

Merge Sort

Prof. Harish D.G.
Dept. of Computer and IT
College of Engineering, Pune
www.harishgadade.com

Merge Sort

- The merge sort algorithm uses the divide and conquer strategy.
- Merge sort on an input array with 'n' elements consists of three steps.
 1. **Divide** - Partitions (divide) array into two sublists **s1 & s2** with $n / 2$ approximate elements each.
 2. **Conquer**- Then sort sub list **s1 & s2**
 3. **Combine**- Merge **s1 & s2** into a unique sorted group.

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

45	14
----	----

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

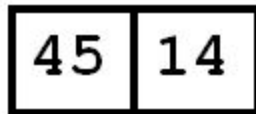
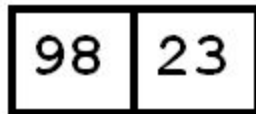
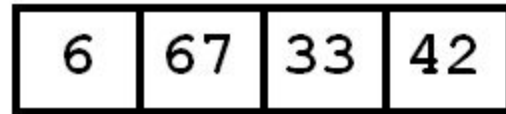
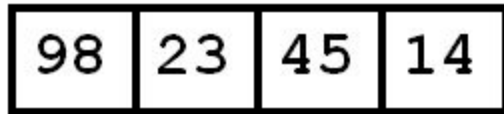
98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

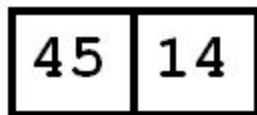
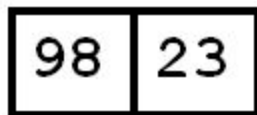
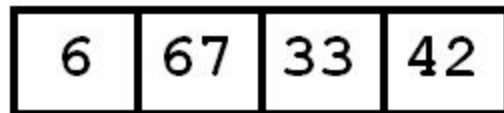
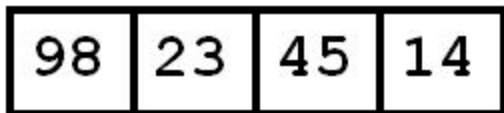
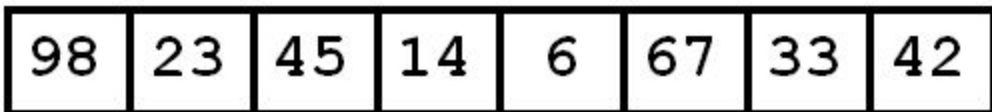
98	23
----	----

45	14
----	----

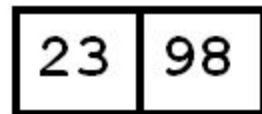
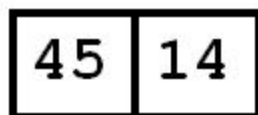
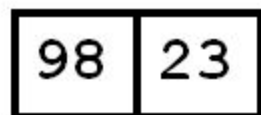
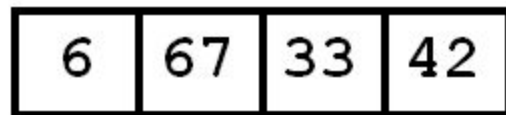
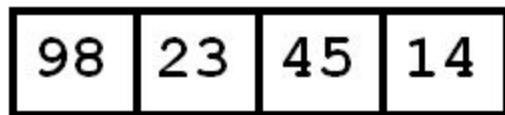
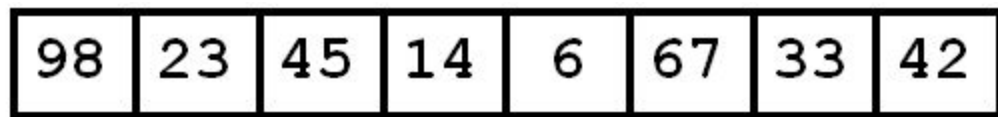
98	23
----	----



Merge



Merge



Merge

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

45	14
----	----

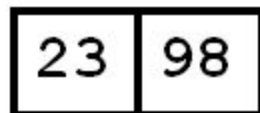
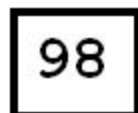
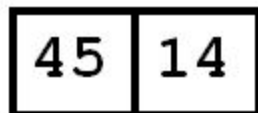
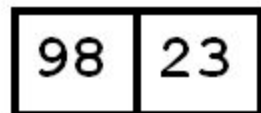
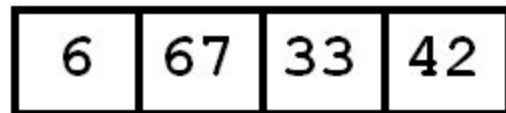
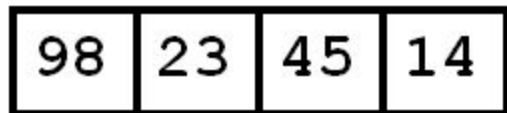
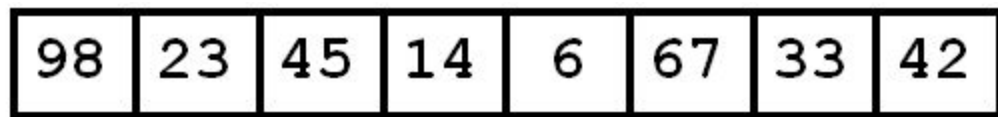
98

23

45

14

23	98
----	----



Merge

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

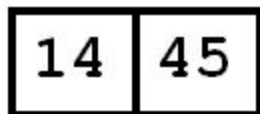
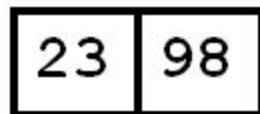
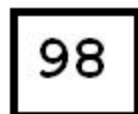
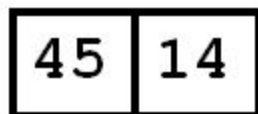
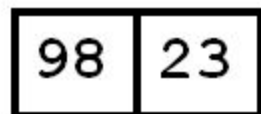
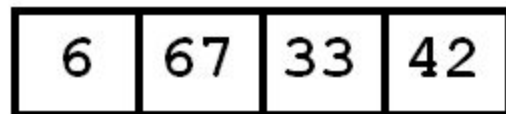
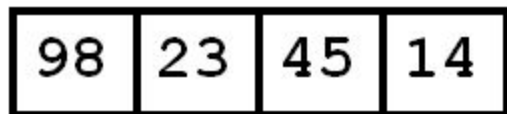
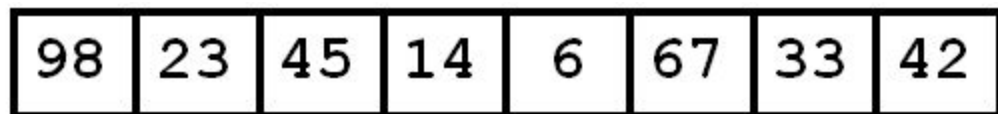
45	14
----	----

98	23	45	14
----	----	----	----

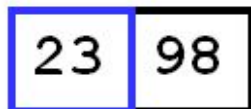
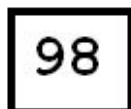
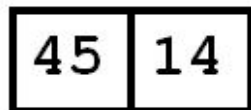
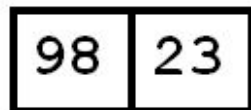
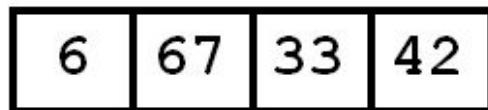
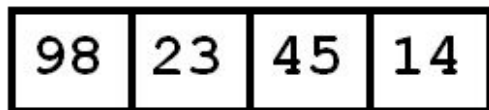
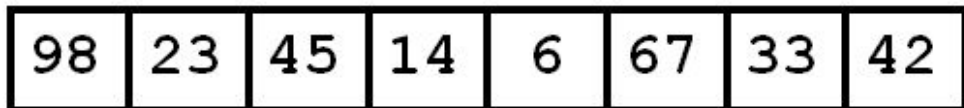
23	98
----	----

14

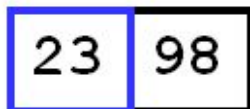
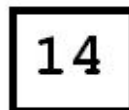
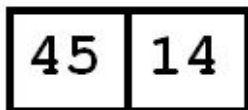
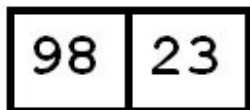
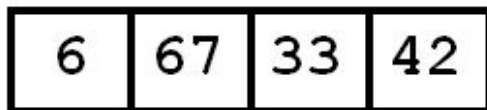
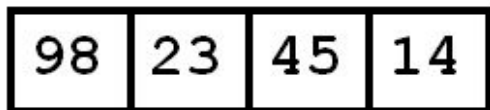
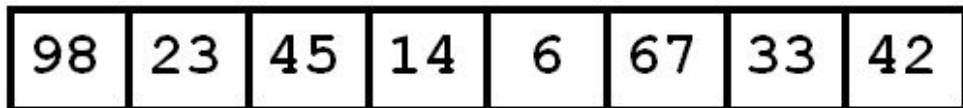
Merge



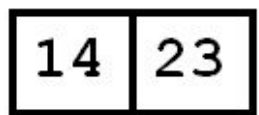
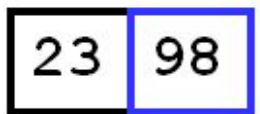
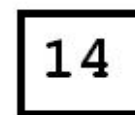
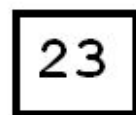
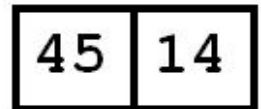
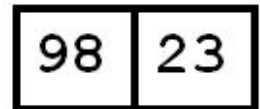
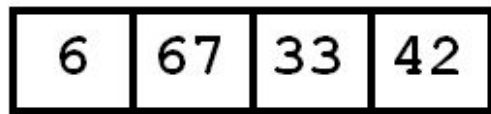
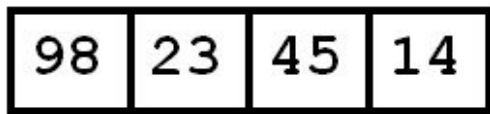
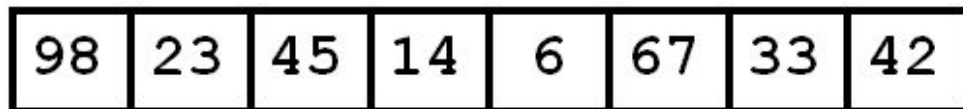
Merge



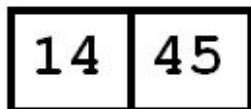
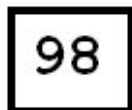
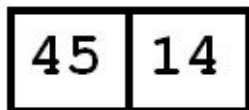
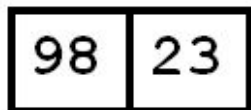
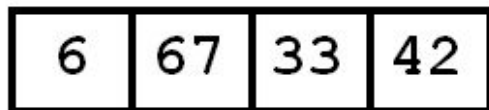
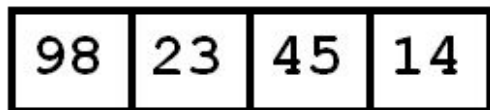
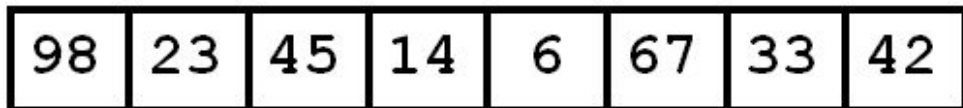
Merge



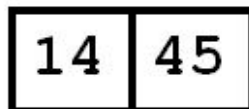
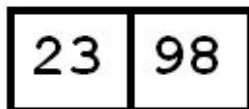
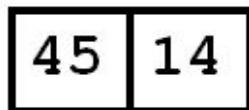
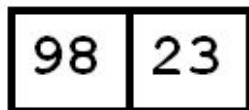
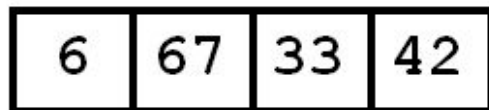
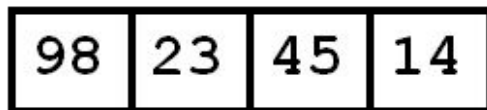
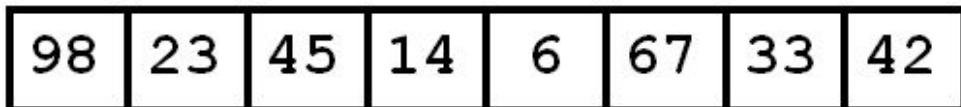
Merge



Merge



Merge



Merge

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

45	14
----	----

6	67
---	----

33	42
----	----

98

23

45

14

23	98
----	----

14	45
----	----

14	23	45	98
----	----	----	----

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

45	14
----	----

6	67
---	----

33	42
----	----

98

23

45

14

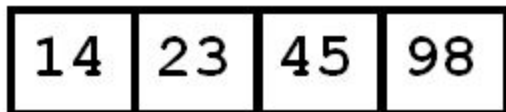
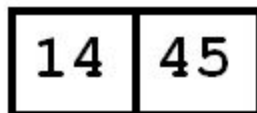
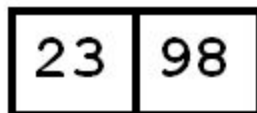
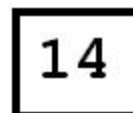
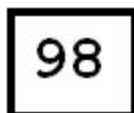
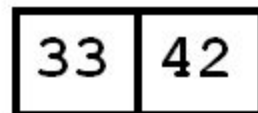
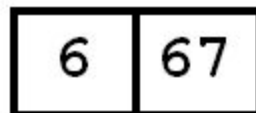
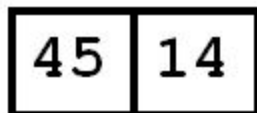
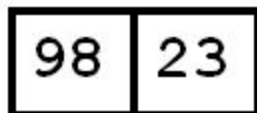
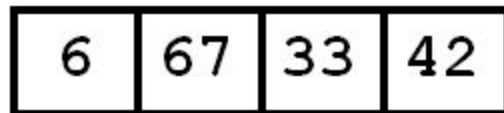
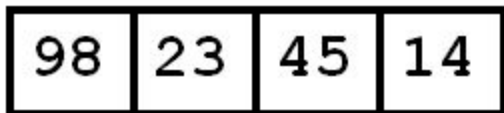
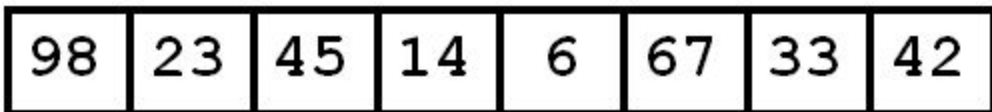
6

67

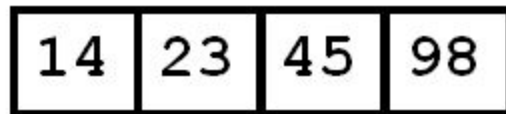
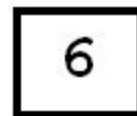
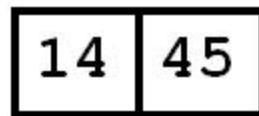
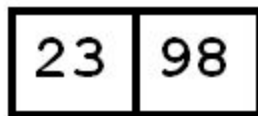
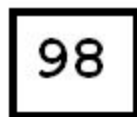
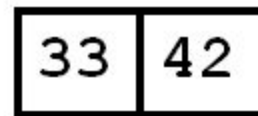
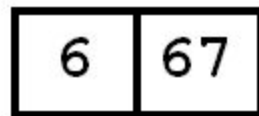
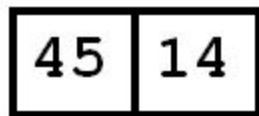
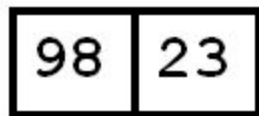
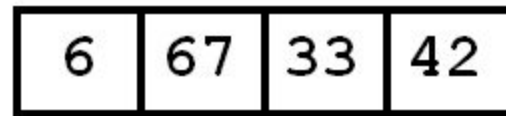
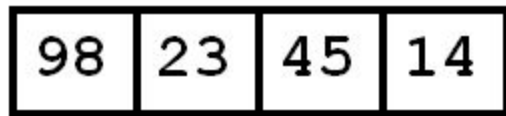
23	98
----	----

14	45
----	----

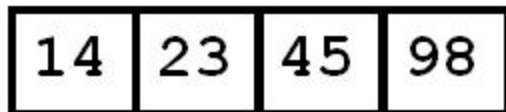
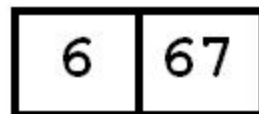
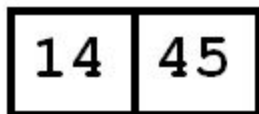
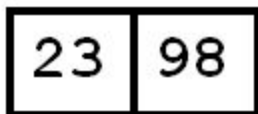
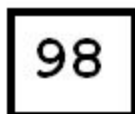
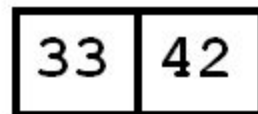
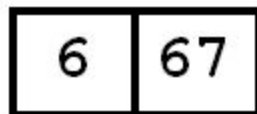
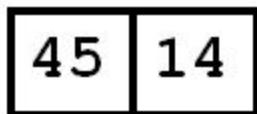
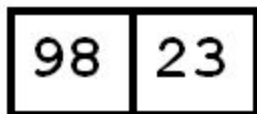
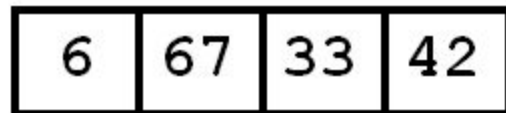
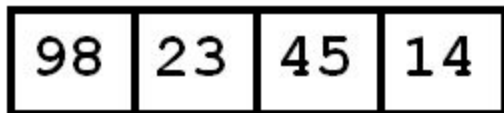
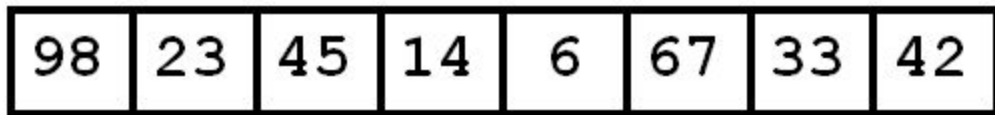
14	23	45	98
----	----	----	----



Merge



Merge



Merge

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

45	14
----	----

6	67
---	----

33	42
----	----

98

23

45

14

6

67

33

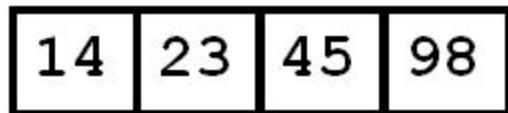
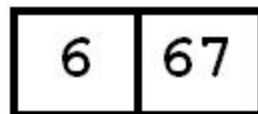
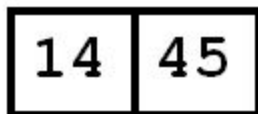
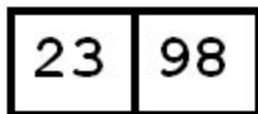
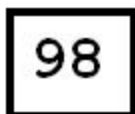
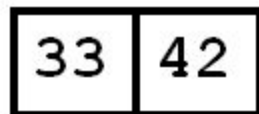
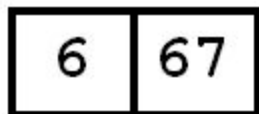
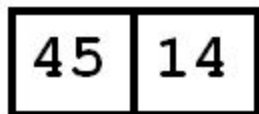
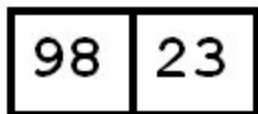
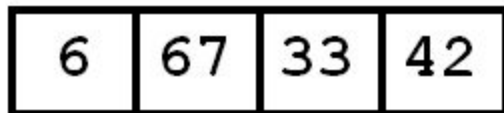
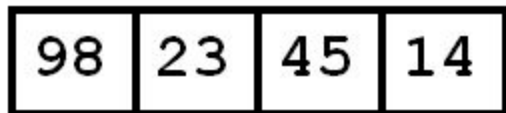
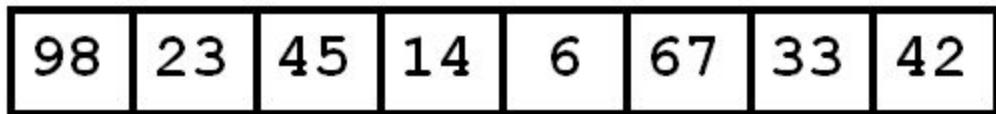
42

23	98
----	----

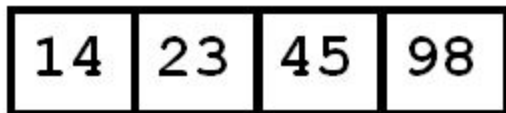
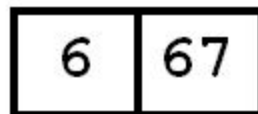
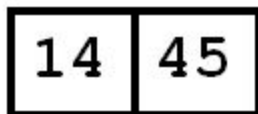
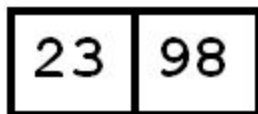
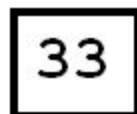
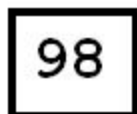
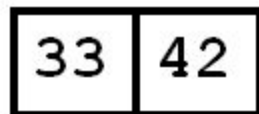
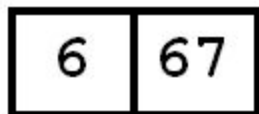
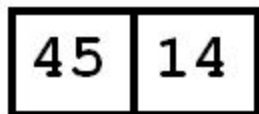
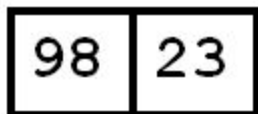
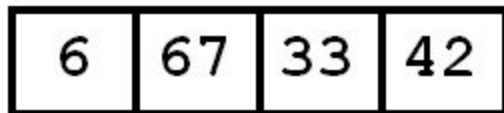
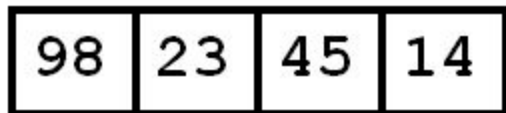
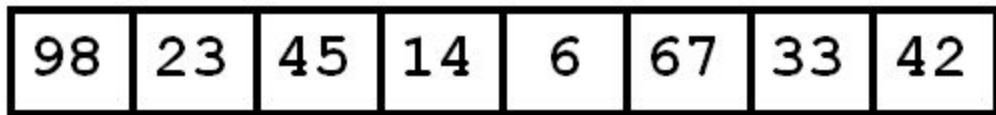
14	45
----	----

6	67
---	----

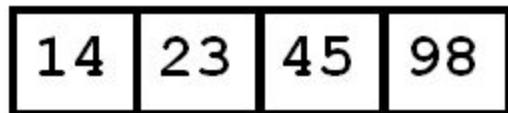
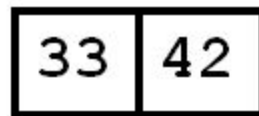
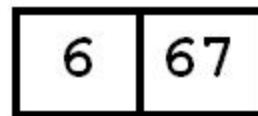
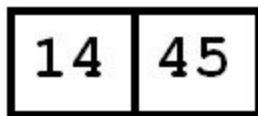
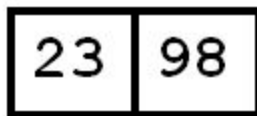
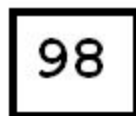
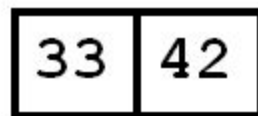
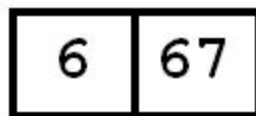
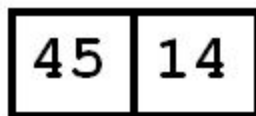
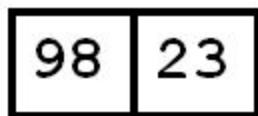
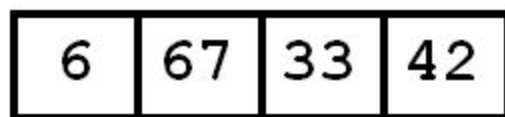
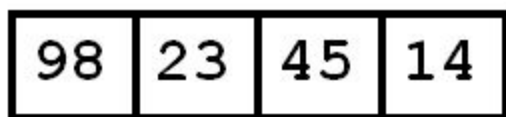
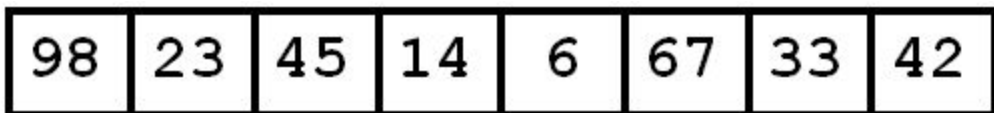
14	23	45	98
----	----	----	----



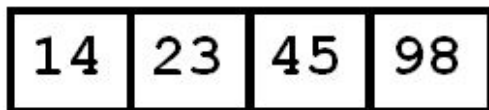
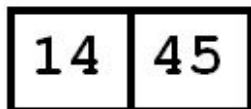
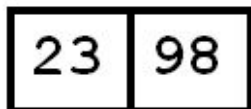
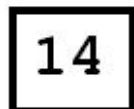
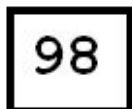
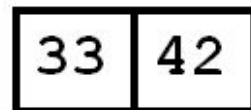
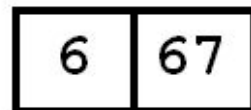
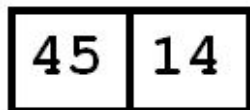
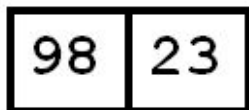
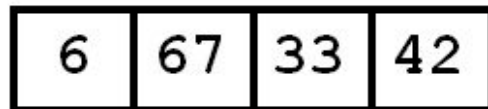
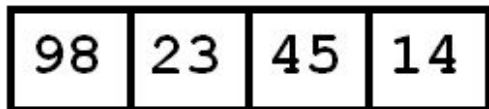
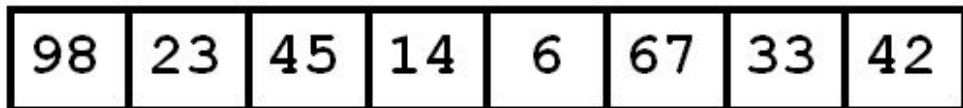
Merge



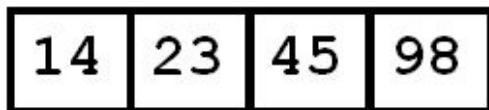
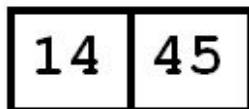
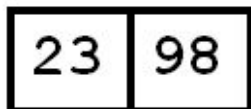
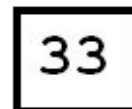
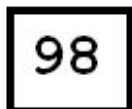
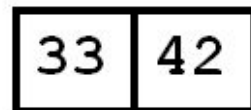
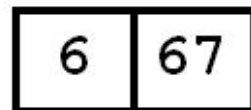
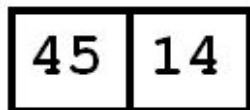
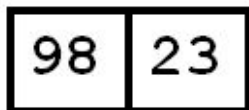
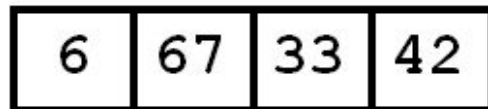
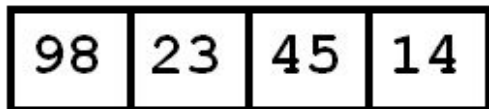
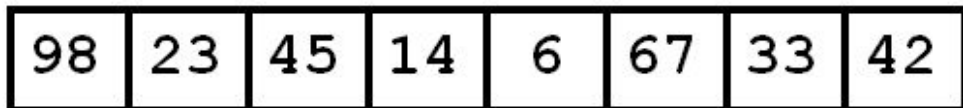
Merge



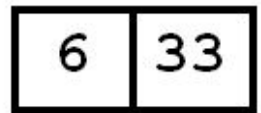
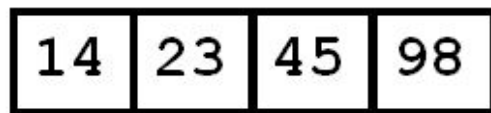
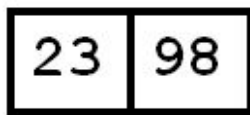
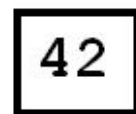
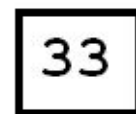
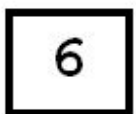
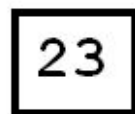
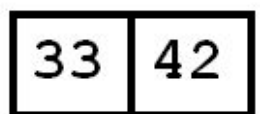
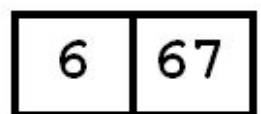
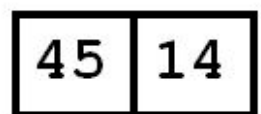
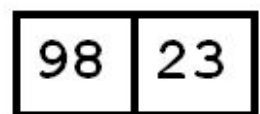
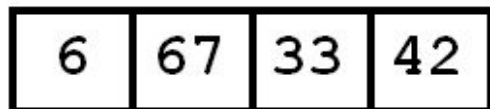
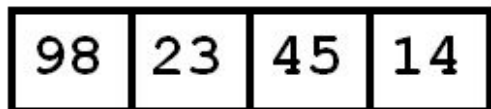
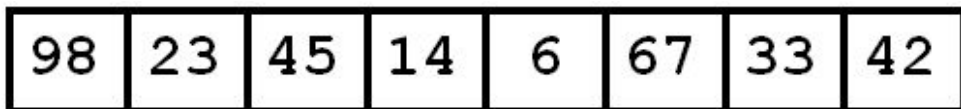
Merge



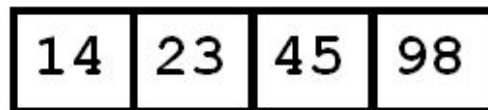
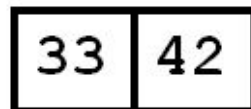
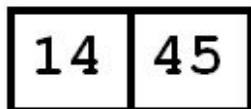
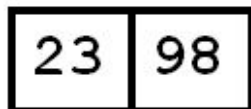
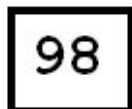
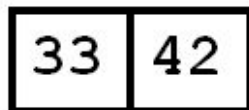
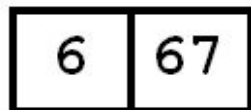
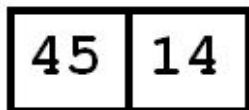
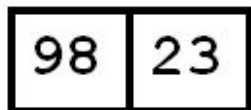
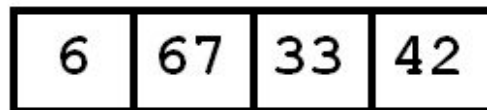
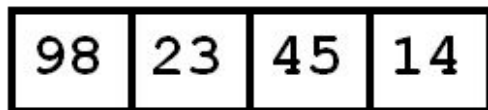
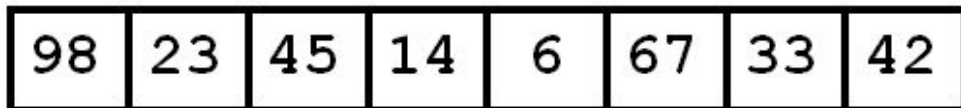
Merge



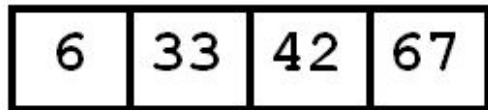
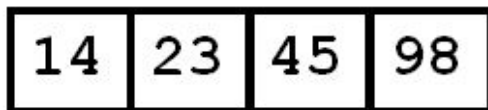
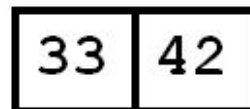
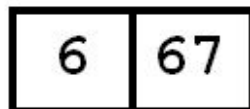
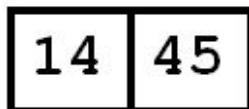
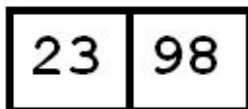
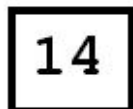
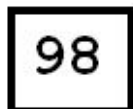
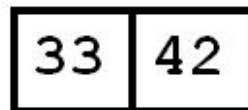
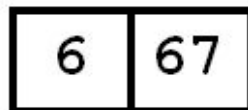
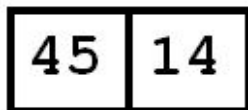
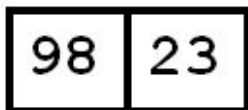
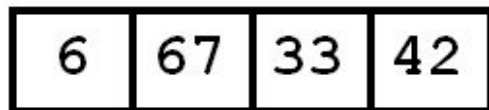
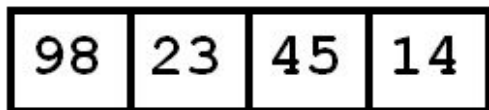
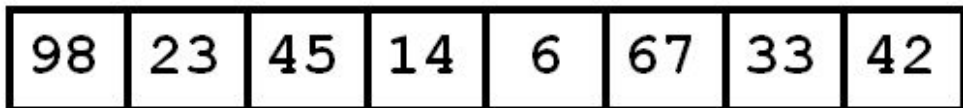
Merge



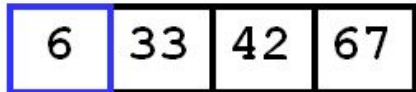
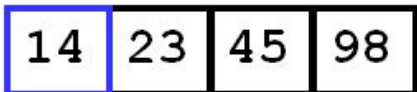
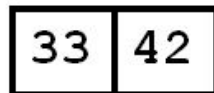
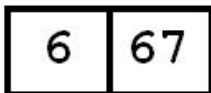
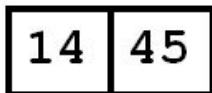
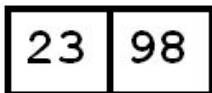
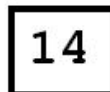
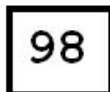
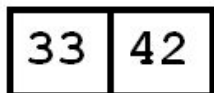
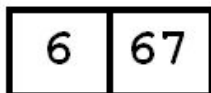
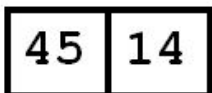
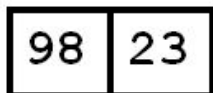
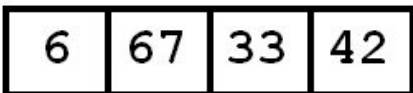
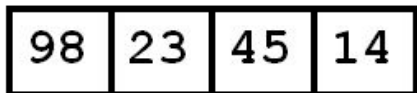
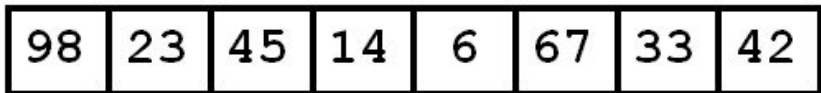
Merge



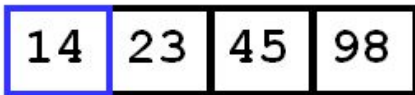
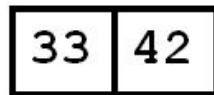
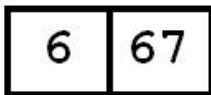
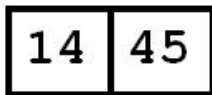
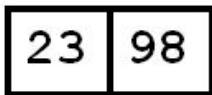
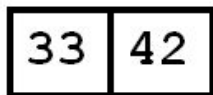
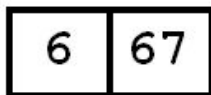
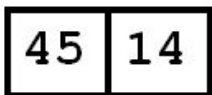
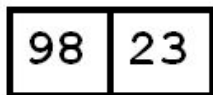
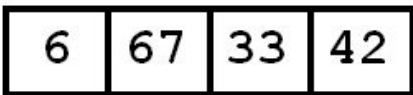
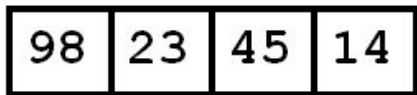
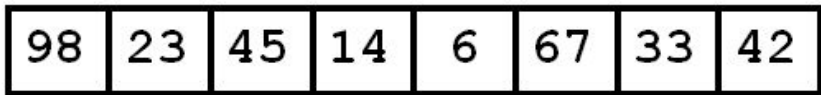
Merge



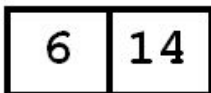
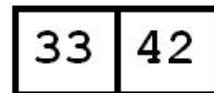
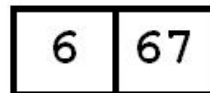
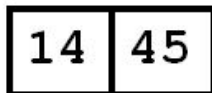
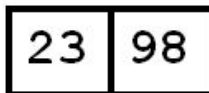
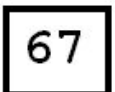
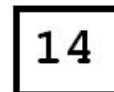
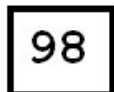
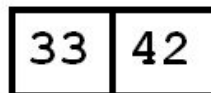
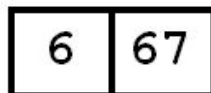
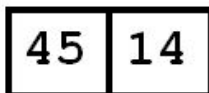
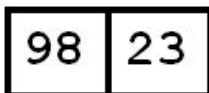
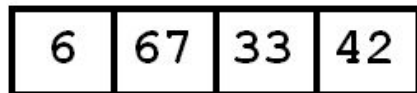
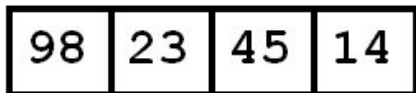
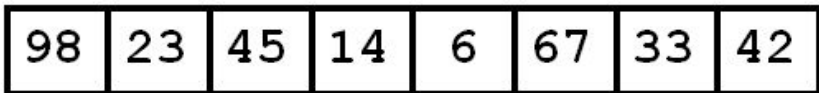
Merge



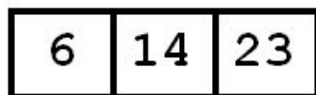
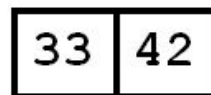
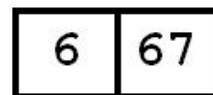
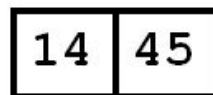
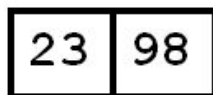
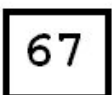
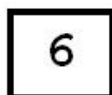
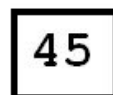
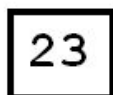
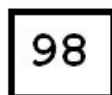
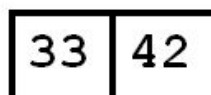
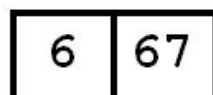
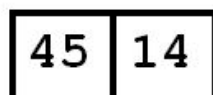
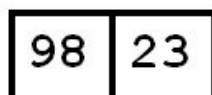
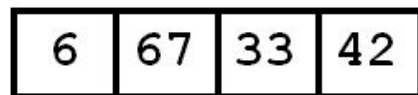
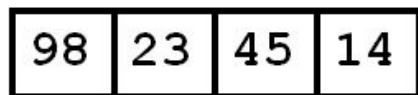
Merge



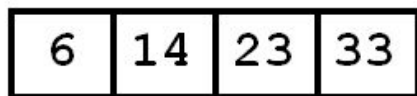
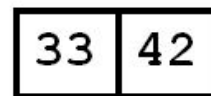
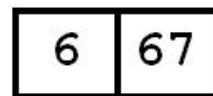
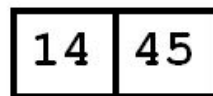
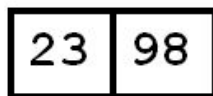
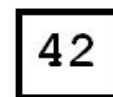
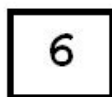
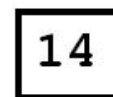
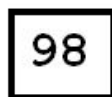
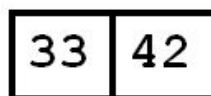
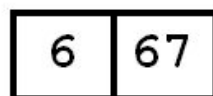
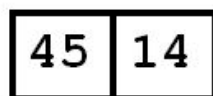
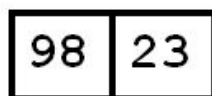
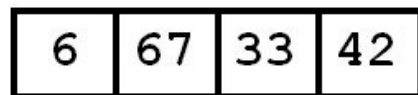
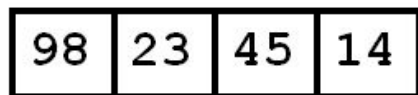
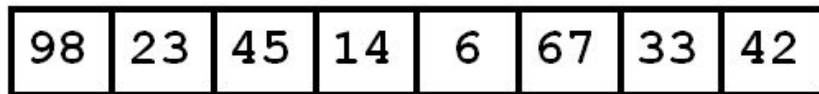
Merge



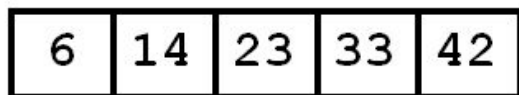
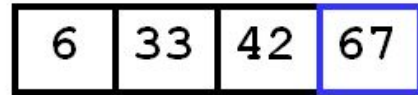
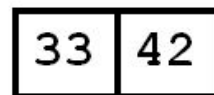
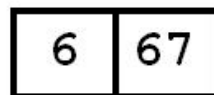
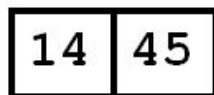
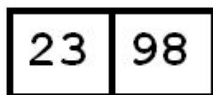
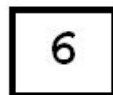
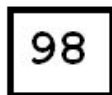
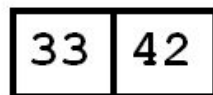
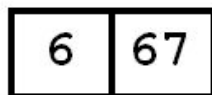
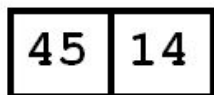
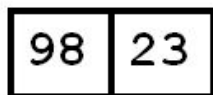
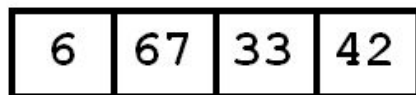
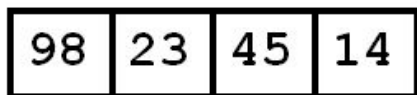
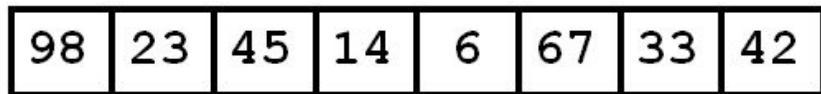
Merge



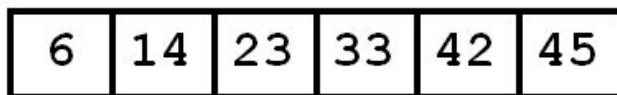
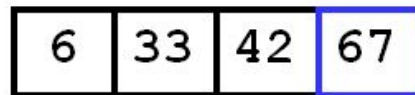
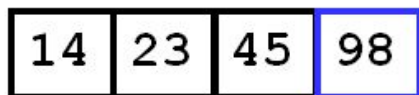
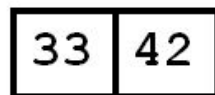
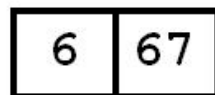
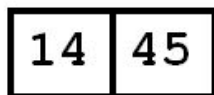
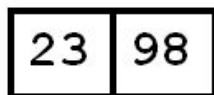
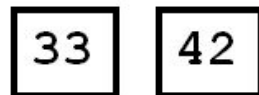
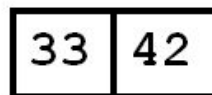
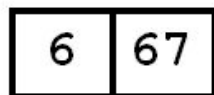
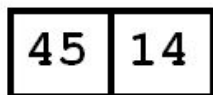
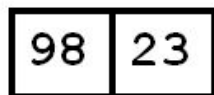
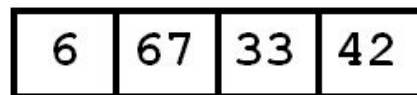
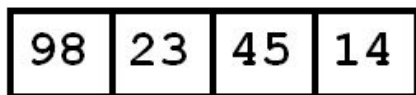
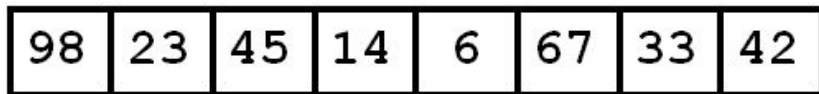
Merge



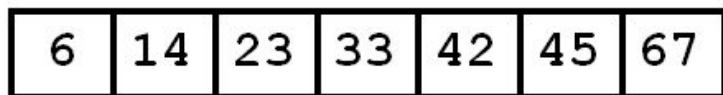
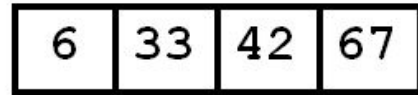
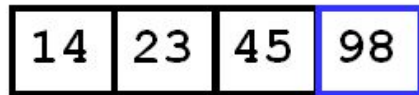
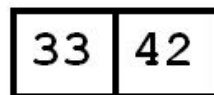
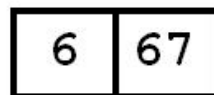
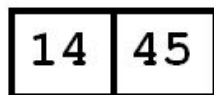
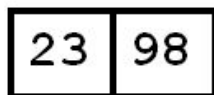
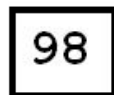
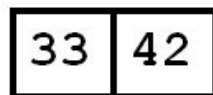
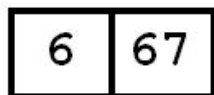
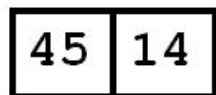
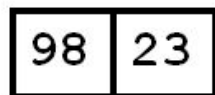
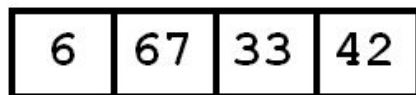
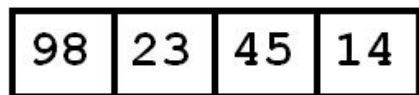
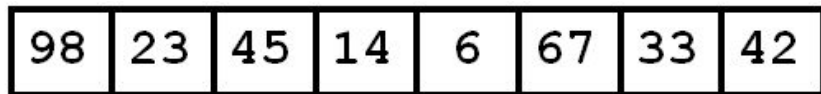
Merge



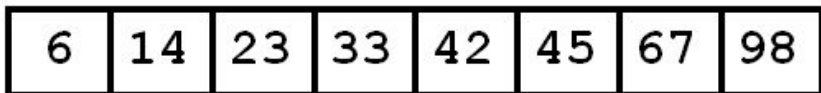
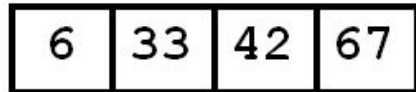
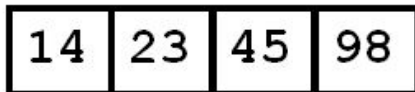
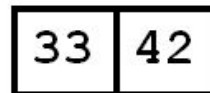
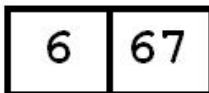
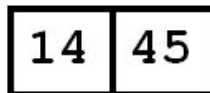
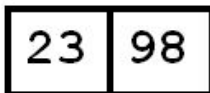
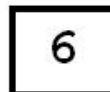
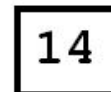
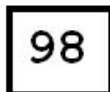
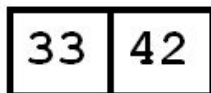
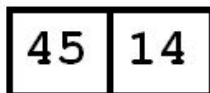
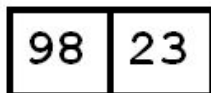
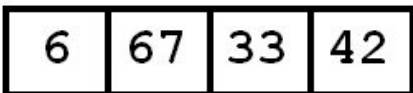
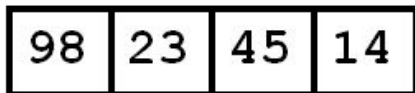
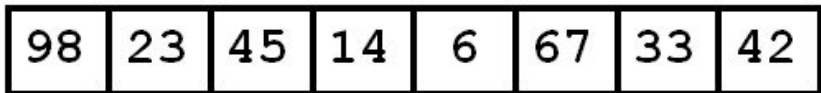
Merge



Merge



Merge



Merge

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----

98	23	45	14
----	----	----	----

6	67	33	42
---	----	----	----

98	23
----	----

45	14
----	----

6	67
---	----

33	42
----	----

98

23

45

14

6

67

33

42

23	98
----	----

14	45
----	----

6	67
---	----

33	42
----	----

14	23	45	98
----	----	----	----

6	33	42	67
---	----	----	----

6	14	23	33	42	45	67	98
---	----	----	----	----	----	----	----

98	23	45	14	6	67	33	42
----	----	----	----	---	----	----	----



6	14	23	33	42	45	67	98
---	----	----	----	----	----	----	----

Merge Sort

- Divide the unsorted collection into two
- Until the sub-arrays only contain one element
- Then merge the sub-problem solutions together

Time Complexity = $O(n \log n)$