PROGRAMMING FOR PROBLEM SOLVING -- PPS

SUBJECT CODE-BTPS-101-18

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PPS SYLLABUS

Unit 4

Basic Algorithms (6 lectures)

Searching, Basic Sorting Algorithms (Bubble, Insertion and Selection), Finding roots of equations, notion of order of complexity through example programs (no formal definition required)

Sorting

- The process of arranging the elements in a list in either ascending or descending order.
- Types of Sorting:

- *Bubble Sort*
- *Insertion Sort*
- *Selection Sort*
- *Merge Sort*
- *Quick sort*
- *Heap Sort*
- *Radix Sort*

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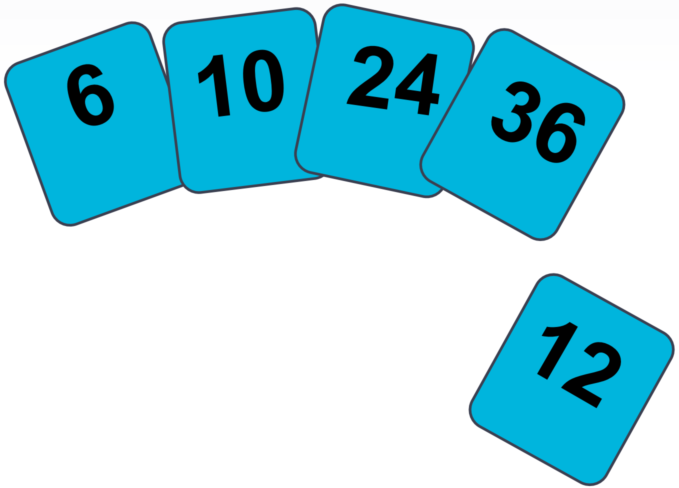
Insertion Sort

- Idea: like sorting a hand of playing cards
- Start with an empty left hand and the cards facing down on the table.
- Remove one card at a time from the table, and insert it into the correct position in the left hand
- compare it with each of the cards already in the hand, from right to left
- The cards held in the left hand are sorted
- these cards were originally the top cards of the pile on the table

Insertion Sort



- To insert 12, we need to make room for it by moving first 36 and then 24.

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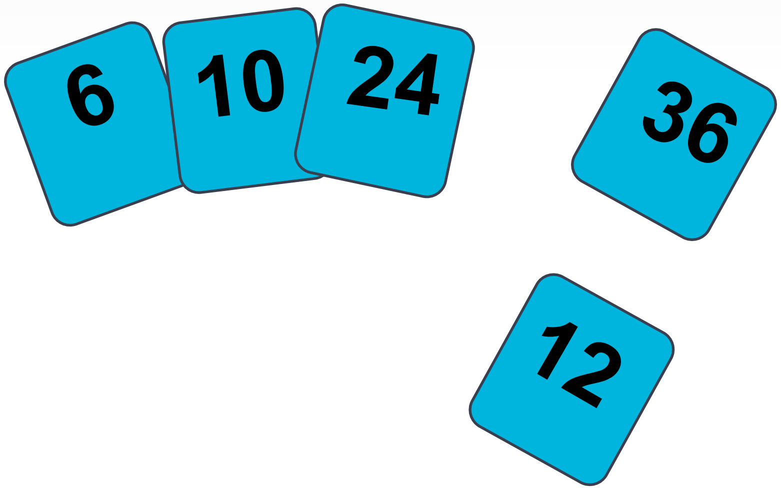
Insertion Sort



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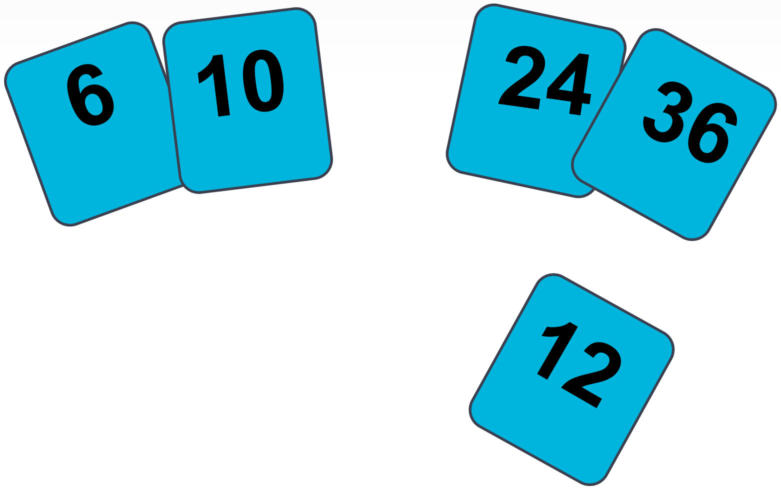
Insertion Sort



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Insertion Sort

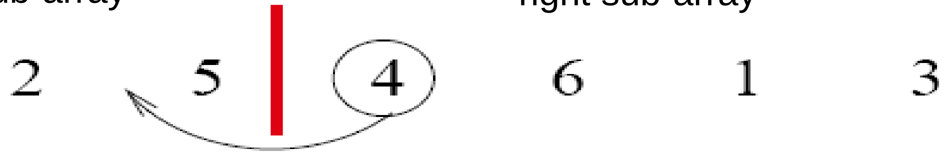
input array

5 2 4 6 1 3

at each iteration, the array is divided in two sub-arrays:

left sub-array

right sub-array



sorted

unsorted

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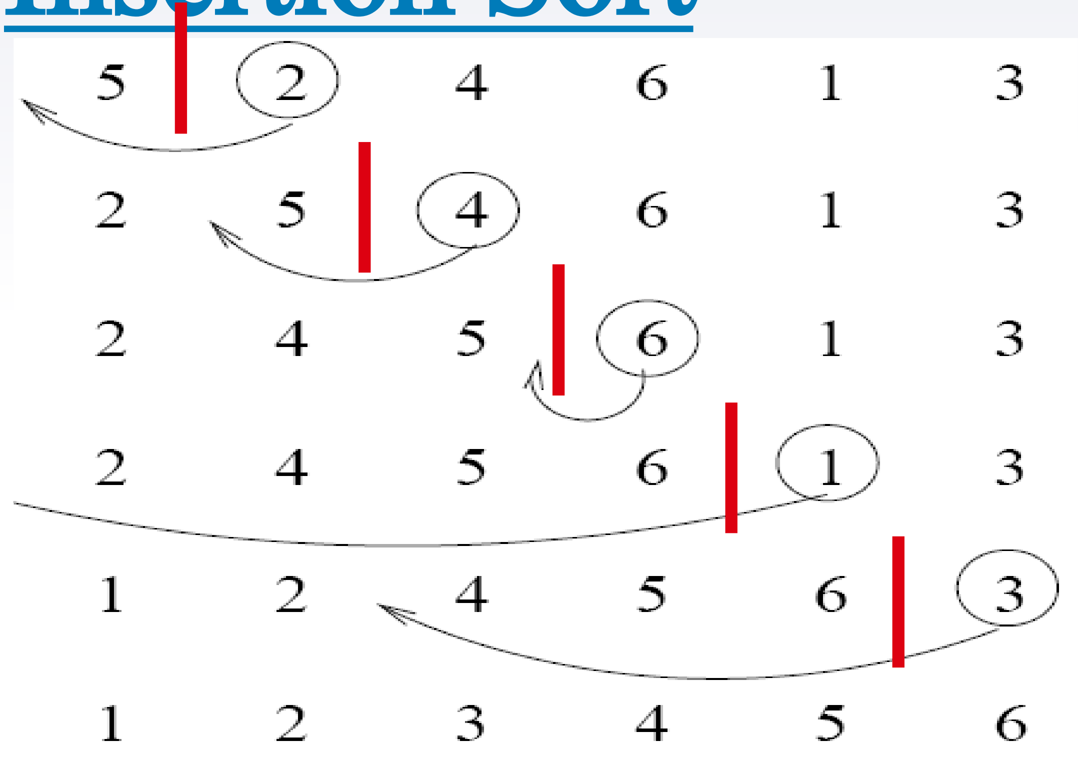
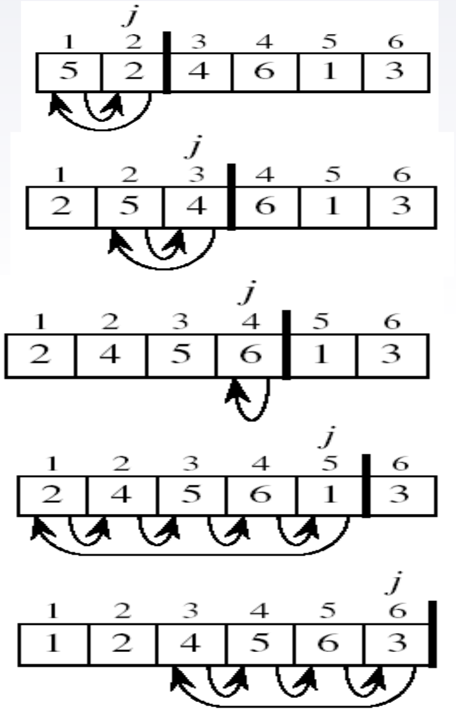
Insertion Sort





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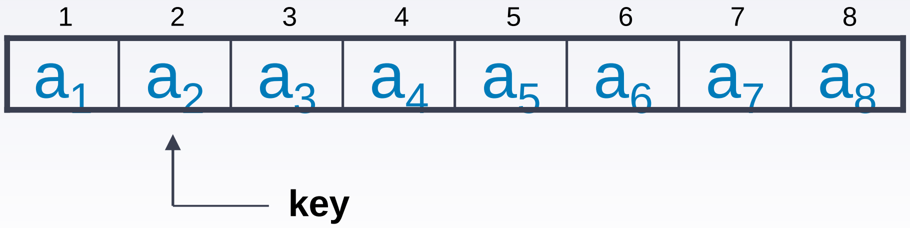
INSERTION-SORT

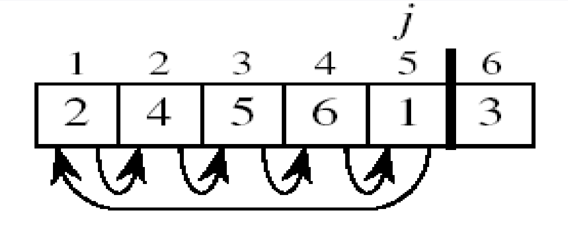


Alg.: INSERTION-SORT*(A)*

```
for j ← 2 to n
    do key ← A[ j ]
        Insert A[ j ] into the sorted sequence A[1 . . j -1]
       i ← j - 1
       while i >= 0 and A[i] > key
            do A[i + 1] ← A[i]
                i ← i – 1
       A[i + 1] ← key
```

- Insertion sort – sorts the elements in place

Loop Invariant for Insertion Sort



Alg.: INSERTION-SORT(A)

for j ← 2 to n

do key ← A[j]

Insert A[j] into the sorted sequence A[1 . . j -1]

i ← j - 1

while i > 0 and A[i] > key

do A[i + 1] ← A[i]

i ← i – 1

A[i + 1] ← key

Invariant: at the start of the for loop the elements in A[1 . . j-1] are in sorted order

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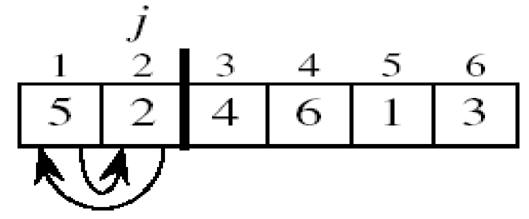
Proving Loop Invariants

- Proving loop invariants works like induction
- Initialization (base case):
  - It is true prior to the first iteration of the loop
- Maintenance (inductive step):
  - If it is true before an iteration of the loop, it remains true before the next iteration
- Termination:
  - When the loop terminates, the invariant gives us a useful property that helps show that the algorithm is correct
  - Stop the induction when the loop terminates

Loop Invariant for Insertion Sort

- Initialization:
  - Just before the first iteration, j = 2:

    the subarray A[1 . . j-1] = A[1], (the element originally in A[1]) – is sorted



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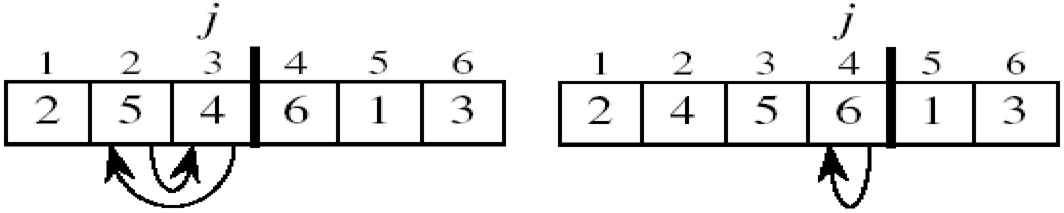
Loop Invariant for Insertion Sort

- Maintenance:
  - the while inner loop moves A[j -1], A[j -2], A[j -3], and so on, by one position to the right until the proper position for key (which has the value that started out in A[j]) is found
  - At that point, the value of key is placed into this position.



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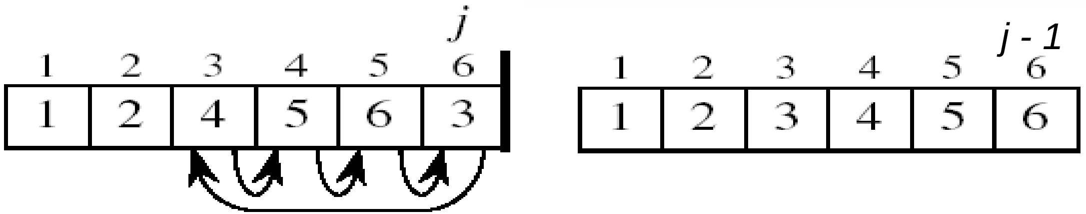
Loop Invariant for Insertion Sort

- Termination:
  - The outer for loop ends when j = n + 1 ⇒ j-1 = n
  - Replace n with j-1 in the loop invariant:
    - the subarray A[1 . . n] consists of the elements originally in A[1 . . n], but in sorted order



- The entire array is sorted!

Invariant: at the start of the for loop the elements in A[1 . . j-1] are in sorted order

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Insertion Sort - Summary

- Advantages
  - Good running time for "almost sorted" arrays $\Theta(n)$
- Disadvantages
  - $\Theta(n^2)$ running time in worst and average case
  - $\approx n^2/2$ comparisons and exchanges

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Thank You

Queries????