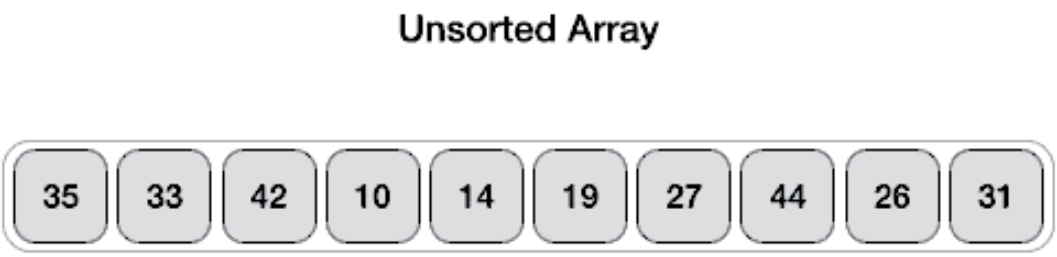
Quick Sort Algorithm

Quick sort is a highly efficient sorting algorithm and is based on partitioning of array of data into smaller arrays. A large array is partitioned into two arrays one of which holds values smaller than the specified value, say pivot, based on which the partition is made and another array holds values greater than the pivot value.

Quicksort partitions an array and then calls itself recursively twice to sort the two resulting subarrays. This algorithm is quite efficient for large-sized data sets as its average and worst-case complexity are O(n2), respectively.

Partition in Quick Sort

Following animated representation explains how to find the pivot value in an array.



The pivot value divides the list into two parts. And recursively, we find the pivot for each sub-lists until all lists contains only one element.

Quick Sort Pivot Algorithm

Based on our understanding of partitioning in quick sort, we will now try to write an algorithm for it, which is as follows.

```
1. Choose the highest index value has pivot
2. Take two variables to point left and right of the list
excluding pivot
3. Left points to the low index
4. Right points to the high
5. While value at left is less than pivot move right
6. While value at right is greater than pivot move left
7. If both step 5 and step 6 does not match swap left and right
8. If left ≥ right, the point where they met is new pivot
```

Quick Sort Pivot Pseudocode

The pseudocode for the above algorithm can be derived as –

```
function partitionFunc(left, right, pivot)
   leftPointer = left
   rightPointer = right - 1

   while True do
      while A[++leftPointer] < pivot do
      //do-nothing
      end while

      while rightPointer > 0 && A[--rightPointer] > pivot do
         //do-nothing
      end while

      if leftPointer >= rightPointer
         break
      else
         swap leftPointer,rightPointer
      end if
   end while

   swap leftPointer,right
   return leftPointer
end function
```

Quick Sort Algorithm

Using pivot algorithm recursively, we end up with smaller possible partitions. Each partition is then processed for quick sort. We define recursive algorithm for quicksort as follows −

```
1. Make the right-most index value pivot
2. Partition the array using pivot value
3. Quicksort left partition recursively
4. Quicksort right partition recursively
```

Quick Sort Pseudocode

To get more into it, let see the pseudocode for quick sort algorithm −

```
procedure quickSort(left, right)
   if right-left <= 0
      return
   else
      pivot = A[right]
      partition = partitionFunc(left, right, pivot)
      quickSort(left,partition-1)
      quickSort(partition+1,right)
   end if
end procedure
```

Analysis

The worst case complexity of Quick-Sort algorithm is **O(n^2)**. However, using this technique, in average cases generally we get the output in **O (n log n)** time.

Implementation

Following are the implementations of Quick Sort algorithm in various programming languages −

C C++ Java Python

```c
#include <stdbool.h>
#define MAX 7
int intArray[MAX] = {
   4,6,3,2,1,9,7
};
void printline(int count) {
   int i;
   for (i = 0; i < count - 1; i++) {
      printf("=");
   }
   printf("=\n");
}
void display() {
   int i;
   printf("[");

   // navigate through all items
   for (i = 0; i < MAX; i++) {
      printf("%d ", intArray[i]);
   }
   printf("]\n");
}
void swap(int num1, int num2) {
   int temp = intArray[num1];
   intArray[num1] = intArray[num2];
   intArray[num2] = temp;
}
int partition(int left, int right, int pivot) {
   int leftPointer = left - 1;
   int rightPointer = right;
   while (true) {
      while (intArray[++leftPointer] < pivot) {
         //do nothing
      }
      while (rightPointer > 0 && intArray[--rightPointer] > pivo
```

```
      }

      if (leftPointer >= rightPointer) {
         break;
      } else {
         printf(" item swapped :%d,%d\n", intArray[leftPointer],
         swap(leftPointer, rightPointer);
      }
   }

   printf(" pivot swapped :%d,%d\n", intArray[leftPointer], intA
   swap(leftPointer, right);
   printf("Updated Array: ");
   display();
   return leftPointer;
}

void quickSort(int left, int right) {
   if (right - left <= 0) {
      return;
   } else {
      int pivot = intArray[right];
      int partitionPoint = partition(left, right, pivot);
      quickSort(left, partitionPoint - 1);
      quickSort(partitionPoint + 1, right);
   }
}

int main() {
   printf("Input Array: ");
   display();
   printline(50);
   quickSort(0, MAX - 1);
   printf("Output Array: ");
   display();
   printline(50);
}
```

Output

```
Input Array: [4 6 3 2 1 9 7 ]
================================================
 pivot swapped :9,7
Updated Array: [4 6 3 2 1 7 9 ]
 pivot swapped :4,1
Updated Array: [1 6 3 2 4 7 9 ]
 item swapped :6,2
 pivot swapped :6,4
Updated Array: [1 2 3 4 6 7 9 ]
 pivot swapped :3,3
Updated Array: [1 2 3 4 6 7 9 ]
Output Array: [1 2 3 4 6 7 9 ]
================================================
```