy loop to create delay
        for(j=0;j<500000;j++){ temp=38/600;}
        end=clock();
        printf("\n Time taken to sort %d numbers is %f Secs",n,
        (((double)(end-start))/CLOCKS_PER_SEC));
        n=n+1000;
    }
    break;
case 3: exit(0);
}
getchar();
}
}

```

```

void swap(int* p1, int* p2)
{
    int temp;
    temp = *p1;
    *p1 = *p2;
    *p2 = temp;
}

```

```

}

int partition(int arr[], int low, int high)
{
    // choose the pivot
    int pivot = arr[high];

    // Index of smaller element and Indicate
    // the right position of pivot found so far
    int i = (low - 1);

    for (int j = low; j <= high; j++) {
        // If current element is smaller than the pivot
        if (arr[j] < pivot) {
            // Increment index of smaller element
            i++;
            swap(&arr[i], &arr[j]);
        }
    }
    swap(&arr[i + 1], &arr[high]);
    return (i + 1);
}

void quicksort(int arr[], int low, int high)
{
    if (low < high) {

        int pivot = partition(arr, low, high);

        quicksort(arr, low, pivot - 1);
        quicksort(arr, pivot + 1, high);
    }
}

```

Output

```

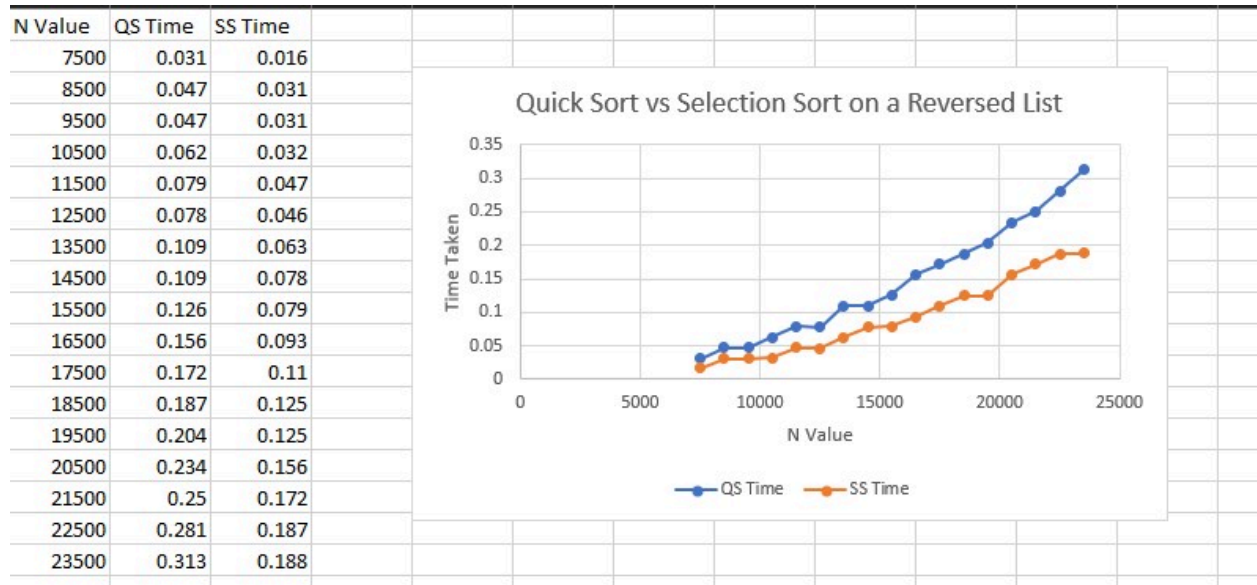
1:For manual entry of N value and array elements
2:To display time taken for sorting number of elements N in the range 7500 to 25000
3:To exit
Enter your choice:1

Enter the number of elements: 6

Enter array elements: 1 6 3 5 2 4

Sorted array is: 1      2      3      4      5      6
Time taken to sort 6 numbers is 0.000001 Secs

```



Lab 7

Implement Johnson Trotter algorithm to generate permutations.

```
#include <stdio.h>
#include <stdlib.h>
int flag = 0;
int swap(int *a,int *b)
{
    int t =*a;
    *a = *b;
    *b = t;
}
int search(int arr[],int num,int mobile)
{
    int g;
    for(g=0; g<num; g++)
    {
        if(arr[g] == mobile)
            return g+1;
        else
        {
            flag++;
        }
    }
    return -1;
}

int find_Moblie(int arr[],int d[],int num)
{

```



```

int mobile = 0;
int mobile_p = 0;
int i;
for(i=0; i<num; i++)
{
    if((d[arr[i]-1] == 0) && i != 0)
    {
        if(arr[i]>arr[i-1] && arr[i]>mobile_p)
        {
            mobile = arr[i];
            mobile_p = mobile;
        }
        else
        {
            flag++;
        }
    }
    else if((d[arr[i]-1] == 1) && i != num-1)
    {
        if(arr[i]>arr[i+1] && arr[i]>mobile_p)
        {
            mobile = arr[i];
            mobile_p = mobile;
        }
        else
        {
            flag++;
        }
    }
    else
    {
        flag++;
    }
}
if((mobile_p == 0) && (mobile == 0)) return 0;
else return mobile;
}

void permutations(int arr[],int d[],int num)
{
    int i;
    int mobile = find_Moblle(arr,d,num);
    int pos = search(arr,num,mobile);

```

```

        if(d[arr[pos-1]-1]==0) swap(&arr[pos-1],&arr[pos-2]);
        else
            swap(&arr[pos-1],&arr[pos]);
        for(int i=0; i<num; i++)
        {
            if(arr[i] > mobile)
            {
                if(d[arr[i]-1]==0) d[arr[i]-1] = 1;
                else d[arr[i]-1] = 0;
            }
        }
        for(i=0; i<num; i++)
        {
            printf(" %d ",arr[i]);
        }
    }

int factorial(int k)
{
    int f = 1;
    int i = 0;
    for(i=1; i<k+1; i++)
    {
        f = f*i;
    }
    return f;
}

int main()
{
    int num =0;
    int i;
    int j;
    int z =0;
    printf("Johnson trotter algorithm to find all permutations of given numbers \n");
    printf("Enter the number: ");
    scanf("%d",&num);
    int arr[num],d[num];
    z = factorial(num);
    printf("total permutations = %d",z);
    printf("\nAll possible permutations are: \n");
    for(i=0; i<num; i++)
    {

```

```

        d[i] = 0;
        arr[i] = i+1;
        printf(" %d ",arr[i]);
    }
    printf("\n");
    for(j=1; j<z; j++)
    {
        permutations(arr,d,num);
        printf("\n");
    }
    return 0;
}

```

Output

```

Johnson trotter algorithm to find all permutations of given numbers
Enter the number: 4
total permutations = 24
All possible permutations are:
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

```

Substring matching or pattern matching of substring in text return the position of it.

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

int main(){
    int m, n;
    printf("Enter m and n: ");
    scanf("%d%d", &m, &n);
    char s1[m], s2[n];
    fflush(stdin);
    printf("Enter string 1: ");
    scanf("%s", s1);
    printf("Enter string 2: ");
    scanf("%s", s2);
    // printf("%s %s", s1, s2);
    int i = 0, j = 0;
    while (i < n - m + 1){
        if (s1[0] == s2[i]){
            bool found = true;
            while (j < m){
                if (s1[j] != s2[i+j]) found = false;
                j++;
            }
            if (found) printf("Found at %d", i);
        }
        i++;
    }
    return 0;
}
```

Output

```
Enter m and n: 3 7
Enter string 1: hin
Enter string 2: abhinav
Found at 2
```

Lab 8

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

```
#include <stdio.h>

#define V 4

#define INF 99999

void printSolution(int dist[][V]);

void floydWarshall(int dist[][V])
{
    int i, j, k;

    for (k = 0; k < V; k++) {
        for (i = 0; i < V; i++) {
            for (j = 0; j < V; j++) {
                if (dist[i][k] + dist[k][j] < dist[i][j])
                    dist[i][j] = dist[i][k] + dist[k][j];
            }
        }
    }
    printSolution(dist);
}

void printSolution(int dist[][V])
{
    printf(
        "The following matrix shows the shortest distances between every
```

```

pair of vertices \n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            if (dist[i][j] == INF)
                printf("%7s", "INF");
            else
                printf("%7d", dist[i][j]);
        }
        printf("\n");
    }
}

int main()
{
    int graph[V][V] = { { 0, 3, INF, 1 },
                        { INF, 0, 6, 2 },
                        { INF, INF, 0, 1 },
                        { INF, INF, INF, 0 } };

    floydWarshall(graph);
    return 0;
}

```

Output

The following matrix shows the shortest distances between every pair of vertices

0	3	9	1
INF	0	6	2
INF	INF	0	1
INF	INF	INF	0

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

```

#include <stdio.h>

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

```

```

        *b = temp;
    }

void display(int arr[],int n){
    for(int i=0;i<n;i++)
        printf("%d ",arr[i]);
    printf("\n");
}
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], &arr[largest]);

        heapify(arr, N, largest);
    }
    printf("heapify:");
    display(arr,N);
}

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], &arr[i]);
            heapify(arr, i, 0);
            printf("heapsort:");
            display(arr,N);
        }
    }

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

int main()
{
    int arr[] = { 14,8,3,9,44,32};
    int N = sizeof(arr) / sizeof(arr[0]);
    heapSort(arr, N);
    printf("Sorted array is\n");
    printArray(arr, N);
}

```

Output

```

Input array: 14 8 3 9 44 32
Sorted array is:3 8 9 14 32 44

```




Lab 9

Implement 0/1 Knapsack problem using dynamic programming.

```
#include <stdio.h>

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

void knapsack(int n, int W, int weights[], int values[]) {
    int i, w;
    int dp[n+1][W+1];

    for (i = 0; i <= n; i++) {
        for (w = 0; w <= W; w++) {
            if (i == 0 || w == 0) {
                dp[i][w] = 0;
            } else if (weights[i-1] <= w) {
                dp[i][w] = max(dp[i-1][w], dp[i-1][w - weights[i-1]] +
values[i-1]);
            } else {
                dp[i][w] = dp[i-1][w];
            }
        }
    }
}
```

```

    }
}

printf("DP Table:\n");
for (i = 0; i <= n; i++) {
    for (w = 0; w <= W; w++) {
        printf("%d\t", dp[i][w]);
    }
    printf("\n");
}

printf("Selected items: ");
int res = dp[n][W];
w = W;
for (i = n; i > 0 && res > 0; i--) {
    if (res == dp[i-1][w])
        continue;
    else {
        printf("%d ", i);
        res = res - values[i-1];
        w = w - weights[i-1];
    }
}
printf("\nMaximum profit: %d\n", dp[n][W]);
}

int main() {
    int n = 4;
    int weights[] = {2, 3, 4, 5};
    int values[] = {3, 4, 5, 8};
    int W = 5;

    knapsack(n, W, weights, values);
    return 0;
}

```

Output

DP Table:

0	0	0	0	0	0
0	0	3	3	3	3
0	0	3	4	4	7
0	0	3	4	5	7
0	0	3	4	5	8

Selected items: 4

Maximum profit: 8

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

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

#define MAX_VERTICES 5

int minKey(int n, int key[], int mstSet[]) {
    int min = INT_MAX, min_index;

    for (int v = 0; v < n; v++) {
        if (mstSet[v] == 0 && key[v] < min) {
            min = key[v];
            min_index = v;
        }
    }

    return min_index;
}

void printMST(int n, int parent[], int cost[MAX_VERTICES][MAX_VERTICES]) {
    int sum = 0;

    printf("Edges in MST:\n");
```

```

    for (int i = 1; i < n; i++) {
        printf("%d - %d\n", parent[i], i);
        sum += cost[i][parent[i]];
    }

    printf("Cost of MST is: %d\n", sum);
}

void primMST(int n, int cost[MAX_VERTICES][MAX_VERTICES]) {
    int parent[MAX_VERTICES];
    int key[MAX_VERTICES];
    int mstSet[MAX_VERTICES];

    for (int i = 0; i < n; i++) {
        key[i] = INT_MAX;
        mstSet[i] = 0;
    }

    key[0] = 0;
    parent[0] = -1;

    for (int count = 0; count < n - 1; count++) {

        int u = minKey(n, key, mstSet);
        mstSet[u] = 1;

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

            if (cost[u][v] && mstSet[v] == 0 && cost[u][v] < key[v]) {
                parent[v] = u;
                key[v] = cost[u][v];
            }
        }
    }

    printMST(n, parent, cost);
}

int main() {
    int n = MAX_VERTICES;

```

```

int cost[MAX_VERTICES][MAX_VERTICES] = {
    {0, 2, 0, 6, 0},
    {2, 0, 3, 8, 5},
    {0, 3, 0, 0, 7},
    {6, 8, 0, 0, 9},
    {0, 5, 7, 9, 0}
};

printf("Cost adjacency matrix:\n");
for (int i = 0; i < n; i++) {
    for (int j = 0; j < n; j++) {
        printf("%d ", cost[i][j]);
    }
    printf("\n");
}

primMST(n, cost);

return 0;
}

```

Output

```

Cost adjacency matrix:
0 2 0 6 0
2 0 3 8 5
0 3 0 0 7
6 8 0 0 9
0 5 7 9 0
Edges in MST:
0 - 1
1 - 2
0 - 3
1 - 4
Cost of MST is: 16

```

Lab 10

1. Find Minimum Cost Spanning Tree of a given undirected graph using Kruskal's algorithm.
2. From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.

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

#define MAX 100
#define INF 9999

typedef struct Edge {
    int src, dest, weight;
} Edge;

int find(int parent[], int i) {
```

```

    if (parent[i] == i)
        return i;
    return find(parent, parent[i]);
}

void Union(int parent[], int rank[], int x, int y) {
    int xroot = find(parent, x);
    int yroot = find(parent, y);

    if (rank[xroot] < rank[yroot])
        parent[xroot] = yroot;
    else if (rank[xroot] > rank[yroot])
        parent[yroot] = xroot;
    else {
        parent[yroot] = xroot;
        rank[xroot]++;
    }
}

int compareEdges(const void* a, const void* b) {
    Edge* edgeA = (Edge*) a;
    Edge* edgeB = (Edge*) b;
    return edgeA->weight > edgeB->weight;
}

void KruskalMST(int graph[MAX][MAX], int numVertices) {
    int E = 0;
    Edge edges[MAX * MAX];
    for (int i = 0; i < numVertices; i++) {
        for (int j = i + 1; j < numVertices; j++) {
            if (graph[i][j] != 0 && graph[i][j] != INF) {
                edges[E].src = i;
                edges[E].dest = j;
                edges[E].weight = graph[i][j];
                E++;
            }
        }
    }

    qsort(edges, E, sizeof(edges[0]), compareEdges);

    int parent[numVertices];
    int rank[numVertices];

```

```

    for (int v = 0; v < numVertices; v++) {
        parent[v] = v;
        rank[v] = 0;
    }

    Edge result[numVertices];
    int e = 0, i = 0;

    while (e < numVertices - 1 && i < E) {
        Edge next_edge = edges[i++];
        int x = find(parent, next_edge.src);
        int y = find(parent, next_edge.dest);

        if (x != y) {
            result[e++] = next_edge;
            Union(parent, rank, x, y);
        }
    }

    printf("Edges in the MST:\n");
    for (i = 0; i < e; i++)
        printf("%d -- %d == %d\n", result[i].src, result[i].dest,
result[i].weight);
}

int minDistance(int dist[], bool sptSet[], int numVertices) {
    int min = INT_MAX, min_index;
    for (int v = 0; v < numVertices; v++)
        if (sptSet[v] == false && dist[v] <= min)
            min = dist[v], min_index = v;
    return min_index;
}

void printSolution(int dist[], int numVertices) {
    printf("Vertex \t Distance from Source\n");
    for (int i = 0; i < numVertices; i++)
        printf("%d \t\t %d\n", i, dist[i]);
}

void dijkstra(int graph[MAX][MAX], int src, int numVertices) {
    int dist[numVertices];
    bool sptSet[numVertices];

```



```

    for (int i = 0; i < numVertices; i++)
        dist[i] = INT_MAX, sptSet[i] = false;

    dist[src] = 0;

    for (int count = 0; count < numVertices - 1; count++) {
        int u = minDistance(dist, sptSet, numVertices);
        sptSet[u] = true;

        for (int v = 0; v < numVertices; v++)
            if (!sptSet[v] && graph[u][v] && dist[u] != INT_MAX
                && dist[u] + graph[u][v] < dist[v])
                dist[v] = dist[u] + graph[u][v];
    }

    printSolution(dist, numVertices);
}

int main() {
    int numVertices = 5;
    int graph[MAX][MAX] = {
        {0, 2, INF, 6, INF},
        {2, 0, 3, 8, 5},
        {INF, 3, 0, INF, 7},
        {6, 8, INF, 0, 9},
        {INF, 5, 7, 9, 0}
    };

    printf("Kruskal's MST:\n");
    KruskalMST(graph, numVertices);

    printf("\nDijkstra's Shortest Paths from vertex 0:\n");
    dijkstra(graph, 0, numVertices);

    return 0;
}

```

Output

Kruskal's MST:

Edges in the MST:

0 -- 1 == 2

1 -- 2 == 3

1 -- 4 == 5

0 -- 3 == 6

Dijkstra's Shortest Paths from vertex 0:

Vertex	Distance from Source
--------	----------------------

0	0
---	---

1	2
---	---

2	5
---	---

3	6
---	---

4	7
---	---

Implement Fractional Knapsack using Greedy technique.

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

```
void knapsack(int n, int p[], int w[], int W) {
```

```
    int used[n];
```

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

```
        used[i] = 0;
```

```
    }
```

```
    int cur_w = W;
```

```
    float tot_v = 0.0;
```

```
    int i, maxi;
```

```
    while (cur_w > 0) {
```

```
        maxi = -1;
```

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

```
            if ((used[i] == 0) && ((maxi == -1) || ((float)p[i]/w[i] >
```

```

(float)p[maxi]/w[maxi])) {
    maxi = i;
}

if (maxi == -1) break; // no more items to select

used[maxi] = 1;

if (w[maxi] <= cur_w) {
    cur_w -= w[maxi];
    tot_v += p[maxi];
    printf("Added object %d (weight: %d, profit: %d) completely in
the bag. Space left: %d.\n", maxi + 1, w[maxi], p[maxi], cur_w);
} else {
    int taken = cur_w;
    cur_w = 0;
    tot_v += (float)taken/w[maxi] * p[maxi];
    printf("Added %d%% (weight: %d, profit: %d) of object %d in the
bag.\n", (int)((float)taken/w[maxi] * 100), w[maxi], p[maxi], maxi + 1);
}
}

printf("Filled the bag with objects worth %.2f.\n", tot_v);
}

int main() {
    int n, W;
    printf("Enter the number of objects: ");
    scanf("%d", &n);

    int p[n], w[n];

    printf("Enter the profits of the objects: ");
    for (int i = 0; i < n; i++) {
        scanf("%d", &p[i]);
    }

    printf("Enter the weights of the objects: ");
    for (int i = 0; i < n; i++) {
        scanf("%d", &w[i]);
    }
}

```

```

    printf("Enter the maximum weight of the bag: ");
    scanf("%d", &W);

    knapsack(n, p, w, W);

    return 0;
}

```

Output

```

Enter the number of objects: 4
Enter the profits of the objects: 20 30 66 40
Enter the weights of the objects: 10 20 30 40
Enter the maximum weight of the bag: 50
Added object 3 (weight: 30, profit: 66) completely in the bag. Space left: 20.
Added object 1 (weight: 10, profit: 20) completely in the bag. Space left: 10.
Added 50% (weight: 20, profit: 30) of object 2 in the bag.
Filled the bag with objects worth 101.00.

```

Lab 11

Implement “N-Queens Problem” using Backtracking.

```

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

bool place(int[], int);
void printSolution(int[], int);
void nQueens(int);

int main() {
    int n;
    printf("Enter the number of queens: ");
    scanf("%d", &n);
    nQueens(n);
    return 0;
}

void nQueens(int n) {

```

```

int x[10] = {0}; // Initialize the array to zero
int count = 0;
int k = 1;

while (k != 0) {
    x[k] = x[k] + 1;

    while (x[k] <= n && !place(x, k)) {
        x[k] = x[k] + 1;
    }

    if (x[k] <= n) {
        if (k == n) {
            printSolution(x, n);
            printf("Solution found\n");
            count++;
        } else {
            k++;
            x[k] = 0;
        }
    } else {
        k--;
    }
}

printf("Total solutions: %d\n", count);
}

bool place(int x[], int k) {
    for (int i = 1; i < k; i++) {
        if ((x[i] == x[k]) ||
            (i - x[i] == k - x[k]) ||
            (i + x[i] == k + x[k])) {
            return false;
        }
    }
    return true;
}

void printSolution(int x[], int n) {
    for (int i = 1; i <= n; i++) {
        printf("%d ", x[i]);
    }
}

```

```
    printf("\n");  
}
```

Output

```
Enter the number of queens: 4  
2 4 1 3  
Solution found  
3 1 4 2  
Solution found  
Total solutions: 2
```