Charutar Vidya Mandal University

VV Nagar, Anand

A.D. Patel Institute of Technology

New V.V.Nagar, Anand

Design and Analysis of Algorithms

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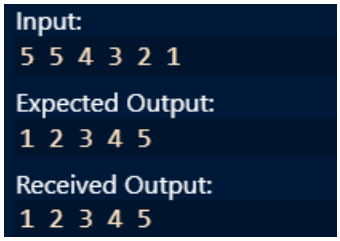
1.Write a program to sort given elements of an array in ascending order using bubble sort. Analyze the time complexity for best, average and worst case.

```
#include <bits/stdc++.h>
using namespace std;
void Sort(int arr[], int n)
{
   for (int i = 0; i < n - 1; i++)
   {
     for (int j = 0; j < n - i - 1; j++)
     {
         if (arr[j] > arr[j + 1])
         {
            swap(arr[j], arr[j + 1]);
         }
     }
   }
}
int main()
{
   int n;
   cin>>n;
   int arr[n];
   for(int i=0;i<n;i++)
   {
      cin>>arr[i];
   }
   Sort(arr, n);
   for (int i = 0; i < n; i++)
   {
      cout << arr[i] << " ";
   }
   return 0;
}
```

Output:

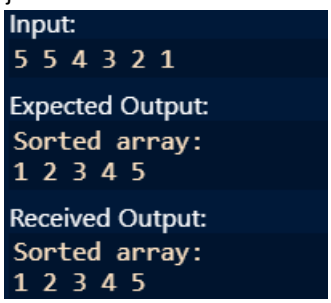


Best Case Time Complexity: $\Omega(N)$
Average Case Time Complexity: $\theta(N^2)$
Worst Case Time Complexity: $O(N^2)$

2.Write a program to sort given elements of an array in ascending order using selection sort. Analyze the time complexity for best, average and worst case.

Code in C++:

```
#include <bits/stdc++.h>
using namespace std;
void Sort(int arr[], int n)
{
   int i, j, min_idx;
 for (i = 0; i < n-1; i++)
   {
      min_idx = i;
      for (j = i+1; j < n; j++)
      if (arr[j] < arr[min_idx])
         min_idx = j;
      if(min_idx!=i)
         swap(arr[min_idx],arr[i]);
   }
}
int main()
{
   int n;
   cin>>n;
   int arr[n];
   for(int i=0;i<n;i++)
   {
      cin>>arr[i];
   }
   Sort(arr, n);
   cout << "Sorted array: \n";
    for (int i=0; i < n; i++)
      cout << arr[i] << " ";
   return 0;
}
```



Best Case Time Complexity: $\Omega(N^2)$

Average Case Time Complexity: $\theta(N^2)$

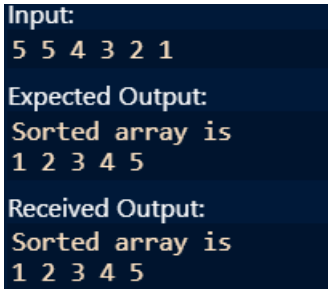
Worst Case Time Complexity: $O(N^2)$

3. Write a program to implement heap sort.

Code in C++:

```
#include <bits/stdc++.h>
using namespace std;
void heapify(int arr[], int N, int i)
{
   int largest = i;
   int l = 2 * i + 1;
   int r = 2 * i + 2;
   if (l < N && arr[l] > arr[largest])
      largest = l;
   if (r < N && arr[r] > arr[largest])
      largest = r;
   if (largest != i) {
      swap(arr[i], arr[largest]);
      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], arr[i]);
      heapify(arr, i, 0);
   }
}
int main()
{
    int n;
   cin>>n;
   int arr[n];
   for(int i=0;i<n;i++)
   {
      cin>>arr[i];
   }
   heapSort(arr, n);
   cout << "Sorted array is \n";
   for(int i=0;i<n;i++)
   {
     cout<<arr[i]<<" ";
   }
}
```

Output:


Input:
5 5 4 3 2 1
Expected Output:
Sorted array is
1 2 3 4 5
Received Output:
Sorted array is
1 2 3 4 5

4. Write a program to search given element from an array using sequential search and binary search. Analyze the time complexity for best, average and worst case.

Sequential Search:

```
#include <iostream>
using namespace std;
int search(int arr[], int N, int x)
{
   int i;
   for (i = 0; i < N; i++)
      if (arr[i] == x)
         return i;
   return -1;
}
int main(void)
{
   int n;
   cin>>n;
   int arr[n];
   for(int i=0;i<n;i++)
   {
      cin>>arr[i];
   }
   int result = search(arr, n, 5);
   if(result==-1)
   {
       cout << "Element is not present in array";
   }
   else
   {
      cout << "Element is present at index " << result+1;
   }
   return 0;
}
```

```
Input:
5
1 2 3 4 5
Expected Output:
Element is present at index 5
Received Output:
Element is present at index 5
```

Best Case Time Complexity: Ω(1)
Average Case Time Complexity: θ(N)
Worst Case Time Complexity: O(N)

Binary Search:

Code in C++:

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

```
using namespace std;
int binarySearch(int arr[], int l, int r, int x)
{
   if (r >= l) {
      int mid = l + (r - l) / 2;
      if (arr[mid] == x)
         return mid;
      if (arr[mid] > x)
         return binarySearch(arr, l, mid - 1, x);
      return binarySearch(arr, mid + 1, r, x);
   }
   return -1;
}
int main()
{
   int n;
   cin>>n;
   int arr[n];
   for(int i=0;i<n;i++)
   {
      cin>>arr[i];
   }
   int result = binarySearch(arr, 0, n - 1, 5);
   if(result == -1)
       cout << "Element is not present in array";
   else
       cout << "Element is present at index " << result+1;
   return 0;
}
```

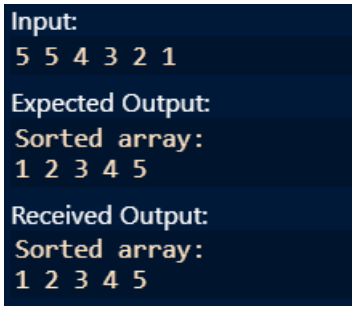
```
Input:
5
1 2 3 4 5
Expected Output:
Element is present at index 5
Received Output:
Element is present at index 5
```

Best Case Time Complexity: Ω(1)
Average Case Time Complexity: θ(logN)
Worst Case Time Complexity: O(logN)

5. Write a program to sort given elements of an array in ascending order using merge sort. Analyze the time complexity for best, average and worst case.

```
#include <bits/stdc++.h>
using namespace std;
void merge(int arr[], int p, int q, int r)
{
   int n1 = q - p + 1;
   int n2 = r - q;
   int L[n1], M[n2];
   for (int i = 0; i < n1; i++)
      L[i] = arr[p + i];
   for (int j = 0; j < n2; j++)
      M[j] = arr[q + 1 + j];
   int i=0, j=0, k=p;
   while (i < n1 && j < n2)
   {
      if (L[i] <= M[j])
         arr[k] = L[i],i++;
      else
         arr[k] = M[j],j++;
      k++;
   }
   while (i < n1)
   {
      arr[k] = L[i],i++,k++;
   }

   while (j < n2)
   {
      arr[k] = M[j],j++,k++;
   }
}
void mergeSort(int arr[], int l, int r)
{
   if (l < r)
   {
      int m = l + (r - l) / 2;
      mergeSort(arr, l, m);
      mergeSort(arr, m + 1, r);
      merge(arr, l, m, r);
   }
}
int main()
{
   int n;
   cin >> n;
   int arr[n];
   for (int i = 0; i < n; i++)
```

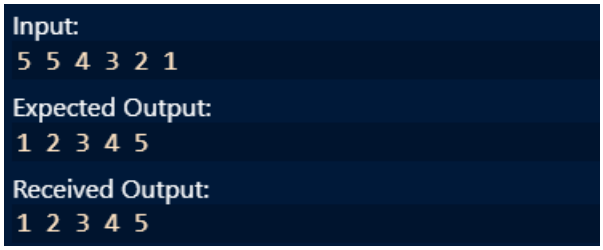
```
        cin >> arr[i];
    mergeSort(arr, 0, n - 1);
    cout << "Sorted array: \n";
    for (int i = 0; i < n; i++)
        cout << arr[i] << " ";
    return 0;
}
```



Best Case Time Complexity: Ω(NlogN)
Average Case Time Complexity: θ(NlogN)
Worst Case Time Complexity: O(NlogN)

6. Write a program to sort given elements of an array in ascending order using quick sort. Analyze the time complexity for best, average and worst case.

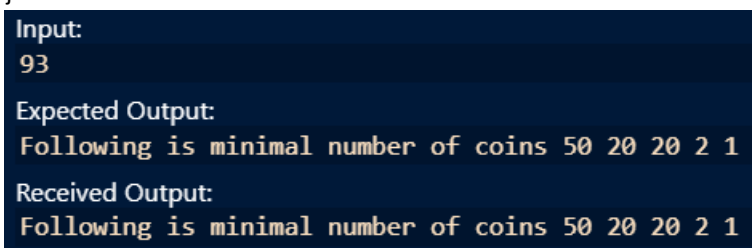
```
#include <bits/stdc++.h>
using namespace std;
int partition(int arr[], int start, int end)
{
   int pivot = arr[start];
   int count = 0;
   for (int i = start + 1; i <= end; i++) {
      if (arr[i] <= pivot)
         count++;
   }
  int pivotIndex = start + count;
   swap(arr[pivotIndex], arr[start]);
   int i = start, j = end;
   while (i < pivotIndex && j > pivotIndex) {
      while (arr[i] <= pivot)
         i++;
      while (arr[j] > pivot)
         j--;
      if (i < pivotIndex && j > pivotIndex)
         swap(arr[i++], arr[j--]);
   }

   return pivotIndex;
}
void quickSort(int arr[], int start, int end)
{
 if (start >= end)
      return;
   int p = partition(arr, start, end);
   quickSort(arr, start, p - 1);
   quickSort(arr, p + 1, end);
}
int main()
{
    int n;
   cin >> n;
   int arr[n];
   for (int i = 0; i < n; i++)
      cin >> arr[i];
   quickSort(arr, 0, n - 1);
   for (int i = 0; i < n; i++)
      cout << arr[i] << " ";
   return 0;
}
```



Best Case Time Complexity: Ω(NlogN)
Average Case Time Complexity: θ(NlogN)
Worst Case Time Complexity: $O(N^2)$

7. Write a program to implement making change problem using greedy algorithm.

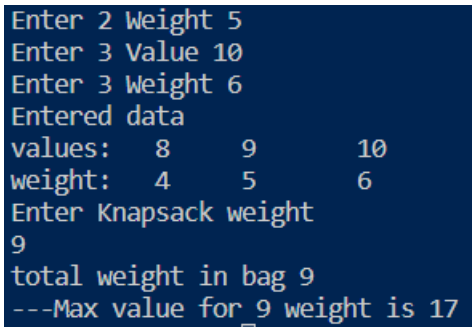
```
#include <bits/stdc++.h>
using namespace std;
int denomination[] = { 1, 2, 5, 10, 20,50, 100, 500, 1000 };
int n = sizeof(denomination) / sizeof(denomination[0]);
void findMin(int V)
{
   sort(denomination, denomination + n,greater<int>());
   vector<int> ans;
   for (int i = 0; i <n; i++) {
      while (V >= denomination[i]) {
         V -= denomination[i];
         ans.push_back(denomination[i]);
      }
   }
  for (int i = 0; i < ans.size(); i++)
      cout << ans[i] << " ";
}
int main()
{
   int n;
   cin>>n;
   cout << "Following is minimal number of coins ";
   findMin(n);
   return 0;
}
```



8.Write a program to implement the knapsack problem using greedy algorithm.

```
#include <bits/stdc++.h>
using namespace std;
typedef struct {
   int value;
   int weight;
   float density;
}Item;
void input(Item items[],int sizeOfItems){
   cout << "Enter total "<< sizeOfItems <<" item's values and weight" << endl;
   for(int i=0; i<sizeOfItems; i++){
      cout << "Enter "<< i+1 << " Value ";
      cin >> items[i].value;
      cout << "Enter "<< i+1 << " Weight ";
      cin >> items[i].weight;
   }
}
void display(Item items[],int sizeOfItems){
 cout << "values:   ";
 for(int i=0; i<sizeOfItems; i++){
    cout << items[i].value << "\t";
 }
 cout << endl << "weight:   ";
 for(int i=0; i<sizeOfItems; i++){
    cout << items[i].weight << "\t";
 }
 cout << endl;
}
bool compare(Item i1, Item i2){
   return (i1.density > i2.density);
}

float knapsack(Item items[],int sizeOfItems, int W){
   float totalValue=0, totalWeight=0;
 for(int i=0; i<sizeOfItems; i++){
      items[i].density = items[i].value/items[i].weight;
   }
 sort(items, items+sizeOfItems,compare);
 for(int i=0; i<sizeOfItems; i++){
   if(totalWeight + items[i].weight<= W){
    totalValue += items[i].value ;
    totalWeight += items[i].weight;
   } else {
    int wt = W-totalWeight;
    totalValue += (wt * items[i].density);
    totalWeight += wt;
    break;
   }
```

```
}
  cout << "total weight in bag " << totalWeight<<endl;
  return totalValue;
}
int main()
{
  int W;
  Item items[3];
  input(items,3);
  cout << "Entered data \n";
  display(items,3);
  cout<< "Enter Knapsack weight \n";
  cin >> W;
  float mxVal = knapsack(items,3,W);
  cout << "---Max value for "<< W <<" weight is "<< mxVal;
  return 0;
}
```



9.Write a program to implement making change problem using dynamic programming.

```
#include<bits/stdc++.h>
using namespace std;
int minCoins(int coins[], int m, int V)
{
  if (V == 0) return 0;
  int res = INT_MAX;
  for (int i=0; i<m; i++)
  {
    if (coins[i] <= V)
    {
       int sub_res = minCoins(coins, m, V-coins[i]);
       if (sub_res != INT_MAX && sub_res + 1 < res)
         res = sub_res + 1;
    }
  }
  return res;
}
int main()
{
   int coins[] =  {9, 6, 5, 1};
   int m = sizeof(coins)/sizeof(coins[0]);
   int V;
   cin>>V;
   cout << "Minimum coins required is "
      << minCoins(coins, m, V);
   return 0;
}
```

```
Input:
11
Expected Output:
Minimum coins required is 2
Received Output:
Minimum coins required is 2
```

10.Write a program to implement the knapsack problem using dynamic programming.

```
#include <bits/stdc++.h>
using namespace std;
int knapsackUtil(vector<int>& wt, vector<int>& val, int ind, int W, vector<vector<int>>& dp){
   if(ind == 0){
      if(wt[0] <=W) return val[0];
      else return 0;
   }
   if(dp[ind][W]!=-1)
      return dp[ind][W];
   int notTaken = 0 + knapsackUtil(wt,val,ind-1,W,dp);
   int taken = INT_MIN;
   if(wt[ind] <= W)
      taken = val[ind] + knapsackUtil(wt,val,ind-1,W-wt[ind],dp);
   return dp[ind][W] = max(notTaken,taken);
}
int knapsack(vector<int>& wt, vector<int>& val, int n, int W){
   vector<vector<int>> dp(n,vector<int>(W+1,-1));
   return knapsackUtil(wt, val, n-1, W, dp);
}
int main() {
  vector<int> wt = {1,2,4,5};
  vector<int> val = {5,4,8,6};
  int W=5;
  int n = wt.size();
  cout<<"The Maximum value of items, thief can steal is " <<knapsack(wt,val,n,W);
}
```

```
Input:
5
Expected Output:
The Maximum value of items, thief can steal is 13
Received Output:
The Maximum value of items, thief can steal is 13
```

11. Write a program to implement Floyd's algorithm for finding shortest path using dynamic programming.

```
#include <bits/stdc++.h>
using namespace std;
#define V 4
#define INF 99999
void printSolution(int dist[][V]);
void floydWarshall(int graph[][V])
{
   int dist[V][V], i, j, k;
   for (i = 0; i < V; i++)
      for (j = 0; j < V; j++)
         dist[i][j] = graph[i][j];
   for (k = 0; k < V; k++) {
      for (i = 0; i < V; i++) {
         for (j = 0; j < V; j++) {
            if (dist[i][j] > (dist[i][k] + dist[k][j])
               && (dist[k][j] != INF
                  && dist[i][k] != INF))
               dist[i][j] = dist[i][k] + dist[k][j];
         }
      }
   }
   printSolution(dist);
}
void printSolution(int dist[][V])
{
   cout << "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)
            cout << "INF"
                 << "     ";
         else
            cout << dist[i][j] << "     ";
      }
      cout << endl;
   }
}
int main()
{
   int graph[V][V] = { { 0, 5, INF, 10 },
                       { INF, 0, 3, INF },
                       { INF, INF, 0, 1 },
                       { INF, INF, INF, 0 } };
   floydWarshall(graph);
```

```
    return 0;
}
```

```
The following matrix shows the shortest distances between every pair of vertices
      0      5      8      9
    INF      0      3      4
    INF    INF      0      1
    INF    INF    INF      0
```

12.Write a program to implement chained matrix multiplication using dynamic programming.

```
#include <bits/stdc++.h>
using namespace std;
int MatrixChainOrder(int p[], int i, int j)
{
   if (i == j)
      return 0;
   int k;
   int mini = INT_MAX;
   int count;
   for (k = i; k < j; k++)
   {
      count = MatrixChainOrder(p, i, k)
            + MatrixChainOrder(p, k + 1, j)
            + p[i - 1] * p[k] * p[j];

      mini = min(count, mini);
   }
  return mini;
}
int main()
{
   int arr[] = { 1, 2, 3, 4, 3 };
   int N = sizeof(arr) / sizeof(arr[0]);
    cout << "Minimum number of multiplications is "
       << MatrixChainOrder(arr, 1, N - 1);
   return 0;
}
```

```
Expected Output:
Minimum number of multiplications is 30
Received Output:
Minimum number of multiplications is 30
```

13. Write a program to implement longest common subsequence using dynamic programming.

```
#include <bits/stdc++.h>
using namespace std;
int main()
{

    string s1, s2;
    cin >> s1 >> s2;
    int dp[s1.length() + 1][s2.length() + 1];
    int n = s1.length(), m = s2.length();
    for (int i = 0; i <= n; i++)
    {
       for (int j = 0; j <= m; j++)
          if (i == 0 || j == 0)
             dp[i][j] = 0;
          else
          {
             if (s1[i - 1] == s2[j - 1])
                dp[i][j] = dp[i - 1][j - 1] + 1;
             else
                dp[i][j] = max(dp[i - 1][j], dp[i][j - 1]);
          }
    }
    cout << dp[n][m] << "\n";

  return 0;
}
```