

Insertion Sort

\checkmark 75, \checkmark 90, \checkmark 100, \checkmark 95, \checkmark 85, \checkmark 50, \checkmark 100, \checkmark 110, \checkmark 7
 0 1 2 3 4 5 6 7 8

75	90
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0 1 2 $90 < 100$

75	90	100
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95 $100 > 95$

75	90	100	95	100
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0 1 2 3 $90 > 85$
 $95 > 85$
 85 90 $95 > 100$

75	90	95	100	<u>85</u>	100
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0 1 2 3 4

$75 > 50$
 $85 > 50$
 $90 > 50$
 $95 > 50$
 $100 > 50$

0	1	2	3	4	5
75	85	90	95	100	50

50 75 85 90 95 100
 $100 < 110$

0	1	2	3	4	5	6	7
50	75	85	90	95	100	100	110

7 50 75 85 90 95 100 110
 $110 > 7$
 $100 > 7$
 $100 > 7$
 $95 > 7$

$90 > 7$
 $85 > 7$
 $75 > 7$
 $50 > 7$

7, 50, 75, 85, 90, 95, 100, 100, 110

0 1 2 3 4 5 6 7 8

↳ sorted array

Best case

Ascending order $\begin{cases} n-1 \text{ comparisons} \\ 0 \text{ swaps} \end{cases}$

10, 20, 30, 40, 50
0 1 2 3 4

$n=5$

10 ——— No comparison

10 | 20 $10 < 20$ ①

10 | 20 | 30 $20 < 30$ ②

10 | 20 | 30 | 40 $30 < 40$ ③

10 | 20 | 30 | 40 | 50 $40 < 50$ ④

n $\begin{cases} (n-1) \text{ comparisons} = O(n) \\ 0 \text{ swaps} \end{cases}$

$T(n) = O(n)$

Worst case

↳ Decending order

$n = 5$

50, 40, 30, 20, 10
0 1 2 3 4

n elements

50
0

C S

1 1

50 > 40

2 2

50 | 40 50
0 1

3 3

50 > 30

4 4

40 | 50 | 30
30 40 50

40 > 30

1 1
 $n-1$ $n-1$

20 30 40 50
30 | 40 | 50 | 20

50 > 20

40 > 20

30 > 20

↪ ↪ ↪

10 20 30 40 50

50 > 10

20 | 30 | 40 | 50 | 10

40 > 10

30 > 10

20 > 10

↪ ↪ ↪ ↪

comparisons → 1 + 2 + 3 + ... + $n-1$

$$\Rightarrow \frac{(n-1)n}{2} = O(n^2)$$

Swaps

$$\hookrightarrow 1 + 2 + 3 + \dots + n-1$$

$$\frac{(n-1)n}{2} = O(n^2)$$

$$\underline{\underline{T(n) = O(n^2)}}$$

Best case \rightarrow Ascending order

(Almost sorted \rightarrow ascending order)

**INSERTION
SORT** \Rightarrow

\Downarrow

$$\underline{O(n)}$$

Worst case \rightarrow Descending order

\Downarrow

$$\underline{O(n^2)}$$