Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Integer Arrays

- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Linear Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays
- Linear Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Linear Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Linear Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays
- Linear Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays

- Linear Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Linear

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Linear
Random

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Linear 11
Random

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Linear n
Random

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Linear	n
Random	11

Integer Arrays

- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Linear n

Random n

Integer Arrays
- Search

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Look at the Middle Element

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Look at the Middle Element

$$\frac{0+4}{2} = 2$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 12?

Look at the Middle Element

$$\frac{0+4}{2} = 2$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{6+10}{2} = 8$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{6+10}{2} = 8$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{6+10}{2} = 8$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{6+7}{2} = 6.5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{6+7}{2} = 6$$

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 50?

Look at the Middle Element

$$\frac{6+7}{2} = 6$$

Sorted Integer Arrays
- Search

Where is 50?

Look at the Middle Element

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{0+10}{2} = 5$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{0+4}{2} = 2$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{0+4}{2} = 2$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{0+4}{2} = 2$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{3+4}{2} = 3.5$$

Sorted Integer Arrays - Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{3+4}{2} = 4$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{3+4}{2} = 4$$

Sorted Integer Arrays - Search

5	8	12	$\boxed{16}$	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{3+4}{2} = 4$$

Sorted Integer Arrays
- Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Where is 25?

Look at the Middle Element

$$\frac{3+4}{2} = 4$$

Sorted Integer Arrays

- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

n

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$n \rightarrow \frac{n}{2}$$

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$n \to \frac{n}{2} \to \frac{n}{2^2}$$

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$n \to \frac{n}{2} \to \frac{n}{2^2} \to \frac{n}{2^3}$$

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$n \rightarrow \frac{n}{2} \rightarrow \frac{n}{2^2} \rightarrow \frac{n}{2^3} \rightarrow \cdots$$

Sorted Integer Arrays - Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$n \to \frac{n}{2} \to \frac{n}{2^2} \to \frac{n}{2^3} \to \cdots \to 1$$

Sorted Integer Arrays - Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$n \rightarrow \frac{n}{2} \rightarrow \frac{n}{2^2} \rightarrow \frac{n}{2^3} \rightarrow \cdots \rightarrow 1 = \frac{n}{2^i} (i \text{ steps})$$

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$\frac{n}{2^i} = 1$$

Sorted Integer Arrays - Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

In each step, the number of elements becomes half.

$$\frac{n}{2^i} = 1 \implies i = \log_2 n$$

Sorted Integer Arrays
- Binary Search

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Binary Search takes atmost $\log_2 n$ steps

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5										
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

0	1	2	3	4	5	6	7	8	9	10
5	8	73	16	12	43	99	28	64	50	37

0	1	2	3	4	5	6	7	8	9	10
5	8									

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8									
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12								
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12								
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16							
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28						
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37					
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43				
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50			
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64		
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	
0	1	2	3	4	5	6	7	8	9	10

Strategy

Select the smallest element – Linear Search

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Done!

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

n

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$n + (n - 1)$$

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$n + (n-1) + (n-2)$$

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$n + (n-1) + (n-2) + (n-3)$$

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$n + (n-1) + (n-2) + (n-3) + \ldots$$

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$n + (n-1) + (n-2) + (n-3) + \ldots + 1$$

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$n + (n-1) + (n-2) + (n-3) + \ldots + 1 = n(n+1)/2$$

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Space Complexity

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Space Complexity

n

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	12	16	73	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	12	16	73	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

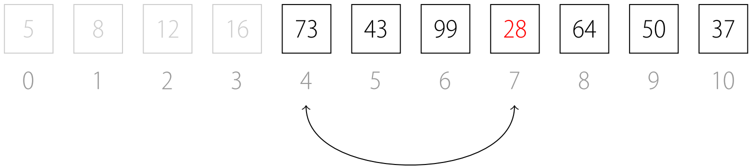
5	8	12	16	73	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

5	8	12	16	73	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	12	16	73	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

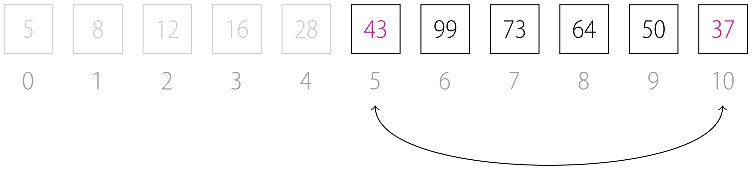


5	8	12	16	28	43	99	73	64	50	37
0	1	2	3	4	5	6	7	8	9	10

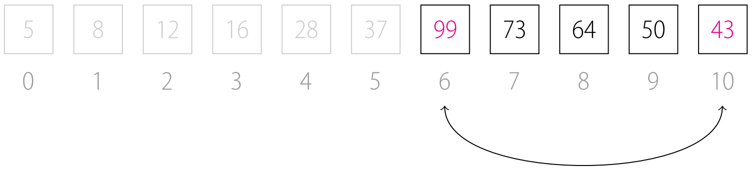
Sorting Integer Arrays

5	8	12	16	28	43	99	73	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays



Sorting Integer Arrays




5
8
12
16
28
37
43
73
64
50
99
0
1
2
3
4
5
6
7
8
9
10

Sorting Integer Arrays

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Space Complexity

`Constant`

Sorting Integer Arrays

- Selection Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Sorting Integer Arrays
- Selection Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Does it change?

Sorting Integer Arrays
- Selection Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Does it change? - Thought Experiment

Sorting Integer Arrays

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

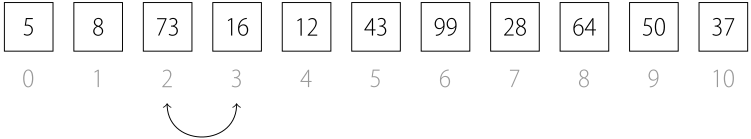
Sorting Integer Arrays
- Bubble Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

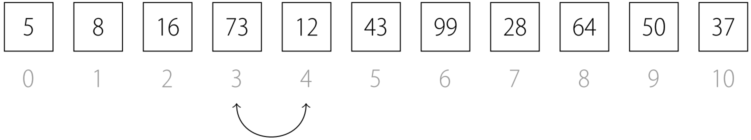
Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

5	8	16	73	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

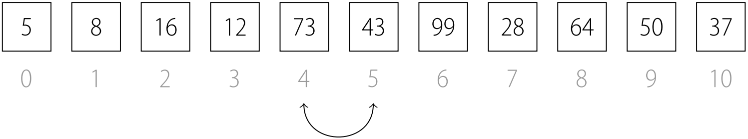


Sorting Integer Arrays

- Bubble Sort

5	8	16	12	73	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays

- Bubble Sort

5	8	16	12	43	73	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

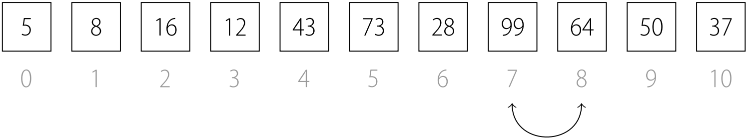
Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	99	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



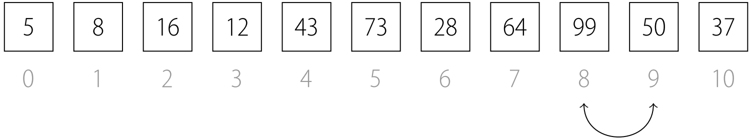
Sorting Integer Arrays

- Bubble Sort

5	8	16	12	43	73	28	64	99	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort



Sorting Integer Arrays

- Bubble Sort

5	8	16	12	43	73	28	64	50	99	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	64	50	99	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Round 1 complete !

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Any guess as to how many rounds are required?

Sorting Integer Arrays

- Bubble Sort

5	8	16	12	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	16	12	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

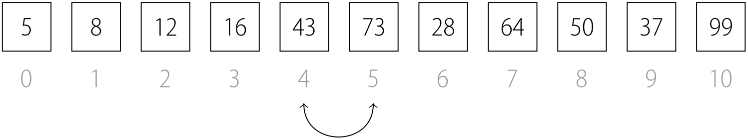
Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

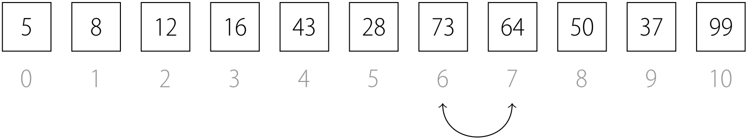
5	8	12	16	43	73	28	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	73	64	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	64	73	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort

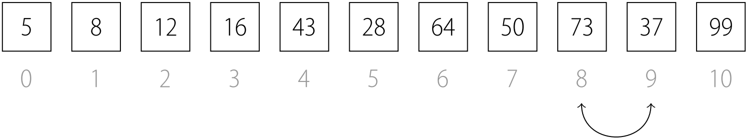
5	8	12	16	43	28	64	73	50	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort

5	8	12	16	43	28	64	50	73	37	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2 complete !

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

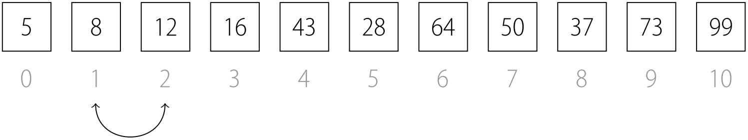
Any guess as to how many rounds are required?

Sorting Integer Arrays

- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays

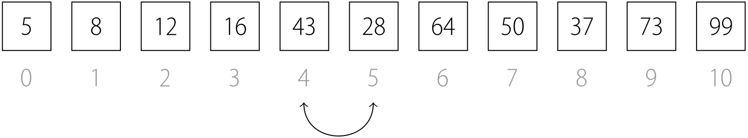
- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	43	28	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

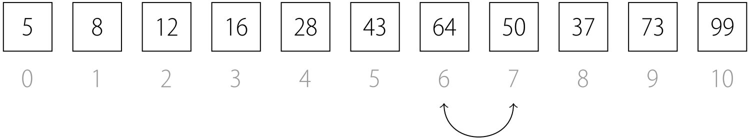
5	8	12	16	28	43	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	64	50	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	64	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	64	37	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

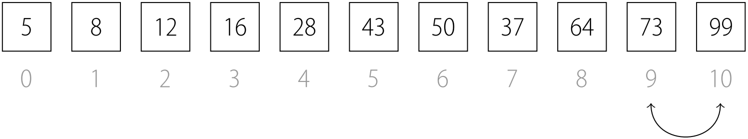
- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 3 complete !

Sorting Integer Arrays
- Bubble Sort

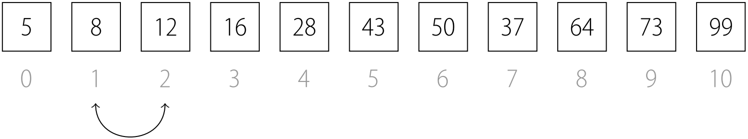
5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Any guess as to how many rounds are required?

Sorting Integer Arrays
- Bubble Sort

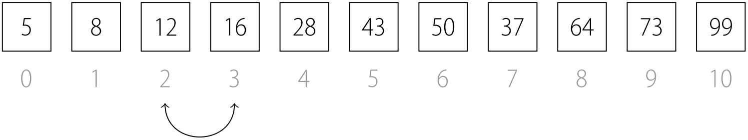
5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays

- Bubble Sort



Sorting Integer Arrays

- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

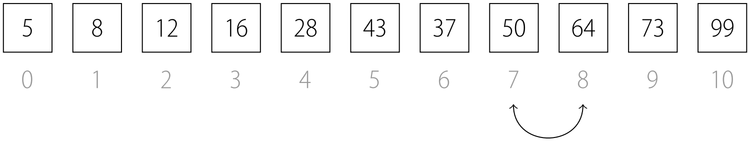
Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	50	37	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

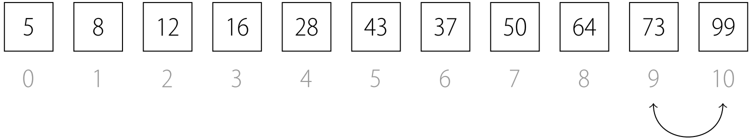


Sorting Integer Arrays

- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays

- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 4 complete !

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Any guess as to how many rounds are required?

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Any guess as to how many rounds are required?

$$n - 1$$

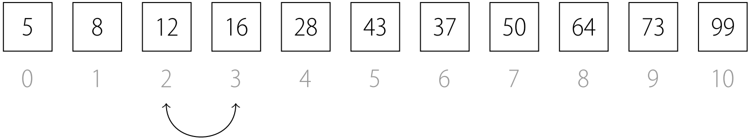
Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

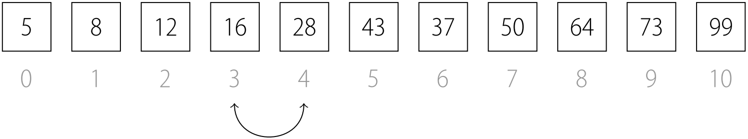
Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

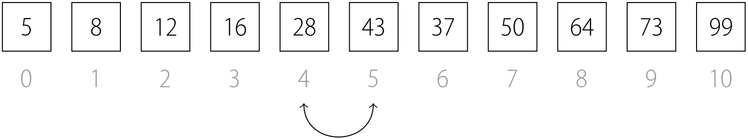
Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays

- Bubble Sort

5	8	12	16	28	43	37	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort

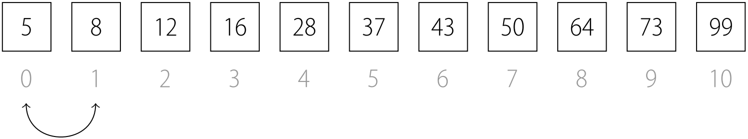
5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 5 complete !

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort

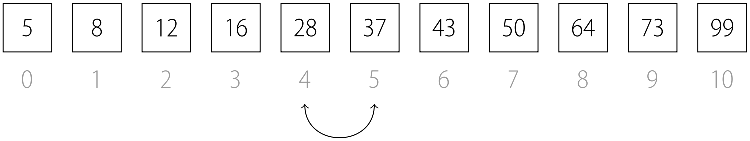
5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays

- Bubble Sort

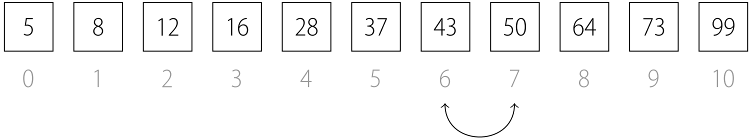


Sorting Integer Arrays

- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort

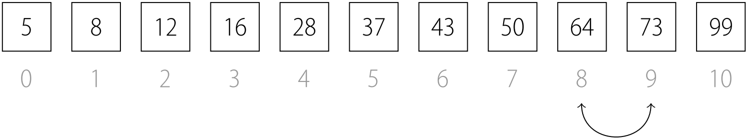


Sorting Integer Arrays

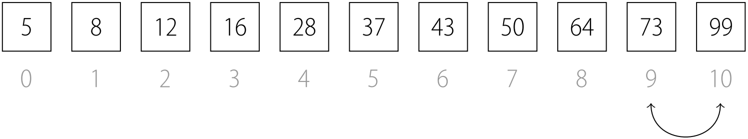
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Bubble Sort



Sorting Integer Arrays
- Bubble Sort



5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Nothing changed !

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Nothing changed !

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Complexity

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Space Complexity

Sorting Integer Arrays - Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Space Complexity

`Constant`

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$(n-1)$$

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$(n-1)+(n-2)$$

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$(n-1) + (n-2) + (n-3)$$

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$(n-1)+(n-2)+(n-3)+\ldots$$

Sorting Integer Arrays - Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$(n-1)+(n-2)+(n-3)+\ldots+1$$

Sorting Integer Arrays
- Bubble Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Time Complexity

$$(n-1)+(n-2)+(n-3)+\ldots+1 \leq \frac{n(n+1)}{2}$$

Sorting Integer Arrays

- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

0	1	2	3	4	5	6	7	8	9

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9

Sorting Integer Arrays

- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
					5				

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
					5			8	

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
			73		5			8	

Sorting Integer Arrays

- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
			73		5	16		8	

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
		12	73		5	16		8	

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
		12	73		5	16		8	
			43						

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
		12	73		5	16		8	99
			43						

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
		12	73		5	16		8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
		12	73	64	5	16		8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16		8	99
			43					28	

Sorting Integer Arrays

- Radix Sort

5	8	73	16	12	43	99	28	64	50	37
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays

- Radix Sort

0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50										
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12									
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays

- Radix Sort

50	12	73								
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43							
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64						
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5					
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16				
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays

- Radix Sort

0	1	2	3	4	5	6	7	8	9	10
50	12	73	43	64	5	16	37			

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8		
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 1

0	1	2	3	4	5	6	7	8	9
50		12	73	64	5	16	37	8	99
			43					28	

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
					50				

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
	12				50				

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
	12				50		73		

Sorting Integer Arrays

- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
	12			43	50		73		

Sorting Integer Arrays

- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
	12			43	50	64	73		

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12			43	50	64	73		

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12			43	50	64	73		
	16								

Sorting Integer Arrays

- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12		37	43	50	64	73		
	16								

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12		37	43	50	64	73		
8	16								

Sorting Integer Arrays
- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		
8	16								

Sorting Integer Arrays

- Radix Sort

50	12	73	43	64	5	16	37	8	28	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays

- Radix Sort

0	1	2	3	4	5	6	7	8	9	10
5										

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays

- Radix Sort

0	1	2	3	4	5	6	7	8	9	10
5	8									

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

5	8	12								
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

0	1	2	3	4	5	6	7	8	9	10
5	8	12	16							

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28						
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37					
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43				
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays - Radix Sort

5	8	12	16	28	37	43	50			
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays

- Radix Sort

5	8	12	16	28	37	43	50	64		
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays

- Radix Sort

5	8	12	16	28	37	43	50	64	73	
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

Sorting Integer Arrays

- Radix Sort

$a < b$

Sorting Integer Arrays
- Radix Sort

$$a < b$$

$$a = a_1\, a_2\, a_3\, a_4$$

Sorting Integer Arrays
- Radix Sort

$$a < b$$

$$a = a_1\ a_2\ a_3\ a_4$$

$$b = b_1\ b_2\ b_3\ b_4$$

Sorting Integer Arrays
- Radix Sort

$$a < b$$

$$a = a_1\, a_2\, a_3\, a_4$$

$$b = b_1\, b_2\, b_3\, b_4$$

$$\ldots a \ldots b \ldots$$

Sorting Integer Arrays - Radix Sort

$$a < b$$

$$a = a_1\, a_2\, a_3\, a_4$$

$$b = b_1\, b_2\, b_3\, b_4$$

$$\ldots a \ldots b \ldots$$

$$a_2 < b_2$$

Sorting Integer Arrays
- Radix Sort

$$a < b$$

$$a \;=\; a_1\, a_2\, a_3\, a_4$$

$$b \;=\; b_1\, b_2\, b_3\, b_4$$

$$\ldots a \ldots b \ldots$$

$$a_2 < b_2$$
$$a_1 == b_1$$

Sorting Integer Arrays
- Radix Sort

Can we do it from the other end?

$$a < b$$

$$a \;=\; a_1\, a_2\, a_3\, a_4$$

$$b \;=\; b_1\, b_2\, b_3\, b_4$$

$$\ldots a \ldots b \ldots$$

$$a_2 < b_2$$
$$a_1 == b_1$$

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Time Complexity

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Time Complexity

Number of rounds

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Time Complexity

Number of rounds * Time for each round

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Time Complexity

$$d * n$$

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Space Complexity

Sorting Integer Arrays
- Radix Sort

5	8	12	16	28	37	43	50	64	73	99
0	1	2	3	4	5	6	7	8	9	10

Round 2

0	1	2	3	4	5	6	7	8	9
5	12	28	37	43	50	64	73		99
8	16								

Space Complexity

n