1. Insertion Sorting

Working logic

n = 6

a →

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

Round - 1

comp 1st and interchange

3	7	5	4	2	6

Round - 2

check

then check

3	5	7	4	2	6

Round - 3

3	5	7	4	2	6
3	5	?	7	2	6
3	?	5	7	2	6
3	4	5	7	2	6

Round - 4

Similar for next round

Program (Insertion Sort)

```
void insertion_sort [int a[ ], int n)
for ( i=1 ; i<n ; i++ )
        ↓ i=1

    key = a[i]
    j = i-1 ;
   while ( j>=0 && a[j] > key ]
   {
        a [j+1] = a[j]
        j = j-1 ;
     }
     a [j+1] = key ;

}
```

here we write j>=0 b/c we compare upto '0' location not in -ve index.

7 > 3

interchange

```
int main ( )
  {     int i ;
    int A[ ] = {24, 35, 4, 5, 11, 45};
    insertion_sort (a, 9) ;
    for ( i=0 ; i<=8 ; i++ )
      prtf ( "%d", a[i] ) ;
    return 0 ;
  }
```

Time Complexity
in best Case → $O(n)$
in General Case → $O(n^2)$

Algorithm

INS. SORT (A, N): A is an Array with N elements.

1. i = 1
2. Repeat step 3 to 5 while i < N
3. temp = A[i], J = i - 1
4. Repeat while J >= 0 and temp < A[J]
   A[J+1] = A[J] and J = J - 1
5. A[J+1] = temp, i = i + 1
6. Exit.

Date : ....

Analysis of Time Complexity for insertion sorting

```
for (i=1 ; i<n ; i++)                 → n
     key = a[i]                       → n-1
     j = i-1                          → n-1
while ( j>=0 &&
        a[j]>key )                    → Σ_{i=2}^{n} t_i
{
a[j+1] = a[j]                         → Σ_{i=2}^{n} (t_i - 1)
j = j-1 ;                             → Σ_{i=2}^{n} (t_i - 1)
   }
 a [j+1] = key ;                      → n-1
}
```

No. of times the while loop is executed for that value of i.

$$T(n) = c_1 n + c_2(n-1) + c_3(n-1) + c_4 \sum_{i=2}^{n} t_i + c_5 \sum_{i=2}^{n} (t_i - 1) + c_6 \sum_{i=2}^{n} (t_i - 1) + c_7 (n-1)$$

for best case :-

when $t_i = 1$ (Array is already shorted)

$$T(n) = c_1 n + c_2(n-1) + c_3(n-1) + c_4 \sum_{i=2}^{n} t_i + c_5 \sum_{i=2}^{n} (t_i - 1) + c_6 \sum_{j=2}^{n} (t_i - 1) + c_7(n-1)$$

Array is already sorted

let's say

1	2	3	4

$\uparrow$ $i = 1$ $(j-1)$ $\quad$ $\uparrow$ $i = 2$

$$\therefore T(n) = c_1 n + c_2(n-1) + c_3(n-1) + c_4(n-1) + c_5(0) + c_6(0) + c_7(n-1)$$

$$= (c_1 + c_2 + c_3 + c_4 + c_7)n - (c_2 + c_3 + c_4 + c_7)$$

$$T(n) = an + b$$