VISVESVARAYA TECHNOLOGICAL UNIVERSITY

"JnanaSangama", Belgaum -590014, Karnataka.

LAB REPORT
On

ANALYSIS AND DESIGN OF ALGORITHMS (23CS4PCADA)

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
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This is to certify that the Lab work entitled **"ANALYSIS AND DESIGN OF ALGORITHMS"** carried out by Shankar Shivappa Pujar**(1BM23CS309)**, who is bonafide student of **B. M. S. College of Engineering**. It is in partial fulfillment for the award of **Bachelor of Engineering in Computer Science and Engineering** of the Visvesvaraya Technological University, Belgaum during the year 2024-25. The Lab report has been approved as it satisfies the academic requirements in respect of Analysis and Design of Algorithms Lab - **(23CS4PCADA)** work prescribed for the said degree.

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Index Sheet

Course outcomes:

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 program 1:

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

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

#define MAX 100

int graph[MAX][MAX];
int visited[MAX];
int stack[MAX];
int top = -1;

void dfs(int v, int vertices) {
    visited[v] = 1;
    for (int i = 0; i < vertices; i++) {
        if (graph[v][i] && !visited[i])
            dfs(i, vertices);
    }
    stack[++top] = v;
}

void topologicalSort(int vertices) {
    for (int i = 0; i < vertices; i++)
        visited[i] = 0;

    for (int i = 0; i < vertices; i++) {
        if (!visited[i])
            dfs(i, vertices);
    }
```

```
    printf("Topological Order: ");
    while (top >= 0)
        printf("%d ", stack[top--]);
}

int main() {
    int vertices, edges;
    printf("Enter number of vertices: ");
    scanf("%d", &vertices);

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

    for (int i = 0; i < vertices; i++)
        for (int j = 0; j < vertices; j++)
            graph[i][j] = 0;

    printf("Enter edges (source destination):\n");
    for (int i = 0; i < edges; i++) {
        int src, dest;
        scanf("%d %d", &src, &dest);
        graph[src][dest] = 1;
    }

    topologicalSort(vertices);

    return 0;
}
```

OUTPUT:

```
Enter number of vertices: 6
Enter number of edges: 6
Enter edges (source destination):
5 2
5 0
4 0
4 1
2 3
3 1
Topological Order: 5 4 2 3 1 0
Process returned 0 (0x0)   execution time : 32.122 s
Press any key to continue.
```

1.1 LeetCode Program related to Topological sorting

Code:

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

#define MAX 100

struct Node {
    int vertex;
    struct Node* next;
};

int queue[MAX], front = -1, rear = -1;

void enqueue(int value) {
    if (rear == MAX - 1) return;
    if (front == -1) front = 0;
    queue[++rear] = value;
```

```
}

int dequeue() {
    if (front == -1 || front > rear) return -1;
    return queue[front++];
}

struct Graph {
    int vertices;
    struct Node** adjList;
    int* inDegree;
};

struct Node* createNode(int v) {
    struct Node* newNode = malloc(sizeof(struct Node));
    newNode->vertex = v;
    newNode->next = NULL;
    return newNode;
}

struct Graph* createGraph(int vertices) {
    struct Graph* graph = malloc(sizeof(struct Graph));
    graph->vertices = vertices;
    graph->adjList = malloc(vertices * sizeof(struct Node*));
    graph->inDegree = calloc(vertices, sizeof(int));
    for (int i = 0; i < vertices; i++)
        graph->adjList[i] = NULL;
    return graph;
}
```

```
void addEdge(struct Graph* graph, int src, int dest) {
    struct Node* newNode = createNode(dest);
    newNode->next = graph->adjList[src];
    graph->adjList[src] = newNode;
    graph->inDegree[dest]++;
}

void topologicalSort(struct Graph* graph) {
    for (int i = 0; i < graph->vertices; i++) {
        if (graph->inDegree[i] == 0)
            enqueue(i);
    }

    int count = 0;
    int topOrder[MAX];

    while (front <= rear) {
        int u = dequeue();
        topOrder[count++] = u;

        struct Node* temp = graph->adjList[u];
        while (temp) {
            int v = temp->vertex;
            graph->inDegree[v]--;
            if (graph->inDegree[v] == 0)
                enqueue(v);
            temp = temp->next;
        }
```

```
    }

    if (count != graph->vertices) {
        printf("Cycle detected! Topological sort not possible.\n");
        return;
    }

    printf("Topological Sort Order: ");
    for (int i = 0; i < count; i++)
        printf("%d ", topOrder[i]);
    printf("\n");
}

int main() {
    int vertices, edges;
    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &vertices, &edges);

    struct Graph* graph = createGraph(vertices);

    printf("Enter edges (source destination):\n");
    for (int i = 0; i < edges; i++) {
        int src, dest;
        scanf("%d %d", &src, &dest);
        addEdge(graph, src, dest);
    }

    topologicalSort(graph);
```

```
    return 0;
}
```

OUTPUT

```
Enter number of vertices and edges: 6 6
Enter edges (source destination):
5 2
5 0
4 0
4 1
2 3
3 1
Topological Sort Order: 4 5 0 2 3 1

Process returned 0 (0x0)   execution time : 27.454 s
Press any key to continue.
```

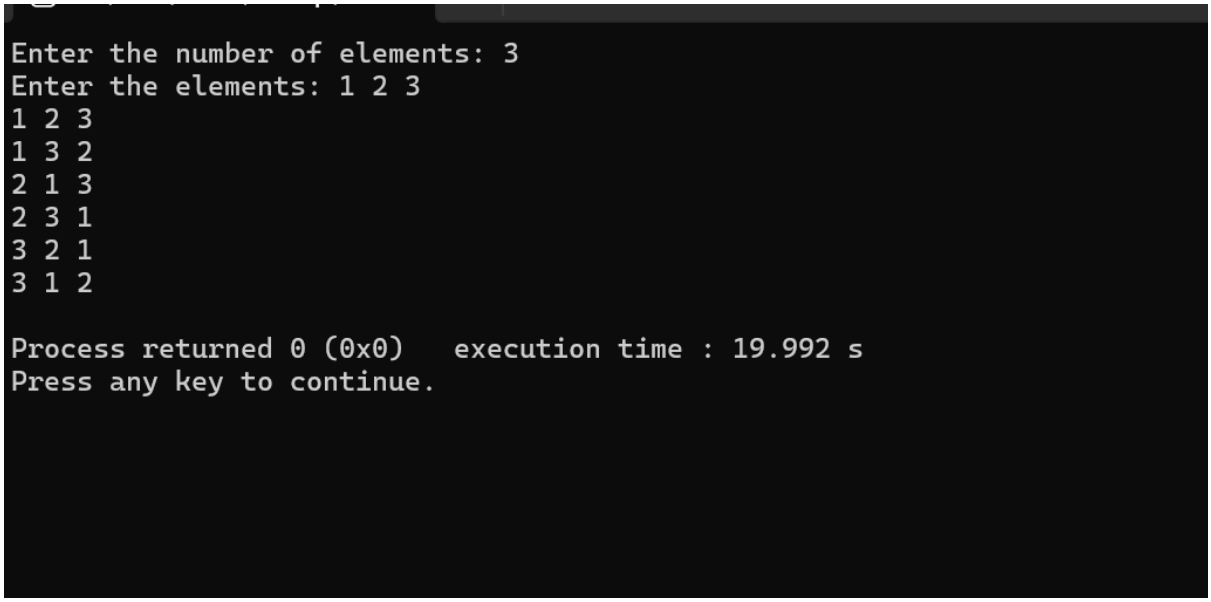
LAB PROGRAM 2:

Implement Johnson Trotter algorithm to generate permutations.

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

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

void generatePermutations(int arr[], int start, int end) {
    if (start == end) {
        for (int i = 0; i <= end; i++) {
```

```
            printf("%d ", arr[i]);
        }
        printf("\n");
    } else {
        for (int i = start; i <= end; i++) {
            swap(&arr[start], &arr[i]);
            generatePermutations(arr, start + 1, end);
            swap(&arr[start], &arr[i]); // backtrack
        }
    }
}

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

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

    generatePermutations(arr, 0, n - 1);
    free(arr);
    return 0;
}
```

OUTPUT



LAB PROGRAM 3:

Sort a given set of N integer elements using 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 <time.h>


int a[20], n;


void merge_sort(int [], int, int);

void merge(int [], int, int, int);


int main() {

   int i;

   clock_t start, end;

   double time_taken;



   printf("Enter the number of elements: ");
```

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


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


start = clock();


merge_sort(a, 0, n - 1);


end = clock();


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


printf("Sorted array: ");
for (i = 0; i < n; i++) {
   printf("%d ", a[i]);
}
printf("\n");


printf("Time taken to sort: %f seconds\n", time_taken);
```

```
    return 0;
}

void merge_sort(int a[], int low, int high) {
    if (low < high) {
        int mid = (low + high) / 2;



        merge_sort(a, low, mid);
        merge_sort(a, mid + 1, high);



        merge(a, low, mid, high);
    }
}

void merge(int a[], int low, int mid, int high) {
    int i = low, j = mid + 1, k = low;
    int c[20];

    while (i <= mid && j <= high) {
        if (a[i] < a[j]) {
            c[k++] = a[i++];
        } else {
            c[k++] = a[j++];
        }
    }

    while (i <= mid) {
```

```
        c[k++] = a[i++];
    }



    while (j <= high) {
        c[k++] = a[j++];
    }


    for (i = low; i <= high; i++) {
        a[i] = c[i];
    }
}
```

OUTPUT

```
Enter the number of elements: 4
Enter the array elements: 23
32
45
56
Sorted array: 23 32 45 56
Time taken to sort: 0.000000 seconds

Process returned 0 (0x0)   execution time : 11.756 s
Press any key to continue.
```

3.1 LeetCode Program related to sorting.

Code

```
#include <stdio.h>


void merge(int arr[], int left, int mid, int right) {
```

```
    int n1 = mid - left + 1;
    int n2 = right - mid;

    int L[n1], R[n2];

    for (int i = 0; i < n1; i++)
        L[i] = arr[left + i];
    for (int j = 0; j < n2; j++)
        R[j] = arr[mid + 1 + j];

    int i = 0, j = 0, k = left;

    while (i < n1 && j < n2) {
        if (L[i] <= R[j])
            arr[k++] = L[i++];
        else
            arr[k++] = R[j++];
    }

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

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

void mergeSort(int arr[], int left, int right) {
    if (left < right) {
        int mid = left + (right - left) / 2;
```

```
        mergeSort(arr, left, mid);
        mergeSort(arr, mid + 1, right);

        merge(arr, left, mid, right);
    }
}

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

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

    mergeSort(arr, 0, n - 1);

    printf("Sorted Array:\n");
    for (int i = 0; i < n; i++)
        printf("%d ", arr[i]);
    printf("\n");

    return 0;
}
```

OUTUT

```
Enter number of elements: 5
Enter 5 elements:
3 1 4 1 5
Sorted Array:
1 1 3 4 5

Process returned 0 (0x0)   execution time : 5.161 s
Press any key to continue.
```

LAB PROGRAM 4:

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

```
#include <stdio.h>

#include <stdlib.h>

#include <time.h>


#define MAX 5000


void quicksort(int[], int, int);

int partition(int[], int, int);


int main() {

   int i, n, a[MAX], ch = 1;

   clock_t start, end;


   srand(time(0));


   while (ch) {

      printf("\nEnter the number of elements: ");
```

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

    if (n <= 0 || n > MAX) {
        printf("Invalid input! Please enter a number between 1 and %d.\n", MAX);
        continue;
    }

    for (i = 0; i < n; i++)
        a[i] = rand() % 200;

    printf("The randomly generated array is:\n");
    for (i = 0; i < n; i++)
        printf("%d ", a[i]);

    start = clock();
    quicksort(a, 0, n - 1);
    end = clock();

    printf("\n\nThe sorted array elements are:\n");
    for (i = 0; i < n; i++)
        printf("%d\n", a[i]);

    printf("\nTime taken = %f seconds\n", (double)(end - start) / CLOCKS_PER_SEC);

    printf("\nDo you wish to continue? (0 for No, 1 for Yes): ");
    scanf("%d", &ch);
}

return 0;
```

```
}

void quicksort(int a[], int low, int high) {
    if (low < high) {
        int mid = partition(a, low, high);
        quicksort(a, low, mid - 1);
        quicksort(a, mid + 1, high);
    }
}

int partition(int a[], int low, int high) {
    int key = a[low], i = low + 1, j = high, temp;

    while (i <= j) {
        while (i <= high && a[i] <= key) i++;
        while (a[j] > key) j--;

        if (i < j) {
            temp = a[i];
            a[i] = a[j];
            a[j] = temp;
        }
    }

    temp = a[j];
    a[j] = a[low];
    a[low] = temp;

    return j;
```

}

OUTPUT

```
Enter the number of elements: 4
The randomly generated array is:
165 41 11 61

The sorted array elements are:
11
41
61
165

Time taken = 0.000000 seconds

Do you wish to continue? (0 for No, 1 for Yes):
```

4.1 LeetCode Program related to sorting.

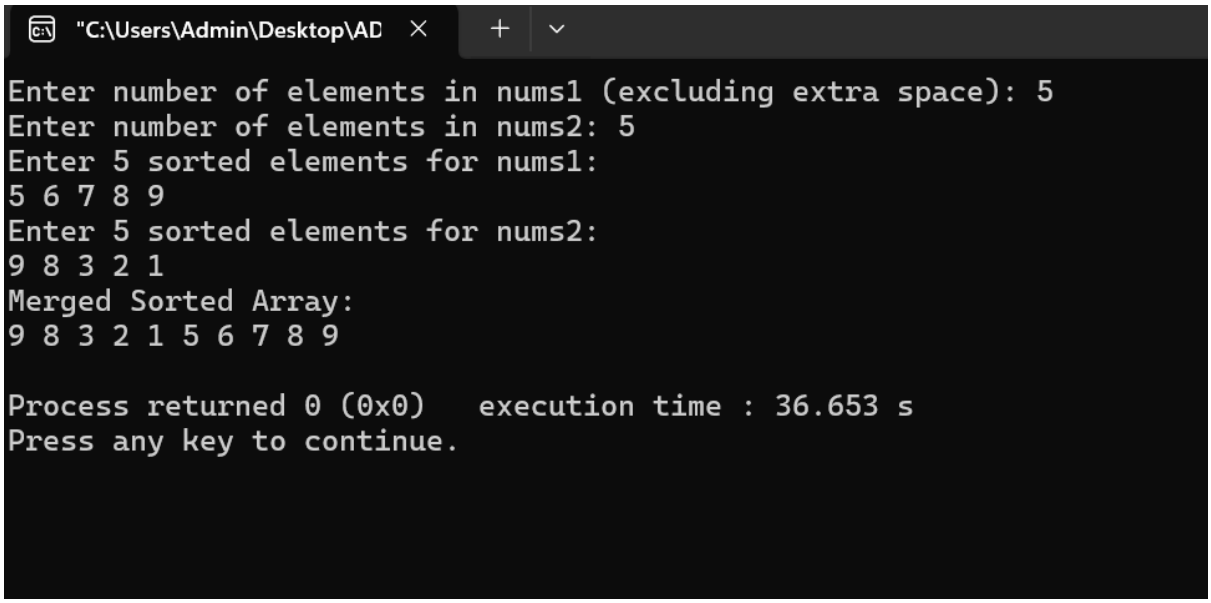
Code

```
#include <stdio.h>


void merge(int* nums1, int m, int* nums2, int n) {
    int i = m - 1;
    int j = n - 1;
    int k = m + n - 1;


    while (i >= 0 && j >= 0) {
        if (nums1[i] > nums2[j])
            nums1[k--] = nums1[i--];
        else
            nums1[k--] = nums2[j--];
    }
```

```
    while (j >= 0)
        nums1[k--] = nums2[j--];
}

int main() {
    int m, n;
    printf("Enter number of elements in nums1 (excluding extra space): ");
    scanf("%d", &m);

    printf("Enter number of elements in nums2: ");
    scanf("%d", &n);

    int nums1[m + n], nums2[n];

    printf("Enter %d sorted elements for nums1:\n", m);
    for (int i = 0; i < m; i++)
        scanf("%d", &nums1[i]);

    for (int i = m; i < m + n; i++)
        nums1[i] = 0;

    printf("Enter %d sorted elements for nums2:\n", n);
    for (int i = 0; i < n; i++)
        scanf("%d", &nums2[i]);

    merge(nums1, m, nums2, n);

    printf("Merged Sorted Array:\n");
    for (int i = 0; i < m + n; i++)
```

```
        printf("%d ", nums1[i]);
    printf("\n");


    return 0;
}
```

OUTPUT



LAB PROGRAM 5:

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

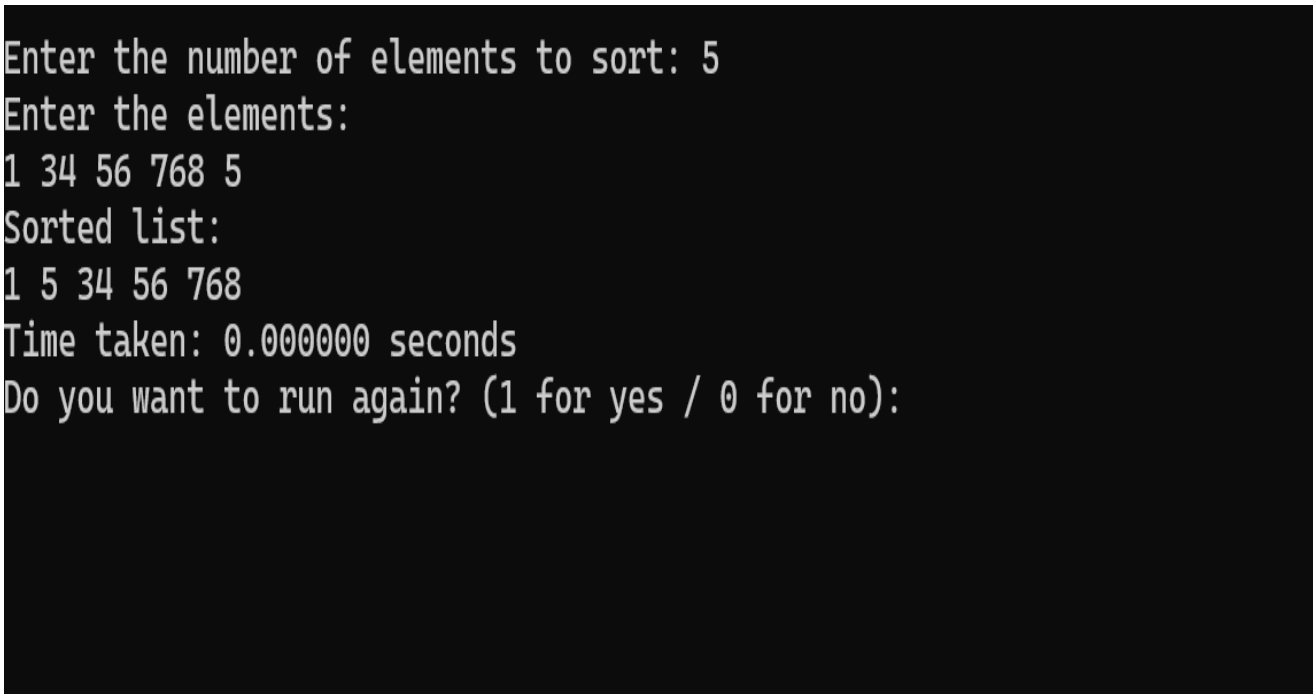
```
#include <stdio.h>
#include <time.h>


#define MAX 20


void heapcom(int a[], int n) {
    int i, j, k, item;
    for (i = 1; i <= n; i++) {
        item = a[i];
        j = i;
```

```
        k = j / 2;
        while (k != 0 && item > a[k]) {
            a[j] = a[k];
            j = k;
            k = j / 2;
        }
        a[j] = item;
    }
}

void adjust(int a[], int n) {
    int item, i, j;
    j = 1;
    item = a[j];
    i = 2 * j;
    while (i < n) {
        if ((i + 1) < n && a[i] < a[i + 1]) {
            i++;
        }
        if (item < a[i]) {
            a[j] = a[i];
            j = i;
            i = 2 * j;
        } else {
            break;
        }
    }
    a[j] = item;
}
```

```
void heapsort(int a[], int n) {
    int i, temp;
    heapcom(a, n);
    for (i = n; i >= 1; i--) {
        temp = a[1];
        a[1] = a[i];
        a[i] = temp;
        adjust(a, i);
    }
}

int main() {
    int i, n, a[MAX], ch = 1;
    clock_t start, end;

    while (ch) {
        printf("\nEnter the number of elements to sort: ");
        scanf("%d", &n);

        printf("Enter the elements:\n");
        for (i = 1; i <= n; i++)
            scanf("%d", &a[i]);

        start = clock();
        heapsort(a, n);
        end = clock();

        printf("Sorted list:\n");
```

```
    for (i = 1; i <= n; i++)
        printf("%d ", a[i]);

    double time_taken = (double)(end - start) / CLOCKS_PER_SEC;
    printf("\nTime taken: %.6f seconds\n", time_taken);

    printf("Do you want to run again? (1 for yes / 0 for no): ");
    scanf("%d", &ch);
  }

  return 0;
}
```

OUTPUT



LAB PROGRAM 6:

Implement 0/1 Knapsack problem using dynamic programming

```
#include <stdio.h>

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

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

void knapsack(int n, int w[10], int p[10], int c) {
   for (i = 0; i <= n; i++) {
      for (j = 0; j <= c; j++) {
         if (i == 0 || j == 0)
            v[i][j] = 0;
         else if (w[i] > j)
            v[i][j] = v[i - 1][j];
         else
            v[i][j] = max(v[i - 1][j], v[i - 1][j - w[i]] + p[i]);
      }
   }

   printf("\n\nMaximum Profit is: %d\n", v[n][c]);
   printf("\nDP Table:\n\n");
   for (i = 0; i <= n; i++) {
      for (j = 0; j <= c; j++) {
         printf("%d\t", v[i][j]);
      }
      printf("\n");
```

```
    }
}

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

    printf("Enter the weights: ");
    for (i = 1; i <= n; i++) {
        scanf("%d", &w[i]);
    }

    printf("Enter the profits: ");
    for (i = 1; i <= n; i++) {
        scanf("%d", &p[i]);
    }

    printf("Enter the capacity: ");
    scanf("%d", &c);

    knapsack(n, w, p, c);
    return 0;
}
```

OUTPUT

```
Enter the number of objects: 3
Enter the weights: 1 2 3
Enter the profits: 10 20 30
Enter the capacity: 5


Maximum Profit is: 50

DP Table:

0       0       0       0       0       0
0       10      10      10      10      10
0       10      20      30      30      30
0       10      20      30      40      50

Process returned 0 (0x0)   execution time : 82.264 s
Press any key to continue.
```

6.1 LeetCode Program related to Knapsack problem or Dynamic Programming.

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

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

int knapsack(int W, int wt[], int val[], int n) {
   int **dp = (int **)malloc((n + 1) * sizeof(int *));
   for (int i = 0; i <= n; i++) {
      dp[i] = (int *)malloc((W + 1) * sizeof(int));
   }

   for (int i = 0; i <= n; i++) {
      for (int w = 0; w <= W; w++) {
         if (i == 0 || w == 0)
```

```
            dp[i][w] = 0;
        else if (wt[i - 1] <= w)
            dp[i][w] = max(val[i - 1] + dp[i - 1][w - wt[i - 1]], dp[i - 1][w]);
        else
            dp[i][w] = dp[i - 1][w];
    }
  }

  int maxValue = dp[n][W];

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

  return maxValue;
}

int main() {
  int n, W;
  printf("Enter number of items and knapsack capacity: ");
  scanf("%d %d", &n, &W);

  int *wt = (int *)malloc(n * sizeof(int));
  int *val = (int *)malloc(n * sizeof(int));

  printf("Enter weights of the items:\n");
  for (int i = 0; i < n; i++)
    scanf("%d", &wt[i]);
```

```
    printf("Enter values of the items:\n");
    for (int i = 0; i < n; i++)
        scanf("%d", &val[i]);

    int maxValue = knapsack(W, wt, val, n);
    printf("Maximum value that can be obtained: %d\n", maxValue);

    free(wt);
    free(val);

    return 0;
}
```

OUTPUT

```
Enter number of items and knapsack capacity: 4 7
Enter weights of the items:
1 3 4 5
Enter values of the items:
1 4 5 7
Maximum value that can be obtained: 9

Process returned 0 (0x0)   execution time : 37.840 s
Press any key to continue.
```

LAB PROGRAM 7:

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

```
#include <stdio.h>

#define MAX 10
#define INF 99999
```

```
void floydWarshall(int dist[MAX][MAX], int n) {
    int i, j, k;
    for (k = 0; k < n; k++) {
        for (i = 0; i < n; i++) {
            for (j = 0; j < n; j++) {
                if (dist[i][k] + dist[k][j] < dist[i][j]) {
                    dist[i][j] = dist[i][k] + dist[k][j];
                }
            }
        }
    }
}

int main() {
    int n, i, j;
    int graph[MAX][MAX];

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

    printf("Enter the adjacency matrix (use %d for INF):\n", INF);
    for (i = 0; i < n; i++)
        for (j = 0; j < n; j++)
            scanf("%d", &graph[i][j]);

    floydWarshall(graph, n);

    printf("All-Pairs Shortest Path Matrix:\n");
    for (i = 0; i < n; i++) {
```

```
        for (j = 0; j < n; j++) {
            if (graph[i][j] == INF)
                printf("INF ");
            else
                printf("%3d ", graph[i][j]);
        }
        printf("\n");
    }

    return 0;
}
```

OUTPUT

```
Enter the number of vertices: 4
Enter the adjacency matrix (use 99999 for INF):
0 3 99999 7
8 0 2 99999
5 99999 0 1
2 99999 99999 0
All-Pairs Shortest Path Matrix:
  0   3   5   6
  5   0   2   3
  3   6   0   1
  2   5   7   0

Process returned 0 (0x0)   execution time : 46.567 s
Press any key to continue.
```

7.1 LeetCode Program related to shortest distance calculation

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

#define MAX 100
#define INF INT_MAX
```

```
int minDistance(int dist[], int visited[], int n) {
    int min = INF, min_index = -1;
    for (int v = 0; v < n; v++) {
        if (!visited[v] && dist[v] <= min) {
            min = dist[v];
            min_index = v;
        }
    }
    return min_index;
}

void dijkstra(int graph[MAX][MAX], int n, int src) {
    int dist[n];
    int visited[n];

    for (int i = 0; i < n; i++) {
        dist[i] = INF;
        visited[i] = 0;
    }

    dist[src] = 0;

    for (int count = 0; count < n - 1; count++) {
        int u = minDistance(dist, visited, n);
        if (u == -1) break;

        visited[u] = 1;

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

```
            if (!visited[v] && graph[u][v] && dist[u] != INF && dist[u] + graph[u][v] < dist[v])
{
                dist[v] = dist[u] + graph[u][v];
            }
        }
    }

    printf("Shortest distances from node %d:\n", src);
    for (int i = 0; i < n; i++) {
        if (dist[i] == INF)
            printf("Node %d: Unreachable\n", i);
        else
            printf("Node %d: %d\n", i, dist[i]);
    }
}

int main() {
    int n, e;
    printf("Enter number of nodes and edges: ");
    scanf("%d %d", &n, &e);

    int graph[MAX][MAX] = {0};

    printf("Enter edges (u v weight):\n");
    for (int i = 0; i < e; i++) {
        int u, v, w;
        scanf("%d %d %d", &u, &v, &w);
        graph[u][v] = w;
        // For undirected graph, also set: graph[v][u] = w;
    }
```

```
    int src;
    printf("Enter source node: ");
    scanf("%d", &src);

    dijkstra(graph, n, src);

    return 0;
}
```

```
Enter number of nodes and edges: 4 4
Enter edges (u v weight):
0 1 1
0 2 4
1 2 2
2 3 1
Enter source node: 0
Shortest distances from node 0:
Node 0: 0
Node 1: 1
Node 2: 3
Node 3: 4

Process returned 0 (0x0)   execution time : 46.809 s
Press any key to continue.
```

LAB PROGRAM 8:

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

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

#define MAX 100

int minKey(int key[], int mstSet[], int V) {
```

```
    int min = INT_MAX, min_index;

    for (int v = 0; v < V; v++)
        if (mstSet[v] == 0 && key[v] < min)
            min = key[v], min_index = v;

    return min_index;
}

void printMST(int parent[], int graph[MAX][MAX], int V) {
    int totalCost = 0;
    printf("Edge \tWeight\n");
    for (int i = 1; i < V; i++) {
        printf("%d - %d \t%d \n", parent[i], i, graph[i][parent[i]]);
        totalCost += graph[i][parent[i]];
    }
    printf("Total cost of Minimum Spanning Tree: %d\n", totalCost);
}

void primMST(int graph[MAX][MAX], int V) {
    int parent[MAX];
    int key[MAX];
    int mstSet[MAX];

    for (int i = 0; i < V; i++)
        key[i] = INT_MAX, mstSet[i] = 0;

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

```
    for (int count = 0; count < V - 1; count++) {
        int u = minKey(key, mstSet, V);
        mstSet[u] = 1;

        for (int v = 0; v < V; v++)
            if (graph[u][v] && mstSet[v] == 0 && graph[u][v] < key[v])
                parent[v] = u, key[v] = graph[u][v];
    }

    printMST(parent, graph, V);
}

int main() {
    int V;
    int graph[MAX][MAX];

    printf("Enter the number of vertices: ");
    scanf("%d", &V);

    printf("Enter the adjacency matrix (use 0 if no edge):\n");
    for (int i = 0; i < V; i++) {
        for (int j = 0; j < V; j++) {
            scanf("%d", &graph[i][j]);

            if (i != j && graph[i][j] == 0)
                graph[i][j] = INT_MAX;
        }
    }
```

```
    primMST(graph, V);

    return 0;
}
```

OUTPUT

```
Enter the number of vertices: 5
Enter the adjacency matrix (use 0 if no edge):
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
Edge    Weight
0 - 1   2
1 - 2   3
0 - 3   6
1 - 4   5
Total cost of Minimum Spanning Tree: 16

Process returned 0 (0x0)   execution time : 18.904 s
Press any key to continue.
```

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

Code

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

#define MAX 100

typedef struct {
    int u, v, weight;
} Edge;
```

```
int parent[MAX];

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

void unionSet(int u, int v) {
    int set_u = find(u);
    int set_v = find(v);
    parent[set_v] = set_u;
}

void kruskal(Edge edges[], int V, int E) {
    Edge result[MAX];
    int totalCost = 0, count = 0;

    for (int i = 0; i < V; i++)
        parent[i] = i;

    for (int i = 0; i < E && count < V - 1; i++) {
        int u = edges[i].u;
        int v = edges[i].v;

        if (find(u) != find(v)) {
            result[count++] = edges[i];
            totalCost += edges[i].weight;
            unionSet(u, v);
```

```
        }
    }

    printf("Edge \tWeight\n");
    for (int i = 0; i < count; i++)
        printf("%d - %d \t%d\n", result[i].u, result[i].v, result[i].weight);
    printf("Total cost of Minimum Spanning Tree: %d\n", totalCost);
}

int compare(const void* a, const void* b) {
    Edge* e1 = (Edge*)a;
    Edge* e2 = (Edge*)b;
    return e1->weight - e2->weight;
}

int main() {
    int V, E;
    Edge edges[MAX];

    printf("Enter number of vertices and edges: ");
    scanf("%d %d", &V, &E);

    printf("Enter %d edges (u v weight):\n", E);
    for (int i = 0; i < E; i++)
        scanf("%d %d %d", &edges[i].u, &edges[i].v, &edges[i].weight);

    qsort(edges, E, sizeof(Edge), compare);
    kruskal(edges, V, E);
```

```
    return 0;
}
```

OUTPUT

```
Enter the number of vertices: 4
Enter the cost adjacency matrix:
999 2   3  999
2  999  999 4
3  999  999 5
999 4   5  999
Edges of the minimal spanning tree:
(0, 1) (0, 2) (1, 3)
Sum of minimal spanning tree: 9

Process returned 0 (0x0)   execution time : 61.687 s
Press any key to continue.
```

LAB PROGRAM 9

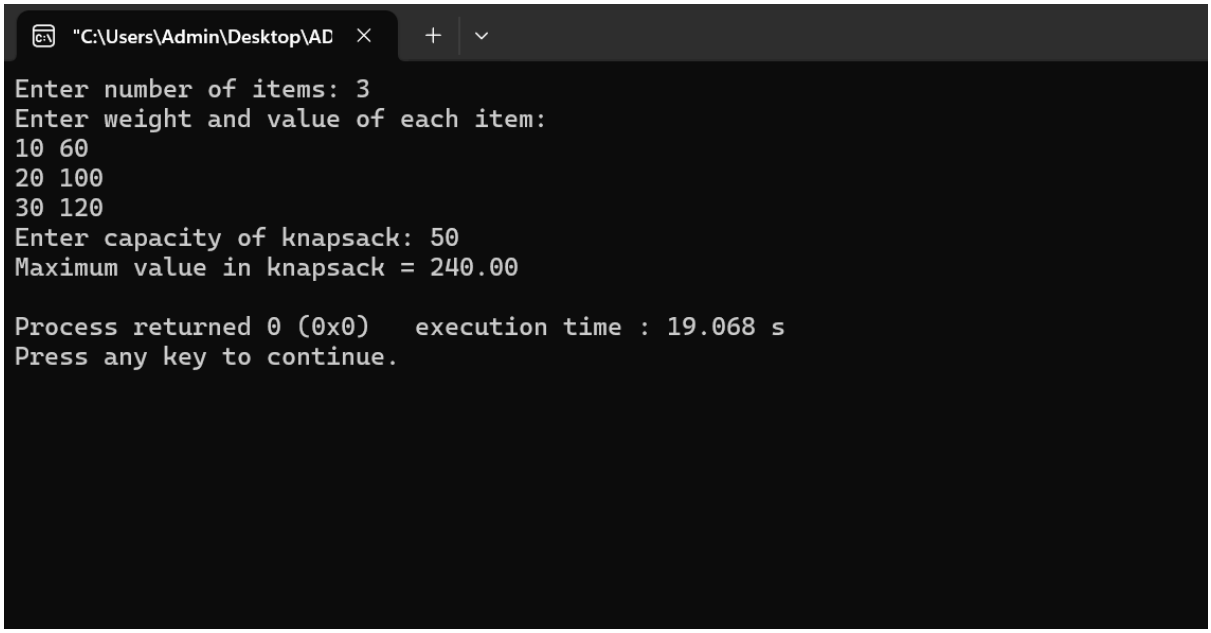
Implement Fractional Knapsack using Greedy technique.

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

typedef struct {
    int weight;
    int value;
    float ratio;
} Item;

int compare(const void *a, const void *b) {
    Item *item1 = (Item *)a;
    Item *item2 = (Item *)b;
    if (item1->ratio < item2->ratio)
        return 1;
    else if (item1->ratio > item2->ratio)
        return -1;
```

```
    else
        return 0;
}

float fractionalKnapsack(Item items[], int n, int capacity) {
    qsort(items, n, sizeof(Item), compare);

    float totalValue = 0.0;
    int currentWeight = 0;

    for (int i = 0; i < n; i++) {
        if (currentWeight + items[i].weight <= capacity) {
            currentWeight += items[i].weight;
            totalValue += items[i].value;
        } else {
            int remain = capacity - currentWeight;
            totalValue += items[i].ratio * remain;
            break;
        }
    }

    return totalValue;
}

int main() {
    int n, capacity;

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

```
    Item items[n];

    printf("Enter weight and value of each item:\n");
    for (int i = 0; i < n; i++) {
        scanf("%d %d", &items[i].weight, &items[i].value);
        items[i].ratio = (float)items[i].value / items[i].weight;
    }

    printf("Enter capacity of knapsack: ");
    scanf("%d", &capacity);

    float maxValue = fractionalKnapsack(items, n, capacity);

    printf("Maximum value in knapsack = %.2f\n", maxValue);

    return 0;
}
```

OUTPUT



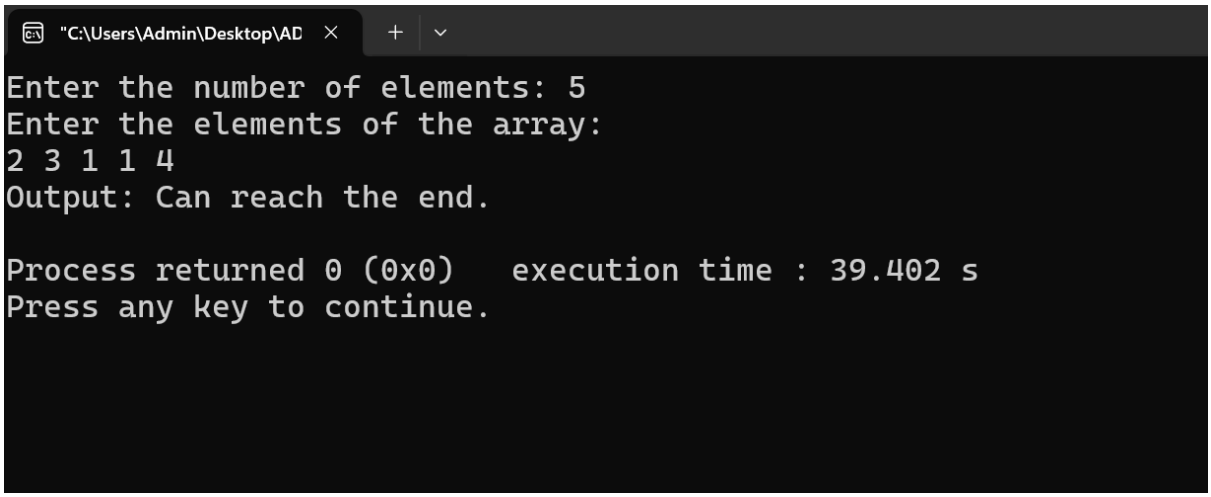
9.1 LeetCode Program related to Greedy Technique algorithms.

Code

```
#include <stdio.h>

int canJump(int* nums, int numsSize) {
    int maxReach = 0;

    for (int i = 0; i < numsSize; i++) {
        if (i > maxReach)
            return 0;  // Cannot reach this index
        if (i + nums[i] > maxReach)
            maxReach = i + nums[i];
    }

    return 1;
}

int main() {
    int nums[100], n;

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

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

    if (canJump(nums, n))
        printf("Output: Can reach the end.\n");
```

```
    else
        printf("Output: Cannot reach the end.\n");

    return 0;
}
```

OUTPUT



LAB PROGRAM 1O:

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

```
#include <stdio.h>

#define MAX 20
#define INF 999

int main() {
    int i, j, n, v, k, min, u, c[MAX][MAX], s[MAX], d[MAX];

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

    printf("Enter the cost adjacency matrix (999 for no edge):\n");
```

```
for (i = 1; i <= n; i++)
    for (j = 1; j <= n; j++)
        scanf("%d", &c[i][j]);

printf("Enter the source vertex: ");
scanf("%d", &v);

for (i = 1; i <= n; i++) {
    s[i] = 0;
    d[i] = c[v][i];
}

d[v] = 0;
s[v] = 1;

for (k = 2; k <= n; k++) {
    min = INF;
    for (i = 1; i <= n; i++) {
        if (s[i] == 0 && d[i] < min) {
            min = d[i];
            u = i;
        }
    }
    s[u] = 1;
    for (i = 1; i <= n; i++) {
        if (s[i] == 0 && d[i] > d[u] + c[u][i]) {
            d[i] = d[u] + c[u][i];
        }
    }
```

```
    }

    printf("The shortest distances from vertex %d are:\n", v);
    for (i = 1; i <= n; i++) {
        printf("%d --> %d = %d\n", v, i, d[i]);
    }

    return 0;
}
```

OUTPUT

```
Enter the number of vertices: 4
Enter the cost adjacency matrix (999 for no edge):
0   4  999   6
4   0   1    999
999 1   0    2
6   999 2    0
Enter the source vertex: 1
The shortest distances from vertex 1 are:
1 --> 1 = 0
1 --> 2 = 4
1 --> 3 = 5
1 --> 4 = 6

Process returned 0 (0x0)   execution time : 8.163 s
Press any key to continue.
```

LAB PROGRAM 11:

Implement "N-Queens Problem" using Backtracking.

```
#include <stdio.h>

#include <stdlib.h>
```

```
#include <math.h>

int x[20], count = 1;

void queens(int, int);
int place(int, int);

int main() {
   int n;
   printf("Enter the number of queens: ");
   scanf("%d", &n);
   queens(1, n);
   return 0;
}

void queens(int k, int n) {
   int j, i;
   for (j = 1; j <= n; j++) {
      if (place(k, j)) {
         x[k] = j;
         if (k == n) {
            printf("\nSolution %d:\n", count++);
            for (i = 1; i <= n; i++) {
               printf("Row %d --> Column %d\n", i, x[i]);
            }
            printf("\n");
         } else {
```

```
            queens(k + 1, n);
        }
      }
    }
}

int place(int k, int j) {
    int i;
    for (i = 1; i < k; i++) {
        if (x[i] == j || abs(x[i] - j) == abs(i - k))
            return 0;
    }
    return 1;
}
```

OUTPUT

```
Enter the number of queens: 4

Solution 1:
Row 1 --> Column 2
Row 2 --> Column 4
Row 3 --> Column 1
Row 4 --> Column 3


Solution 2:
Row 1 --> Column 3
Row 2 --> Column 1
Row 3 --> Column 4
Row 4 --> Column 2


Process returned 0 (0x0)   execution time : 14.515 s
Press any key to continue.
```

****