Syllabus Content:

19.1 Algorithms part:1 (Linear and Binary search, Bubble sort & insertion sort)

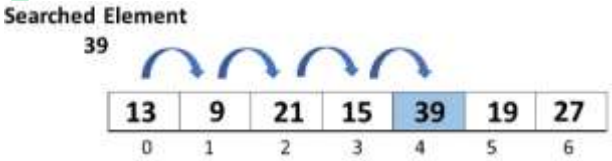
- Show understanding of linear and binary searching methods

  Notes and guidance
  - Write an algorithm to implement a linear search
  - Write an algorithm to implement a binary search
  - The conditions necessary for the use of a binary search
  - How the performance of a binary search varies according to the number of data items
- Show understanding of insertion sort and bubble sort methods

  Notes and guidance
  - Write an algorithm to implement an insertion sort
  - Write an algorithm to implement a bubble sort
  - Performance of a sorting routine may depend on the initial order of the data and the number of data items

Linear Search:

Linear search is a method of searching a list in which each element of an array is checked in order, from the lower bound to the upper bound, until the item is found, or the upper bound is reached.



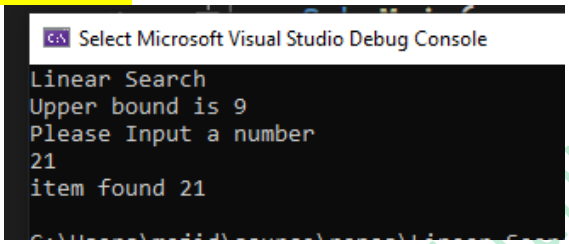
Linear search algorithm Pseudocode

```
DECLARE count, num As Integer
DECLARE found As Boolean = False
//Creating array to search intem (Free notes @ www.majidtahir.com)
DECLARE Mylist() As Integer = {4, 2, 8, 17, 9, 3, 7, 12, 34, 21}

OUTPUT ("Please enter any integer to be checked in List")
INPUT num
For count = 0 To 9
    If item = Mylist(count) Then
        found = True
    End If
Next
If found = True Then
    OUTPUT ("Item Found = ", num)
Else
    OUTPUT ("Item Found is unsuccessful")
End If
```

Sample VB program of linear search:

```
Dim count, num As Integer
Dim found As Boolean = False
Dim Mylist() As Integer = {4, 2, 8, 17, 9, 3, 7, 12, 34, 21}

        Console.WriteLine("please enter an integer to be found")
        num = Console.ReadLine()
        For index = 0 To 9
            If item = Mylist(count) Then
                found = True
            End If
        Next
        If found = True Then
            Console.WriteLine("Item Found = " & item)
        Else
            Console.WriteLine("Item Found is Unsucessful")
        End If
```

OUTPUT



Sample PYTHON program of linear search:

```
MyList = [4,2,8,17,9,3,7,12,34,21]
found = False
num=int(input("Please enter number to be found"))
for index in range(len(MyList)):
    if MyList[index]==item:
        found = True
if(found):
    print ("item found")
else:
    print("item not found")
```

OUTPUT

```
py
Please enter number to be found  34
item found
>>>
```

Binary Search:

A binary search is most efficient if List is already sorted.

The value of the **middle item in the list is first tested** to check if it matches the required item, and half of the list that ***does not*** contain the item is then discarded.
Then in next step, value is again checked from the **middle in remaining half of list** and if not found again half of list is discarded. This is repeated until the item is found or nothing is left in List to check.

Binary search takes far few comparisons compared to **Linear search** which checks each and every item one by one.

Below is Identifier Table and Pseudocode for **Binary Search Algorithm:**

Identifier	Description
myList	Array to be searched
upperBound	Upper bound of the array
lowerBound	Lower bound of the array
index	Pointer to current array element
item	Item to be found
found	Flag to show when item has been found

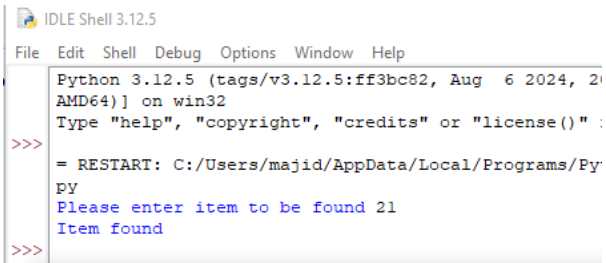
```
DECLARE mylist() As Integer = {11, 22, 33, 44, 55, 66, 77, 88, 99, 110}
DECLARE upperbound, lowerbound, index, item : INTEGER
DECLARE found : BOOLEAN
    upperbound = 10
    lowerbound = 0
    found  = False
    OUTPUT ("please input num to be found")
    INPUT item
    REPEAT
        index = Int((upperbound + lowerbound) / 2)
        IF item = mylist(index) THEN
            found = True
        ELSEIF item > mylist(index) THEN
            lowerbound = index + 1
        ELSE upperbound = index - 1
        END IF
    UNTIL (found = True) OR upperbound = lowerbound

IF found = True THEN
    OUTPUT ("Item found: " & item)
ELSE
    OUTPUT ("Item not found")
END IF
```

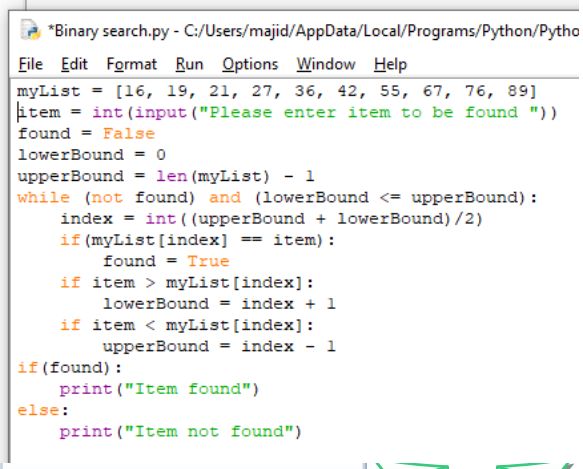
Sample VB Program of Binary Search:

```
Dim mylist() As Integer = {11, 22, 33, 44, 55, 66, 77, 88, 99, 110}
Dim upperbound, lowerbound, count As Integer
Dim item As Integer
Dim found As Boolean = False
    upperbound = 10
    lowerbound = 0
    Console.WriteLine("please input num to be found")
    item = Console.ReadLine()
    Do
        count = Int((upperbound + lowerbound) / 2)
        If item = mylist(index) Then
            found = True
        ElseIf item > mylist(index) Then
            lowerbound = index + 1
        Else upperbound = index - 1
        End If
    Loop Until (found = True) Or upperbound = lowerbound

If found = True Then
    Console.WriteLine("Item found: " & item)
Else
    Console.WriteLine("Item not found")
End If
```

Python program for Binary Search

```
myList = [16, 19, 21, 27, 36, 42, 55, 67, 76, 89]
item = int(input("Please enter item to be found "))
found = False
lowerBound = 0
upperBound = len(myList) - 1
while (not found) and (lowerBound <= upperBound):
    index = int((upperBound + lowerBound)/2)
    if(myList[index] == item):
        found = True
    if item > myList[index]:
        lowerBound = index + 1
    if item < myList[index]:
        upperBound = index - 1
if(found):
    print("Item found")
else:
    print("Item not found")
```





Bubble Sort

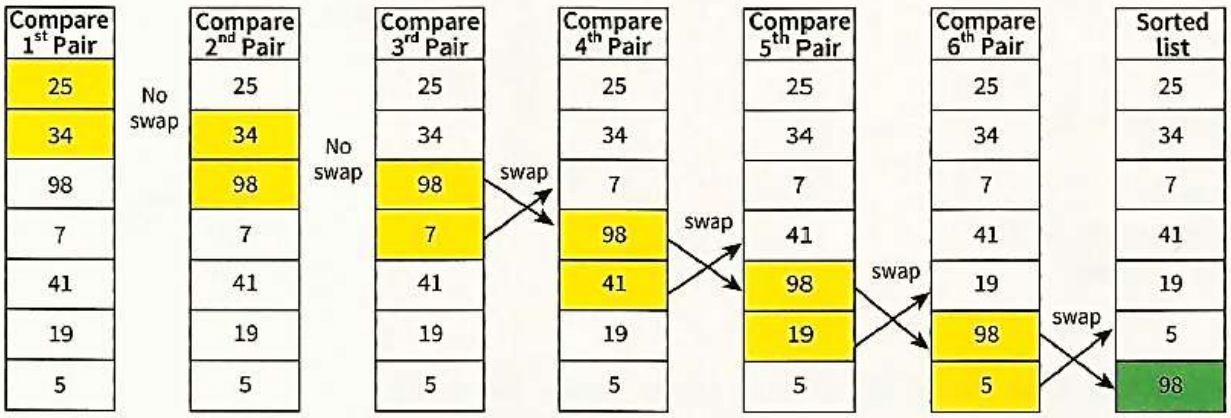


Figure 11.12 Swapping values working down the array

When we have completed the first pass through the entire array, the largest value is in the correct position at the end of the array. The other values may or may not be in the correct order. We need to work through the array again and again. After each pass through the array the next largest value will be in its correct position, as shown in Figure below.

Original list	After pass 1	After pass 2	After pass 3	After pass 4	After pass 5	After pass 6
25	25	25	7	7	7	5
34	34	7	25	19	5	7
98	7	34	19	5	19	19
7	41	19	5	25	25	25
41	19	5	34	34	34	34
19	5	41	41	41	41	41
5	98	98	98	98	98	98

Figure 11.13 States of the array after each pass

In effect we perform a loop within a loop, a nested loop. This method is known as a **bubblesort.** The name comes from the fact that smaller values slowly rise to the top, like bubbles in a liquid.

KEY TERMS

Bubble sort: a sort method where adjacent pairs of values are compared and swapped

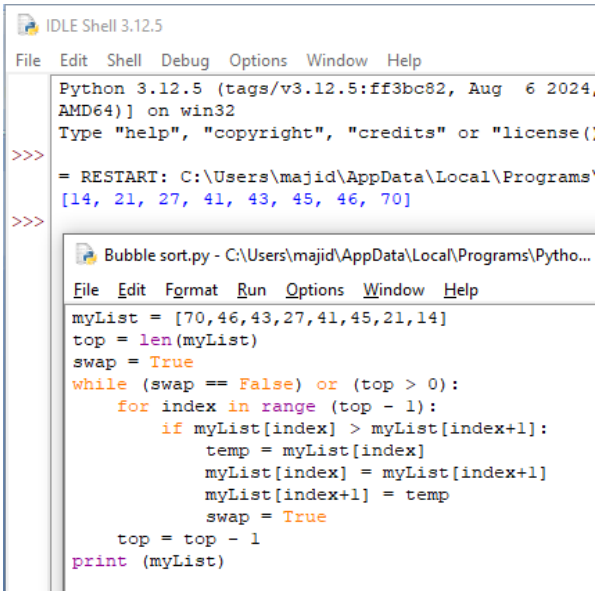
Bubble Sort Algorithm:

```
DECLARE myList : ARRAYS[0:8] OF INTEGER = {70, 46, 43, 27, 57, 41, 45, 21, 14}
DECLARE upperBound, lowerBound, index, top, temp: INTEGER
DECLARE swap        : BOOLEAN
upperBound  ←       LENGTH(myList())
 lowerBound ←       0
      top   ←       upperbound
      REPEAT
            FOR index = lowerBound TO (top – 1)
                Swap ← FALSE
                  IF MyList [index] > MyList [index + 1]
                  THEN   Temp ←  MyList[index]
                         MyList[index] ← MyList[index + 1]
                         MyList[index + 1] ←    Temp
                         swaps ← TRUE
                  END IF
            NEXT
      top ←   top  –  1
      UNTIL (NOT swap) OR (top = 0)
```

Identifier	Description
myList	Array to be searched
upperBound	Upper bound of the array
lowerBound	Lower bound of the array
index	Pointer to current array element
swap	Flag to show when swaps have been made
top	Index of last element to compare
temp	Temporary storage location during swap

Bubble Sort Algorithm using PYTHON:

```
myList = [70,46,43,27,41,45,21,14]
top = len(myList)
swap = True
while (swap == False) or (top > 0):
    for index in range (top - 1):
        if myList[index] > myList[index+1]:
            temp = myList[index]
            myList[index] = myList[index+1]
            myList[index+1] = temp
            swap = True
    top = top - 1
print (myList)
```



Bubble Sort Algorithm using VB Console Mode:

In this tutorial, i will teach you how to create a program for bubble sorting using vb.net console. We all know that bubble sort is a sorting algorithm that is repeatedly searching through lists that need to be sorted, comparing each pair of items and swapping them if they are in the wrong order.

```
Module Module1
    Sub Main()
        Dim myList() As Integer = New Integer() {70, 46, 43, 27, 57, 41, 45, 21, 14}
        Dim index, top, temp As Integer
        Dim Swap As Boolean
        top = myList.Length - 1

        Do
            Swap = False
                                        'LOOP can work fine without STEP also
            For index = 0 To top - 1 Step 1 'STEP is a keyword to increment in loop
                If myList(index) > myList(index + 1) Then
                    temp = myList(index)
                    myList(index) = myList(index + 1)
                    myList(index + 1) = temp
                    Swap = True
                End If
            Next
            top = top - 1
        Loop Until (Not Swap) Or (top = 0)
        'Outpout The Sorted Array
        For index = 0 To myList.Length - 1
              Console.WriteLine(myList(index) & " ")
        Next
        Console.ReadKey()
    End Sub
End Module
```

Total Code Together: (Code can be copied and tried in VB)

```
Module Module1
Sub sorting(ByVal x() As Integer, ByVal upperbound As Integer) 'X() is declared array
Dim index, lowerbound, temp As Integer=
        For index = 0 To upperbound - 1
            For lowerbound = index + 1 To upperbound - 1
                If x(index) > x(lowerbound) Then
                    temp = x(index)
                    x(index) = x(lowerbound)
                    x(lowerbound) = temp
                End If
            Next
        Next
End Sub

  Sub Main()
        Console.WriteLine("Bubble Sorting")
        Console.WriteLine()
        Dim num, count As Integer
        Console.Write("Enter Number of Elements: ")
        num = CInt(Console.ReadLine)
        Dim array(num) As Integer 'Array Made to insert values to be sorted
        Console.WriteLine()

        For count = 0 To num - 1 'LOOP to Insert Values in Array
            Console.Write("Enter Element(" & (count + 1) & "): ")
            array(count) = CInt(Console.ReadLine)
        Next

        Console.WriteLine()
        Console.WriteLine("Inputted Elements")
        Console.WriteLine()

        For count = 0 To num - 1 'LOOP to Show Inserted Values
            Console.WriteLine("Element in (" & count & "): " & array(count))
        Next

        Console.WriteLine()

        sorting(array, num) 'SORTED Procedure applied on Array and Upperbound of Array
        Console.WriteLine("Sorted Elements")
        Console.WriteLine()

        For i = 0 To num - 1 ' To Display Sorted Elements
            Console.WriteLine("Element in (" & i & "): " & array(i))
        Next
        Console.ReadLine()
    End Sub
End Module
```

Output:

```
file:///C:/Users/Nile/AppData/Local/Temporary Projects/ConsoleApplication1/bin/Debug/Console...
Bubble Sorting

Enter Number of Elements: 4

Enter Element(1): 5
Enter Element(2): 9
Enter Element(3): 7
Enter Element(4): 3

Inputted Elements

Element in (0): 5
Element in (1): 9
Element in (2): 7
Element in (3): 3

Sorted Elements

Element in (0): 3
Element in (1): 5
Element in (2): 7
Element in (3): 9
```

Insertion sort:

Imagine you have a number of cards with a different value printed on each card. How would you sort these cards into order of increasing value?

You can consider the pile of cards as consisting of a sorted part and an unsorted part. Place the unsorted cards in a pile on the table. Hold the sorted cards as a pack in your hand. To start with only the first (top) card is sorted. The card on the top of the pile on the table is the next card to be inserted. The last (bottom) card in your hand is your current card.

	Index of element being checked												
myList	1		2	3	4		5	6		7		8	
[0]	27	19	19	19	19	16	16	16	16	16	16	16	16
[1]	19	27	27	27	27	19	19	19	19	19	16	16	16
[2]	36	36	36	36	36	27	27	27	21	21	19	19	19
[3]	42	42	42	42	42	36	36	36	27	27	21	21	21
[4]	16	16	16	16	16	42	42	42	36	36	27	27	27
[5]	89	89	89	89	89	89	89	89	42	42	36	36	36
[6]	21	21	21	21	21	21	21	21	89	89	42	42	42
[7]	16	16	16	16	16	16	16	16	16	16	89	89	55
[8]	55	55	55	55	55	55	55	55	55	55	55	55	89

Figure shows the sorted cards in your hand as blue and the pile of unsorted cards as white. The next card to be inserted is shown in red. Each column shows the state of the pile as the cards are sorted.

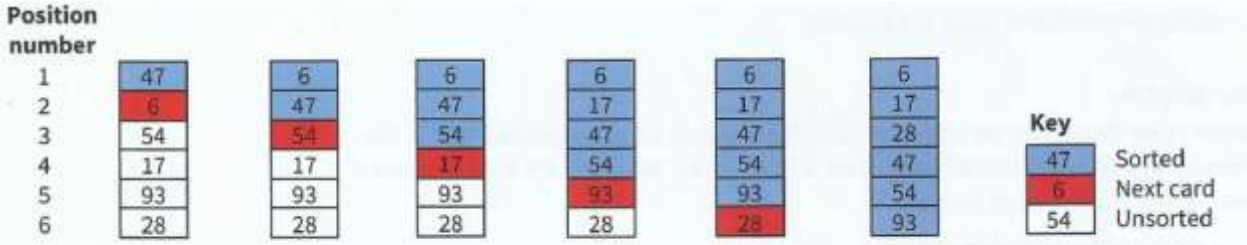


Figure 23.01 Sorting cards

Insertion Sort Algorithm

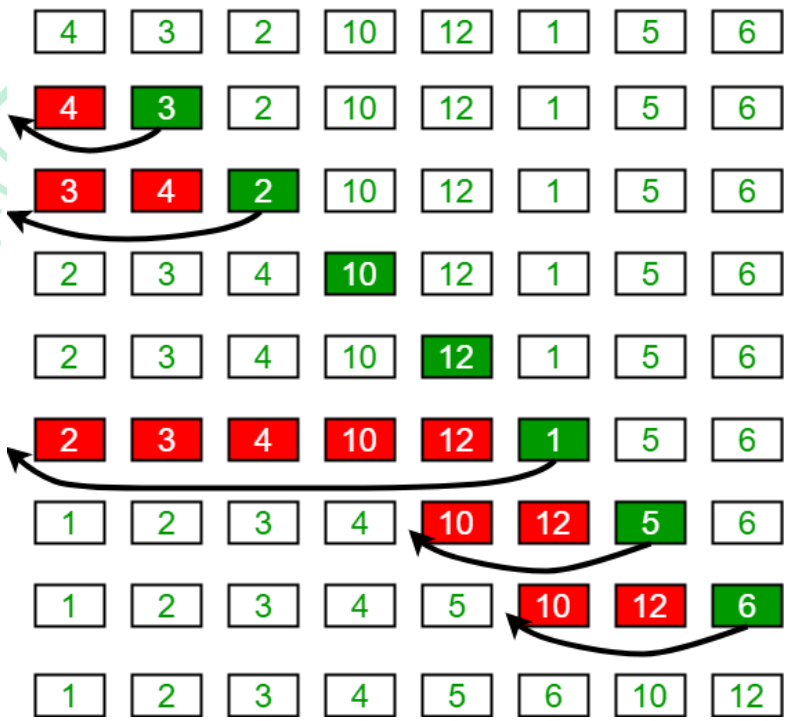
Identifier Table for Insertion sort:

Identifier	Description
myList	Array to be searched
upperBound	Upper bound of the array
lowerBound	Lower bound of the array
index	Pointer to current array element
key	Element being placed
place	Position in array of element being moved

```
DECLARE myList : ARRAYS [ ] OF INTEGER = {70, 46, 43, 27, 57, 41, 45, 21, 14}
DECLARE upperBound, lowerBound, index, key, place, temp : INTEGER
 upperBound ←   LENGTH(myList())
 lowerBound ←   0
       top  ←   upperBound

            FOR index = lowerBound + 1 TO upperbound
              Key   ← MyList [index]
              Place ← index - 1
                IF MyList [Place] > key
                THEN
                      WHILE place >= lowerbound AND mylist[Place]> key
                      temp ←  myList[place + 1]
                      myList[place + 1] ←  myList[place]
                      myList[place ]    ←  temp
                      place ←  place - 1
                ENDIF
            NEXT index
```

```
DECLARE mylist() As Integer = {70, 46, 43, 27, 57, 41, 45, 21, 14}
DECLARE count As Integer 'to access array from left to right
DECLARE current As Integer ' to hold the current item to find place in sorted list
DECLARE position As Integer 'to track from left to right through the sorted list
DECLARE lowerbound As Integer = 0
DECLARE upperbound As Integer = LENGTH(myList())
FOR count = (lowerbound + 1) To upperbound 'starts with second item in array
    current = mylist(count)
    position = count

WHILE position >= 0 And mylist(position - 1) > current 'Loop Line where VB tries to
access position -1 in array
      mylist(position) = mylist(position - 1)
      position = position - 1
              If position = 0 Then 'This code stops VB to go to postion (-1) in array
                    Exit While
                End If
            End While
            mylist(position) = current
        Next

        For index = 0 To mylist.Length - 1
            Console.WriteLine(mylist(index) & "")
        Next
```

Insertion Sort Execution Example



Python program for Insertion Sort

```
myList = [4,46,43,27,57,41,45,21,14]
lowerBound = 0
upperBound = len(myList)
for index in range(lowerBound + 1, upperBound):
    key = myList[index]
    place = index -1
    if myList[place] > key:
        while place >= lowerBound and myList[place] > key:
            temp = myList[place + 1]
            myList[place + 1] = myList [place]
            myList[place] = temp
            place = place -1
            myList[place + 1] = key
#output the sorted array
print(myList)
```

```
.py
[4, 14, 21, 27, 41, 43, 45, 46, 57]
>>>
```

Insersion sort.py - C:\Users\majid\AppData\Local\Programs\Python\Python312\Insersion

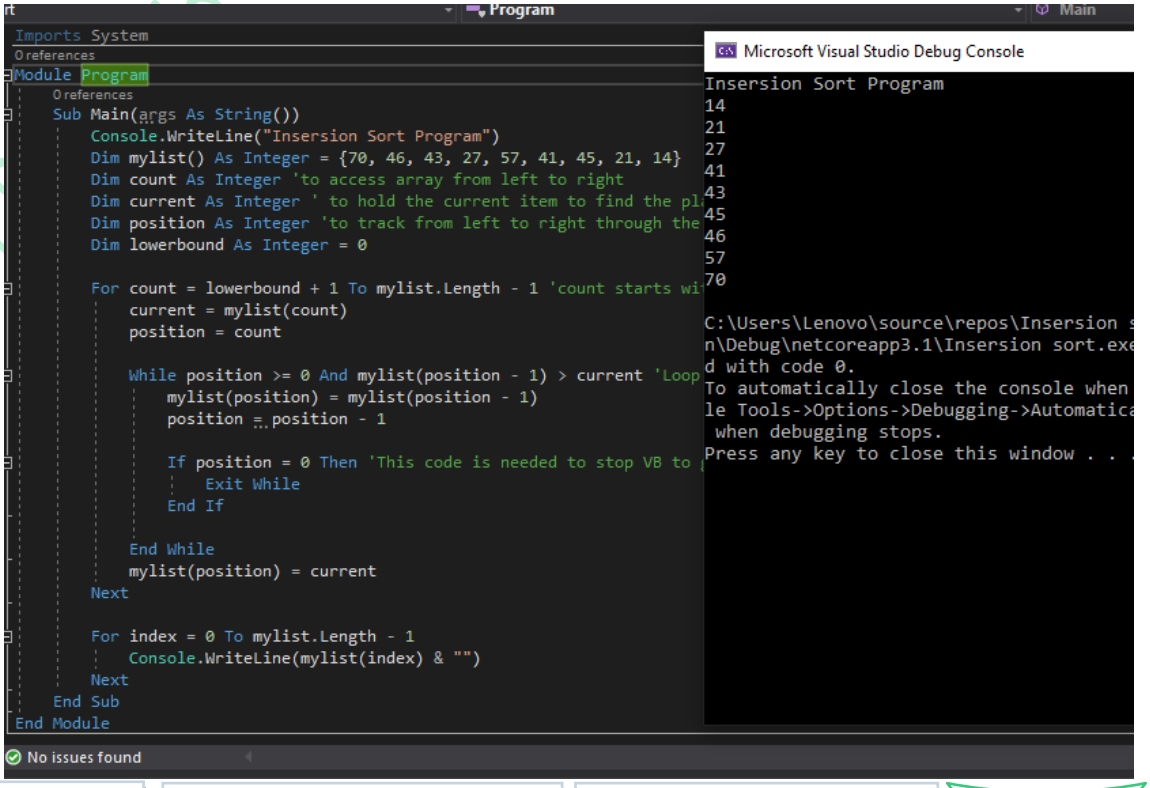
File Edit Format Run Options Window Help

```
#Python program for Insertion Sort
myList = [4,46,43,27,57,41,45,21,14]
lowerBound = 0
upperBound = len(myList)
for index in range(lowerBound + 1, upperBound):
    key = myList[index]
    place = index -1
    if myList[place] > key:
        while place >= lowerBound and myList[place] > key:
            temp = myList[place + 1]
            myList[place + 1] = myList [place]
            myList[place] = temp
            place = place -1
            myList[place + 1] = key
#output the sorted array
print(myList)
```

Insertion sort in VB Console Mode:

```
Sub Main()
        Console.WriteLine("Insersion Sort Program")
        Dim mylist() As Integer = {70, 46, 43, 27, 57, 41, 45, 21, 14}
        Dim count As Integer 'to access array from left to right
        Dim current As Integer ' to hold the current item to find place.
        Dim position As Integer 'to track the position in the sorted list
        Dim lowerbound As Integer = 0

        For count = lowerbound + 1 To mylist.Length - 1 'starts with 2nd item
            current = mylist(count)
            position = count

            While position >= 0 And mylist(position - 1) > current 'Loop Line
where VB tries to access position -1 in array
                mylist(position) = mylist(position - 1)
                position = position - 1

                If position = 0 Then ' stops VB to go to postion (-1) array
                    Exit While
                End If
            End While
            mylist(position) = current
        Next

        For index = 0 To mylist.Length - 1
            Console.WriteLine(mylist(index) & "")
        Next
    End Sub
```

Output:



Python program for Insertion Sort

```
myList = [4,46,43,27,57,41,45,21,14]
lowerBound = 0
upperBound = len(myList)
for index in range(lowerBound + 1, upperBound): #Loops starts at 2nd value
    key = myList[index] #holds the next value
    place = index -1 #holds the previous value
    if myList[place] > key:
        while place >=lowerBound and myList[place]> key:
            temp = myList[place + 1]
            myList[place + 1] = myList [place]
            myList[place] = temp
            place = place -1
            myList[place + 1] = key
#output the sorted array
print(myList)
```

Insersion sort.py - C:/Users/majid/AppData/Local/Programs/Python/Python312/Inse

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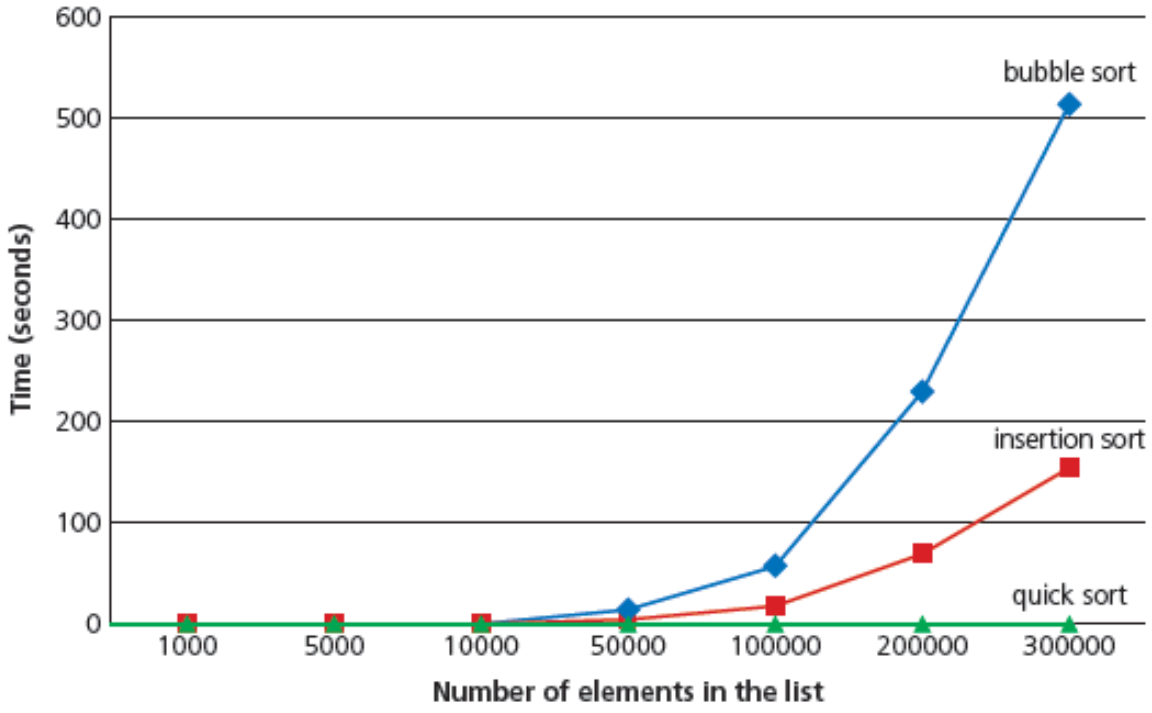
```
#Python program for Insertion Sort
myList = [4,46,43,27,57,41,45,21,14]
lowerBound = 0
upperBound = len(myList)
for index in range(lowerBound + 1, upperBound):
    key = myList[index]
    place = index -1
    if myList[place] > key:
        while place >= lowerBound and myList[place] > key:
            temp = myList[place + 1]
            myList[place + 1] = myList [place]
            myList[place] = temp
            place = place -1
            myList[place + 1] = key
#output the sorted array
print(myList)
```

OUTPUT:

IDLE Shell 3.12.5

File Edit Shell Debug Options Window Help

```
Python 3.12.5 (tags/v3.12.5:ff3bc82, Au
AMD64)] on win32
Type "help", "copyright", "credits" or
>>>
= RESTART: C:/Users/majid/AppData/Local,
.py
[4, 14, 21, 27, 41, 43, 45, 46, 57]
>>>
```



Performance of Sorting Algorithms

As the number of elements in List increases, the time taken to sort the list increases. It has been observed that when number of items in list increases, the performance of **bubble sort** deteriorates faster than **insertion sort**

References:

Computer Science AS & A Level Coursebook by Sylvia Langfield & Dave Duddell
Computer Science Teacher's Resource
Computer Science AS & A level by HODDER EDUCATION
https://www.youtube.com/watch?v=I-kosUr1jtE
https://www.dotnetperls.com/dictionary-vbnet
http://www.worldbestlearningcenter.com/index_files/vb.net-example-insertion-sort.htm