

Quick Sort

Elements: 157, 110, 147, 122, 111, 149, 151, 141, 133, 112, 117, 133

1) pivot element as first element in array.

pivot = 157

$i \rightarrow$ first element

$j \rightarrow$ at last element.

(i) Move i from left to right, ~~if $i < j$ swap~~ stop at element greater than pivot.

(ii) move j from right to left, stop at element less than pivot.

if $i < j$ swap $A[i], A[j]$,

if $i \geq j$ stop

Step 1
157, 110, 147, 122, 111, 149, 151, 141, 133, 112, 117, 133
 \uparrow \downarrow
swap

\Rightarrow 133, 110, 147, 122, 111, 149, 151, 141, 133, 112, 117, 157
 \uparrow pivot $\leftarrow j$

Step 2
133, 110, 147, 122, 111, 149, 151, 141, 133, 112, 117, 157
 \uparrow \downarrow
swap

\Rightarrow 133, 110, 117, 122, 111, 149, 151, 141, 133, 112, 147, 157
 \uparrow pivot \uparrow \downarrow

Step 3
133, 110, 117, 122, 111, 149, 151, 141, 133, 112, 147, 157
 \uparrow \downarrow
swap

133, 110, 117, 122, 111, 112, 151, 141, 133, 149, 147, 157
 \uparrow \downarrow

Step 4
133, 110, 117, 122, 111, 112, 151, 141, 133, 149, 147, 157
 \uparrow \downarrow
swap

\Rightarrow 133, 110, 117, 122, 111, 112, 123, 141, 151, 149, 147, 157
 \uparrow \downarrow

Step 5
133, 110, 117, 122, 111, 112, 123, 141, 151, 149, 147, 157
swap \uparrow \downarrow $j \leq i$ swap pivot
ac

\Rightarrow 123, 110, 117, 122, 111, 112, 133, 141, 151, 149, 147, 157

Now recursively sort left part & right part. as 133 is middle greater now.

Step 6:- pivot
 123, 110, 117, 122, 111, 112, 133, [141, 151, 149, 147, 157]
 swap
 133 ≤ 1
 No swap.

112, 110, 117, 122, 111, 123, 133, 141, [151, 149, 147] 157

Step 7:- pivot
 [112, 110, 117, 122, 111] 123, 133, 141, [151, 149, 147] 157
 swap
 pivot
 151, 149, 147, 157

⇒ 112, 110, 111, 122, 117, 123, 133, 141, 147, 149, 157, 157

Step 8:- pivot
 112, 110, 111, 122, 117, 123, 133, 141, 147, 149, 157, 157
 swap

112, 110, 112, 123, 117, 123, 133, 141, 147, 149, 151, 157

Step 9:- pivot
 111, 110, 112, 122, 117, 123, 133, 141, 147, 149, 151, 157
 swap

⇒ 110 | 111 | 112 | 117 | 122 | 123 | 133 | 141 | 147 | 149 | 151 | 157

⇒ Sorted (9 steps).

(ii) Last element as pivot element:-

pivot = 133

Step 1:-

157, 110, 147, 122, 111, 149, 151, 141, 123, 112, 117, 133
 \uparrow pivot \uparrow pivot
 swap

\Rightarrow 157 133

Step 2:-

\Rightarrow 117, 110, 147, 122, 111, 149, 151, 141, 123, 112, 157, 133
 \uparrow \uparrow
 swap

Step 3:-

117, 110, 112, 122, 111, 149, 151, 141, 123, 147, 157, 133 pivot.
 \uparrow \uparrow
 swap

Step 4:-

117, 110, 112, 122, 111, 123, 151, 141, 149, 147, 157, 133.
 \uparrow \uparrow \uparrow \uparrow
 swap

Step 5:-

[117, 110, 112, 122, 111] [133] [141, 149, 147, 157, 151]
 \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow
 pivot swap

Step 6:-

117, 110, 112, 122, 111, [123] [133], 141, 149, 147, [157] [151]
 \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow
 swap swap

Step 7:-

110, 117, 112, 122, 111, 123, 133, 141, 147, 149, 151, 157.
 \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow
 swap sorted

Step 8:-

110, [111], 122, 122, 117, 123, 133, 141, 147, 149, 151, 157.
 \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow
 swap sorted

Step 9:-

[110, 111] 112, [117], 122, [123, 133, 141, 147, 149, 151, 157]
 \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow \uparrow
 pivot pivot sorted

Step 10:-

110, 111, 112, 117, 122, 123, 133, 141, 147, 149, 151, 157.
 sorted.

10 steps

(iii) Random element.

Pivot = 141

Step 1:- 157, 140, 147, 122, 111, 149, 151, 141, 143, 112, 117, 133
 ↑_i pivot
 swap

Step 2:- 133, 110, 147, 122, 111, 149, 151, 141, 143, 112, 117, 157.
 ↑_i pivot
 swap

Step 3:- 133, 110, 117, 122, 111, 149, 151, 141, 143, 112, 147, 157.
 ↑_i pivot
 swap

Step 4:- 133, 110, 117, 122, 111, 112, 151, 141, 143, 149, 147, 157.
 ↑_i pivot
 swap

Step 5:- 133, 110, 117, 122, 111, 112, 141, 151, 143, 149, 147, 157.
 ↑_i pivot
 swap

Step 6:- 112, 110, 117, 122, 111, 133, 141, 147, 143, 149, 151, 157.
 ↑_i pivot
 swap

Step 7:- 133 110 | 117 122 111 112 151, 143, 149, 147, 157
 ↑_i pivot

Step 8:- 110 111 112 | 117 133 122 143 147 | 149 151 157
 ↑_i pivot

Step 9:- 140, 111, 112, 117, 122 133, 143, 147, 149, 151, 157
 ↑_i pivot

110 111 112 117 122 133 141 143 147 149 151 157

9 steps