```
import random as rn
import time
import matplotlib.pyplot as plt
```

Binary search trees

```
class rootNode:
    def __init__(self, key):
        self.left=None
        self.right=None
        self.val=key

def insertionNode(node,keyvalue):
    if node is None:
        return rootNode(keyvalue)
    else:
        if node.val==keyvalue:
            return node
        else:
            if node.val<keyvalue:
                node.right=insertionNode(node.right,keyvalue)
            else:
                node.left=insertionNode(node.left,keyvalue)
            return node

def inorder(root):
    if root:
        inorder(root.left)
        print(root.val,',',end='')
        inorder(root.right)

bst = rootNode(30)
bst=insertionNode(bst,50)
bst=insertionNode(bst,75)
bst=insertionNode(bst,80)
bst=insertionNode(bst,60)
bst=insertionNode(bst,65)
bst=insertionNode(bst,30)
bst=insertionNode(bst,100)
print("Inorder of binary search tree:")
inorder(bst)
```

```
Inorder of binary search tree:
30 ,50 ,60 ,65 ,75 ,80 ,100 ,
```

```
def inorderTraversal(root):
    if root:
        inorderTraversal(root.left)
        inorderTraversal(root.right)
```

```
size=[10,50,100,500,1000]
bstList=['bst1','bst2','bst3','bst4','bst5','bst6']
runTime=[]
for i in range(len(size)):

    start=time.time()
    bstList[i]= rootNode(rn.randint(1,100000))

    for j in range(size[i]):
        bstlist[i]=insertionNode(bstList[i],rn.randint(1,100000))

    inorder(bstList[i])

    end=time.time()

    runTime.append(end-start)

plt.scatter(size,runTime)
plt.show()
```

```
8587 ,27599 ,27829 ,44052 ,44159 ,45875 ,55075 ,57360 ,75393 ,78376 ,9
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```

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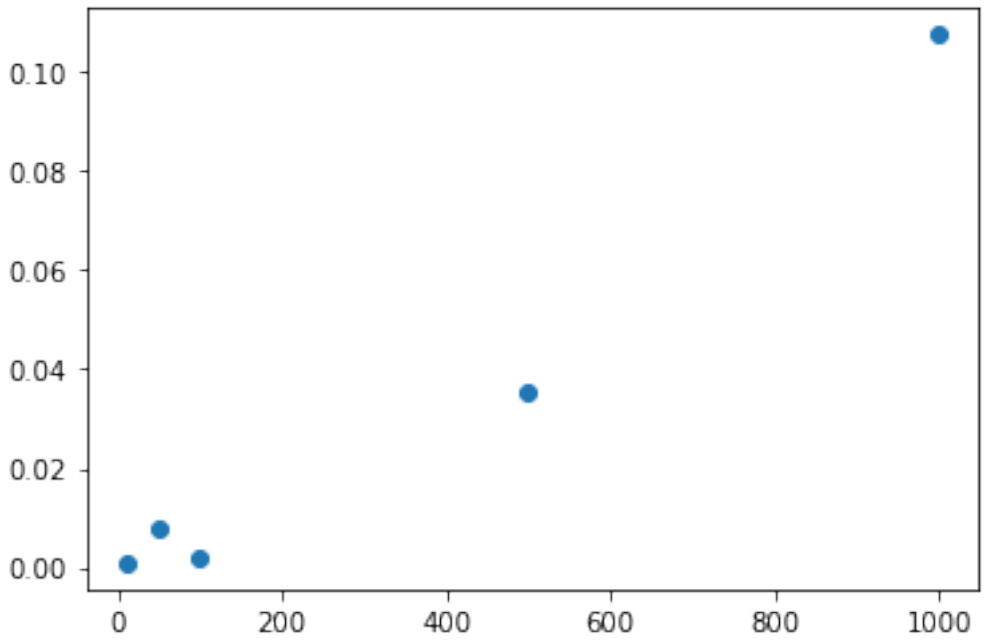


Time Complexity

1) Time complexity for adding n elements is O(n*logn)

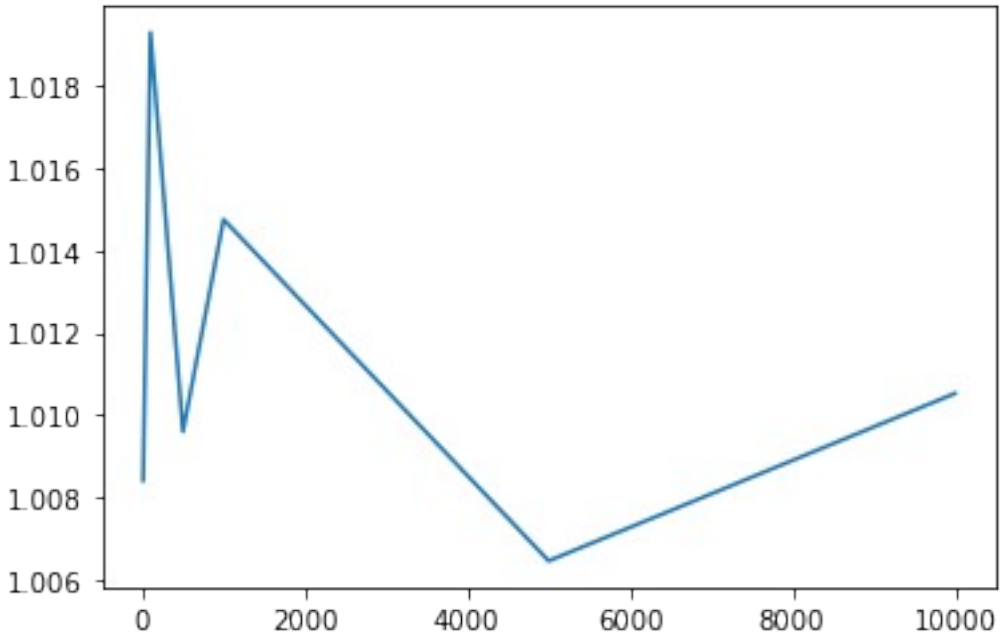
2) The average time complexity for tree sort is O(n*logn)

3) the worst case time complexity for tree sort is O(n^2)

Heapsort

```
def heapify(arr,n,i):

    keyMax=i
    leftchild=2*i+1
    rightchild=2*i+2
    temp=0

    if leftchild<n and arr[keyMax]<arr[leftchild]:
        keyMax=leftchild

    if rightchild<n and arr[keyMax]<arr[rightchild]:
        keyMax=rightchild

    if keyMax!=i:
        temp=arr[i]
        arr[i]=arr[keyMax]
        arr[keyMax]=temp
        heapify(arr,n,keyMax)
```

```
def maxHeap(arr):

    n=len(arr)
    a=n//2-1

    for i in range(a,-1,-1):
        heapify(arr,n,i)

def heapSort(arr):

    for i in range(len(arr)-1,0,-1):
        temp=arr[i]
        arr[i]=arr[0]
        arr[0]=temp1
        heapify(arr,i,0)

T=[]
n=[10,100,500,1000,5000,10000]

for i in range(len(n)):
    for i in range(n[i]):
        array=[]
        array.append(rn.randint(1,1000000))

    start=time.time()
    maxHeap(array)
    heapSort(array)

    time.sleep(1)
    end=time.time()
    T.append(end-start)

plt.plot(n,T)
plt.show()
```



(Here the time taken is 1s more than what is depicted in the graph)

Time Complexity:

1) Time complexity of heap sort is O(n)