VISVESVARAYA TECHNOLOGICAL UNIVERSITY

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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 Deepthi M **(1BM23CS088)**, 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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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:

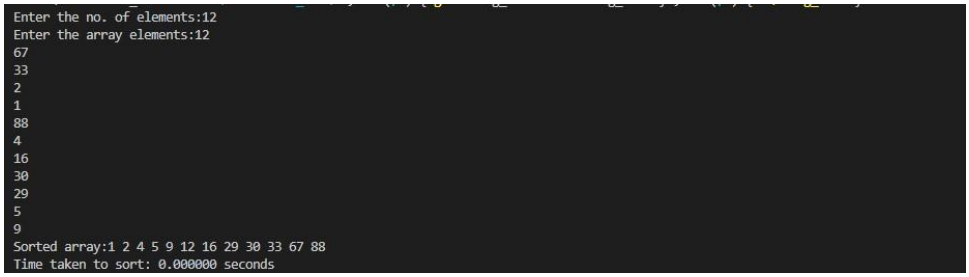
Sort a given set of N integer elements using Merge Sort technique and compute its time taken. Run the program for different values of N and record the time taken to sort.

CODE:

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

int a[20],n;
void simple_sort(int [],int,int,int); 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);
      simple_sort(a,low,mid,high);
   } }
void simple_sort(int a[],int low, int mid, int high){
int i=low,j=mid+1,k=low;
```

```
    int c[n];
    while(i<=mid && j<=high){
        if(a[i]<a[j]){
c[k++]=a[i];
            i++;
}else{
c[k++]=a[j];
            j++;
        }
    }
    while(i<=mid){
c[k++]=a[i];
        i++;
    }
    while(j<=high){
c[k++]=a[j];
        j++;
    }
    for(i=low;i<=high;i++){
a[i]=c[i];
    } } int
main()
{
    int i;
    clock_t start, end;
double time_taken;
    printf("Enter the no. 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; }
```

OUTPUT:



Lab program 2:

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

CODE:

```
#include <stdio.h>
#include <stdlib.h>  // for rand()
#include <time.h>    // for clock()

#define MAX 5000

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

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

   while (1) {
      printf("\nEnter the number of elements: ");
scanf("%d", &n);

      // Generate random array elements
      for (i = 0; i < n; i++) {
         a[i] = rand() % 200;  // Random number between 0 and 199
      }

      // Display the random array
      printf("The random generated array is:\n");
      for (i = 0; i < n; i++) {
printf("%d ", a[i]);
      }
      printf("\n");

      // Measure the time taken for sorting
      start = clock();
quicksort(a, 0, n - 1);
      end = clock();

      // Display the sorted array
      printf("\nThe sorted array elements are:\n");
```

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

        // Calculate and print the time taken for sorting
        printf("Time taken = %f seconds\n", (double)(end - start) / CLOCKS_PER_SEC);

        // Ask user if they want to continue
printf("\nDo you wish to continue? (0/1): ");
scanf("%d", &ch);         if (ch == 0) {
break;
        }
    }

    return 0;
}

// QuickSort function
void quicksort(int a[], int low, int high) {
if (low < high) {
        int mid = partition(a, low, high);
        quicksort(a, low, mid - 1);  // Recursively sort the left part
quicksort(a, mid + 1, high); // Recursively sort the right part
    } }

// Partition function: Returns the partition index int
partition(int a[], int low, int high) {
    int pivot = a[low]; // Pivot is the first element in the array
int i = low + 1;     int j = high;
    int temp;

    while (i <= j) {
        // Find an element greater than the pivot
while (i <= high && a[i] <= pivot) {            i++;
        }

        // Find an element less than the pivot
while (a[j] > pivot) {
            j--;
        }

        // If there are elements to swap, swap them
if (i < j) {            temp = a[i];            a[i] =
a[j];           a[j] = temp;
        }
    }
```

```
    // Swap the pivot element with a[j]
temp = a[low];     a[low] = a[j];
    a[j] = temp;

    return j;  // Return the partition index }
```

OUTPUT:

Lab program 3:

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

CODE:

```
#include<stdio.h> int
cost[10][10], n, t[10][2], sum;
void prims(int cost[10][10], int n);
int main() {
int i, j;
printf("Enter the number of vertices: "); scanf("%d",&n);
printf("Enter the cost adjacency matrix:\n");
for (i = 0; i <n; i++) { for
(j = 0; j <n; j++) {
scanf("%d",&cost[i][j]);
} }
prims(cost, n);
printf("Edges of the minimal spanning tree:\n");
for (i = 0; i <n - 1; i++) { printf("(%d,
%d) ", t[i][0], t[i][1]);
}
printf("\nSum of minimal spanning tree: %d\n", sum);
return 0; }
void prims(int cost[10][10], int n) {
int i, j, u, v; int min, source; int
p[10], d[10], s[10]; min = 999;
source = 0;

for (i = 0; i <n; i++) { d[i] =
cost[source][i]; s[i] = 0; p[i] =
source; } s[source] = 1; sum = 0;
int k = 0; for (i = 0; i <n - 1; i++) {
min = 999; u = -1; for (j = 0; j <n;
j++) { if (s[j] == 0 && d[j] <min) {
min = d[j]; u = j; } } if (u != -1) {
```

```
t[k][0] = u; t[k][1] = p[u]; k++; sum
+= cost[u][p[u]]; s[u] = 1; for (v =
0; v <n; v++) { if (s[v] == 0 &&
cost[u][v] <d[v]) { d[v] =
cost[u][v]; p[v] = u; }
}
}

}
}
```

OUTPUT:

Lab program 4:

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

CODE:

```
#include<stdio.h> int cost[10][10],
n, t[10][2], sum; void kruskal(int
cost[10][10], int n); int find(int
parent[10], int i);
int main() {
int i, j;
printf("Enter the number of vertices: "); scanf("%d",
&n);
printf("Enter the cost adjacency matrix:\n");
for (i = 0; i < n; i++) { for
(j = 0; j < n; j++) {
scanf("%d", &cost[i][j]);
} }
kruskal(cost, n); printf("Edges of the minimal
spanning tree:\n");
```

```
for (i = 0; i < n - 1; i++) { printf("(%d,
%d) ", t[i][0], t[i][1]);
}
printf("\nSum of minimal spanning tree: %d\n", sum);
return 0; }
void kruskal(int cost[10][10], int n) {
int min, u, v, count, k; int parent[10];
k = 0; sum = 0;
for (int i = 0; i < n; i++) { parent[i]
= i;
} count = 0; while (count
< n - 1) { min = 999; u =
-1; v = -1; for (int i = 0; i
< n; i++) { for (int j = 0; j
< n; j++) {
if (find(parent, i) != find(parent, j) && cost[i][j] < min) { min
= cost[i][j];
u = i; v
= j; }
} } int root_u =
find(parent, u); int root_v =
find(parent, v);

if (root_u != root_v) { parent[root_u]
= root_v;
t[k][0] = u;
t[k][1] = v;
sum += min;
k++; count++;
}
} } int find(int parent[10], int
i) { while (parent[i] != i) { i
= parent[i];
} return
i; }
```

OUTPUT:

```
Enter the number of vertices: 5
Enter the cost adjacency matrix:
0
1
2
3
4
1
0
3
5
7
2
3
0
3
9
3
5
3
0
7
4
7
9
7
0
Edges of the minimal spanning tree:
(0, 1) (0, 2) (0, 3) (0, 4)
Sum of minimal spanning tree: 10
```

Lab program 5:

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

CODE:

```
#include <stdio.h>
int n, a[10][10], res[10], s[10], top = 0;
void dfs(int, int, int[][10]); void
dfs_top(int, int[][10]); int main() {
printf("Enter the no. of nodes");
scanf("%d", &n);
int i, j;
for (i = 0; i < n; i++) { for
(j = 0; j < n; j++) {
scanf("%d", &a[i][j]);
} } dfs_top(n, a);
printf("Solution: "); for (i
= n - 1; i >= 0; i--) {
printf("%d ", res[i]);
} return
0; }
void dfs_top(int n, int a[][10]) { int
i;
for (i = 0; i < n; i++) {
s[i] = 0; }
for (i = 0; i < n; i++) {
if (s[i] == 0) { dfs(i,
n, a);
}
} }
void dfs(int j, int n, int a[][10]) { s[j]
= 1;
```

```
int i;
for (i = 0; i < n; i++) { if
(a[j][i] == 1 & s[i] == 0) {
dfs(i, n, a);
} }
res[top++] = j; }
```

OUTPUT:

```
PS D:\013 ADA>  & 'c:\Users\STUDENT\.vscode\extensions\ms-vscode.cpptools-1.24.5-win32-x64
-Out-ep1m3ff0.ymo' '--stderr=Microsoft-MIEngine-Error-hgfyi4bq.zgn' '--pid=Microsoft-MIEng
Enter the no. of nodes 6
0 0 1 1 0 0
0 0 0 1 1 0
0 0 0 1 0 1
0 0 0 0 0 1
0 0 0 0 0 1
0 0 0 0 0 0
Solution: 1 4 0 2 3 5
PS D:\013 ADA>
```

Lab program 6:

Implement 0/1 Knapsack problem using dynamic programming.

CODE:

```
#include<stdio.h>
int i,j,n,c,w[10],p[10],v[10][10];
void knapsack(int n,int w[10],int p[10],int c)
{ int max(int,int);
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\n Maximum Profit is : %d ",v[n][c]);
printf("\n\n\n Table : \n\n");
for(i=0;i<=n;i++)
{
for(j=0;j<=c;j++)
{
printf("\t%d",v[i][j]);
}
printf("\n");
```

```
} }
int max(int a,int b)
{
return ((a>b)?a:b);
} void
main() {
printf("\n Enter the no. of objects : "); scanf("%d",&n);
printf("\n Enter the weights : ");
for(i=1;i<=n;i++)
{
scanf("%d",&w[i]);
}
printf("\n Enter the Profits : ");
for(i=1;i<=n;i++)
{
scanf("%d",&p[i]);
}
printf("\n Enter the capacity : ");
scanf("%d",&c);
knapsack(n,w,p,c); }
```

OUTPUT:

```
Enter the no. of objects : 4

Enter the weights : 2
1
3
2

Enter the Profits : 12
10
20
15

Enter the capacity : 5


Maximum Profit is : 37


Table :

      0      0      0      0      0      0
      0      0      12     12     12     12
      0      10     12     22     22     22
      0      10     12     22     30     32
      0      10     15     25     30     37
```

Lab program 7:

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

CODE:

```
#include <stdio.h> int
a[10][10],D[10][10],n;
void floyd(int [][10],int);
int min(int,int); int main()
{
printf("Enter the no. of vertices:");
```

```
scanf("%d",&n);
printf("Enter the cost adjacency matrix:\n"); int
i,j;
for(i=0;i<n;i++){
for(j=0;j<n;j++){ scanf("%d",&a[i][j]);
} } floyd(a,n);
printf("Distance Matrix:\n");
for(i=0;i<n;i++){
for(j=0;j<n;j++){ printf("%d
",D[i][j]); } printf("\n"); }
return 0; }

void floyd(int a[][10],int n){ int
i,j,k;
for(i=0;i<n;i++){ for(j=0;j<n;j++){
D[i][j]=a[i][j];
}
}

for(k=0;k<n;k++){ for(i=0;i<n;i++){
for(j=0;j<n;j++){
D[i][j]=min(D[i][j],(D[i][k]+D[k][j]));
}
}
}
}

int min(int a,int b){
if(a<b){ return a;
}else{ return b; }
}
```

OUTPUT:

Lab program 8:

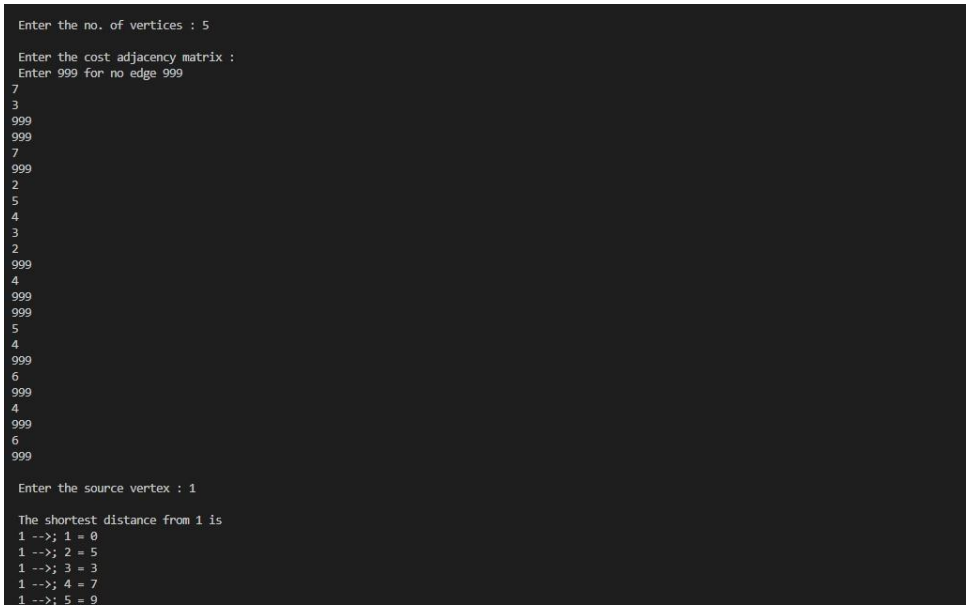
From a given vertex in a weighted connected graph, find shortest paths to other vertices using Dijkstra's algorithm.

CODE:

```
#include<stdio.h> void
main()
{ int
i,j,n,v,k,min,u,c[20][20],s[20],d[20];
printf("\n Enter the no. of vertices : ");
scanf("%d",&n);
printf("\n Enter the cost adjacency matrix : ");
printf("\n Enter 999 for no edge "); for(i=1;i<=n;i++)
{ for(j=1;j<=n;j++)
{ scanf("%d",&c[i][j]);
} }
printf("\n 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=999; 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) {
if(d[i]>(d[u]+c[u][i]))
{
d[i]=d[u]+c[u][i];
}
}

} }
printf("\n The shortest distance from %d is ",v); for(i=1;i<=n;i++)
{
printf("\n %d -->; %d = %d ",v,i,d[i]);
}
```

}

OUTPUT:



Lab program 9:

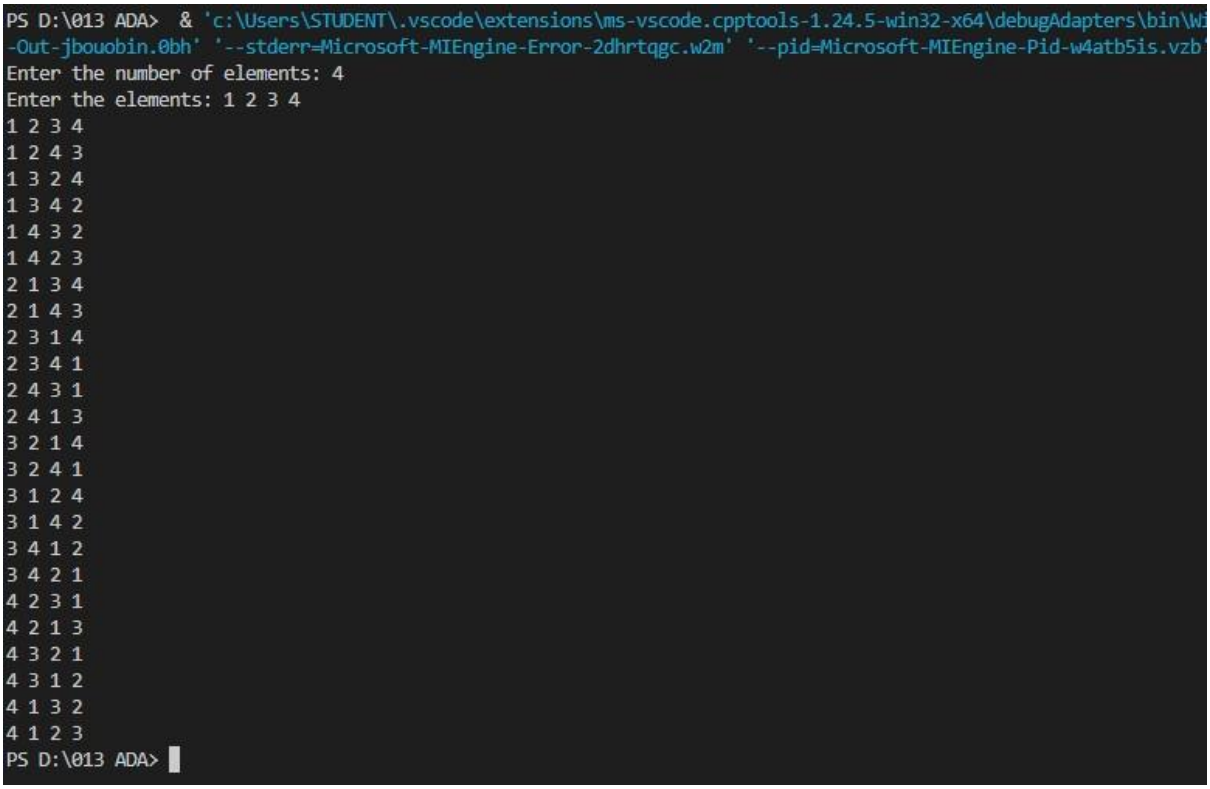
Implement Johnson Trotter algorithm to generate permutations.

CODE:

```
#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 10:

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

CODE:

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

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)
		{
			if(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);
        }
} void
main()
        {
          int i,n,a[20],ch=1;
clock_t start,end;          while(ch)
            {
                printf("\n enter the number of elements to sort\n");
                scanf("%d",&n);
                printf("\n enter the elements to sort\n");
        for(i=1;i<=n;i++)
scanf("%d",&a[i]);              start=clock();
heapsort(a,n);
                end=clock();
                printf("\n the sorted list of elemnts is\n");
                for(i=1;i<=n;i++)
printf("%d\n",a[i]);
                printf("\n Time taken is %lf CPU cycles\n",(end-start)/CLK_TCK);
printf("do u wish to run again (0/1)\n");
                scanf("%d",&ch);
        }
}
```

OUTPUT:

```
 enter the number of elements to sort
5

 enter the elements to sort
8 5 6 3 1

 the sorted list of elemnts is
1
3
5
6
8

 Time taken is 0.000000 CPU cycles
do u wish to run again (0/1)
0
```

Lab program 11:

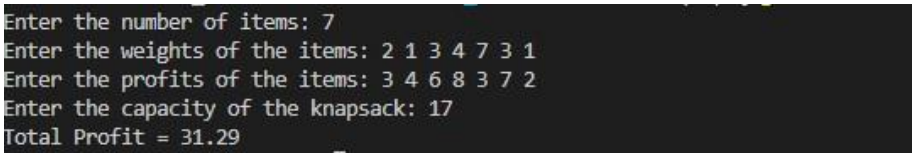
Implement Fractional Knapsack using Greedy technique.

CODE:

```
#include <stdio.h>  #define
MAX 100
void fractionalKnapsack(int n, float weight[], float profit[], float capacity) {
float ratio[MAX],
   temp; int i, j;

   for (i = 0; i < n; i++)
   ratio[i] = profit[i] / weight[i];

   for (i = 0; i < n - 1; i++) {
for (j = i + 1; j < n; j++) {     if
(ratio[i] < ratio[j]) {
   temp = ratio[i]; ratio[i] = ratio[j]; ratio[j] = temp;     temp
= weight[i]; weight[i] = weight[j]; weight[j] = temp;     temp
= profit[i]; profit[i] = profit[j]; profit[j] = temp;     }
   }
   }

   float totalProfit = 0;
   for (i = 0; i < n; i++) {

   if (capacity >= weight[i]) {
capacity -= weight[i];     totalProfit
+= profit[i];
   } else {
   totalProfit += ratio[i] * capacity;
break;
   }
   }
   printf("Total Profit = %.2f\n", totalProfit);

   }

   int main() {
int n;
      float weight[MAX], profit[MAX], capacity;
printf("Enter the number of items: ");         scanf("%d",
&n);

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

      printf("Enter the profits of the items: ");
      for (int i = 0; i < n; i++) {
         scanf("%f", &profit[i]);
      }
```

```
    printf("Enter the capacity of the knapsack: ");
scanf("%f", &capacity);

    fractionalKnapsack(n, weight, profit, capacity);

return 0;    }
```

OTUPUT:



Lab program 11:

Implement “N-Queens Problem” using Backtracking.

CODE:

```
#include<stdio.h>
#include<conio.h>
#include<math.h> int
x[20],count=1; void
queens(int,int);
int place(int,int);

void main()
{
        int n,k=1;
   printf("\n enter the number of queens to be placed\n");        scanf("%d",&n);
        queens(k,n);
}
void queens(int k,int n)
{
        int i,j;
        for(j=1;j<=n;j++)
        {
                if(place(k,j))
                {
                   x[k]=j;
             if(k==n)
                        {
                                printf("\n %d solution",count);
                                count++;
                                for(i=1;i<=n;i++)
                                printf("\n \t %d row <---> %d column",i,x[i]);
                                getch();
                        }
                        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 to be placed
4

 1 solution
        1 row <---> 2 column
        2 row <---> 4 column
        3 row <---> 1 column
        4 row <---> 3 column
 2 solution
        1 row <---> 3 column
        2 row <---> 1 column
        3 row <---> 4 column
        4 row <---> 2 column
```