

Assignment - 2.

1) function linearsearch(arr, target)

if $n == 0$;

return "Array is empty".

for (int $i = 0$ to $n - 1$)

if (arr[i] == target)

return "element found" + i;

else if arr[i] > target

return ("Element not found");

return "Element not found";

2) Iterative insertion sort —

iterative-insertion (arr)

$n = \text{length of arr.}$

for i from 1 to $n - 1$;

key = arr[i]

$j = i - 1$;

while ($j \geq 0$ && (arr[j] > key))

arr[j+1] = arr[j];

$j = j - 1$;

arr[j+1] = key.

Recursive insertion sort

recursive-insertion (arr, n);

if $n \leq 1$;

return insertion (arr, $n - 1$)

last = arr[n-1];

$j = n - 2$

while ($j \geq 0$ && arr[j] > last)

arr[j+1] = arr[j]

$j = j - 1$;

arr[j+1] = last.

Insertion sort is sometimes called "online sorting", as it sorts elements one at a time as they are presented, which makes it suitable for sorting data as it arrives, hence "online".

3)

| | <u>Best</u> | <u>Avg.</u> | <u>Worst</u> | <u>SC</u> |
|-----------|---|---------------|---------------|-----------------------|
| Bubble | $O(n)$ | $O(n^2)$ | $O(n^2)$ | $O(1)$ |
| Selection | $O(n^2)$ | $O(n^2)$ | $O(n^2)$ | $O(1)$ |
| Insertion | $O(n)$ | $O(n^2)$ | $O(n^2)$ | $O(1)$ |
| Merge | $O(n \log n)$ | $O(n \log n)$ | $O(n \log n)$ | $O(n)$ |
| Quick | $O(n \log n)$ | $O(n \log n)$ | $O(n^2)$ | $O(\log n)$ to $O(n)$ |
| Heap | $O(n \log n)$ | $O(n \log n)$ | $O(n \log n)$ | $O(1)$ |
| Counting | $\leftarrow O(n+k) \rightarrow$ | | | $O(n+k)$ |
| Radix | $\leftarrow O\left(\frac{n+b}{\log_b k}\right) \rightarrow$ | | | $O(n+b)$ |

- 4) Inplace algorithm —
1. selection sort
 2. insertion sort
 3. bubble sort
 4. quick sort

Online algorithm —

1. insertion

- Stable algorithm —
1. Merge
 2. insertion
 3. bubble
 4. count
 5. radix

5) Recursive Binary Search —

function binarySearch(arr, low, high, target)

if high \geq low.

mid = low + (high - low) / 2;

if arr[mid] == target

return mid

elseif arr[mid] > target

return binarySearch(arr, low, mid - 1, target)

else

return binarySearch(arr, mid + 1, high, target)

else

return -1;

Iterative Binary Search —

function binarySearch(arr, target)

low = 0

high = length of arr - 1.

while (low \leq high)

mid = low + (high - low) / 2;

if (arr[mid] == target)

return mid

else if (arr[mid] < target)

low = mid + 1;

else

high = mid - 1;

return -1;

Linear Search — T.C = $O(n)$

S.C = $O(1)$

Binary Search — T.C = $O(\log n)$

S.C = $O(\log n)$

6.) Recurrence relation —

$$T(n) = T(n/2) + O(1)$$

where,

$T(n)$ = time taken to search within array of size n .

$T(n/2)$ = time taken to search within half of array.

$O(1)$ = const. time taken for comparison & other operations.

7.) #include <iostream>

using namespace std;

void findIndexes (int A[], int size, int K)

{

for (int i=0; i<size-1; ++i)

for (int j=i+1; j<size; ++j)

if (A[i] + A[j] == K)

cout << "Indexes" << i << ", " << j << endl;

cout << "Numbers" << A[i] << ", " << A[j] << endl;

return;

}

}

}

cout << "No such pair exists" << endl;

}

8.) Insertion sort —

- it is stable & in-place, making it suitable for memory usage is a concern.

Selection sort —

- suitable for small datasets or situations where simplicity is more imp. than performance.

9.) In this context of arrays, an inversion refers to a pair of elements $(arr[i], arr[j])$ such that $i < j$, but $(arr[i] > arr[j])$. In simpler terms, it indicates that the elements are out of order relative to each other.

```
#include <iostream>
```

```
using namespace std;
```

```
long long merge(int arr[], int temp[], int left, int mid, int right)
```

```
{
```

```
    int i = left;
```

```
    int j = mid;
```

```
    int k = left;
```

```
    long long inversions = 0;
```

```
    while(i <= mid && j <= right)
```

```
    {
        if(arr[i] <= arr[j])
```

```
            temp[k++] = arr[i++];
```

```
    }
```

```
    else
```

```
    {
```

```
        temp[k++] = arr[j++];
```

```
        inversions += mid - i + 1;
```

```
    }
```



```

    }
    while (i < mid)
    {
        temp[k++] = arr[j++];
    }
    for (i = left; i <= right; i++)
        arr[i] = temp[i];
    return inversions;
}

```

```

long long mergesort(int arr[], int temp[], int left, int right)
{

```

```

    long long inversions = 0;
    if (left < right)
    {

```

```

        int mid = left + (right - left) / 2;
        inversions += mergesort(arr, temp, left, mid);
        inversions += mergesort(arr, temp, mid + 1, right);
        inversions += mergesort(arr, temp, left, mid + 1, right);
    }

```

```

    return inversions;
}

```

10.) The best case complexity (TC) occurs when the partition process always picks the middle element as the pivot.

$$TC = O(n \log n)$$

The worst case time complexity happens when the pivot selection consistently results in highly unbalanced partitions, such as when the smallest or largest element is always chosen as the pivot.

$$TC = O(n^2)$$

11.) Merge sort —

Best Case — $T(n) = 2T(n/2) + O(n)$

Worst Case — $T(n) = 2T(n/2) + O(n)$

Quick sort —

Best Case — $T(n) = 2T(n/2) + O(n)$

Worst Case — $T(n) = T(n-1) + O(n)$

Similarities —

• both have best $TC = O(n \log n)$
worst $TC = O(n \log n)$

- both use divide & conquer technique.
- both are comparison-based sorting algorithms.

Differences —

1. merge sort is stable sort, whereas Quick sort is not.
2. Merge sort requires more space, whereas Quick sort is in-place sorting algorithms.

12.) To make a stable version of selection sort, we need to modify the selection process so that it doesn't swap equal elements unnecessarily.

```
void stableSelection(int arr[], int n)
```

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

```
    {  
        int min_index = i;
```

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

```
            if (arr[j] < arr[min_index])
```

```
                min_index = j;  
    }
```

```
}
```

```
while (min_index > i)
```

```
{
```

```
    arr[min_index] = arr[min_index - 1];
```

```
    -- min_index;
```

```
}
```

```
min[i] = min_value;
```

```
}
```

```
}
```



```

13.) #include <iostream>
void bubbleSort (int arr [], int n)
{
    for (int i = 0; i < n; i++)
    {
        bool swapped = false;
        for (int j = 0; j < n - i - 1; j++)
        {
            if (arr[j] > arr[j+1])
            {
                int temp = arr[j];
                arr[j] = arr[j+1];
                arr[j+1] = temp;
                swapped = true;
            }
        }
        if (!swapped)
        {
            break;
        }
    }
}

```