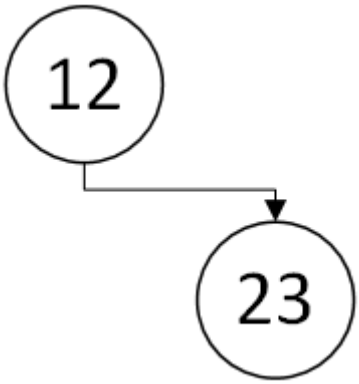
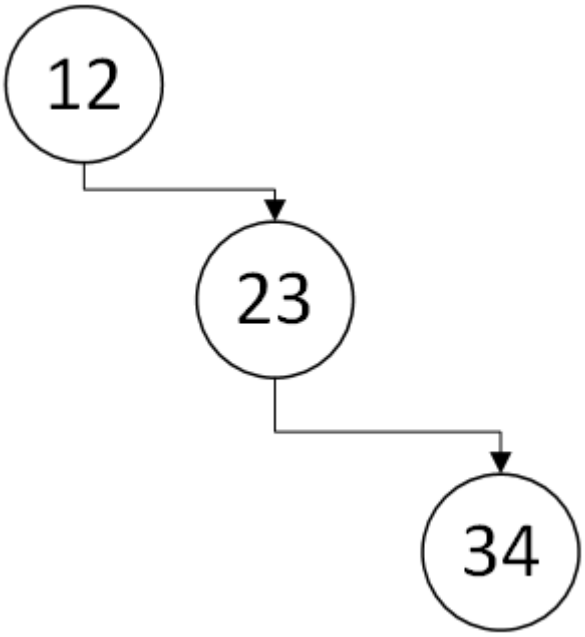
Q1

- insert 12

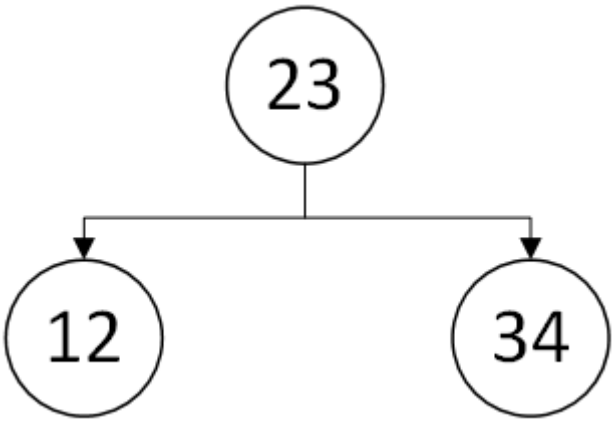
- insert 23



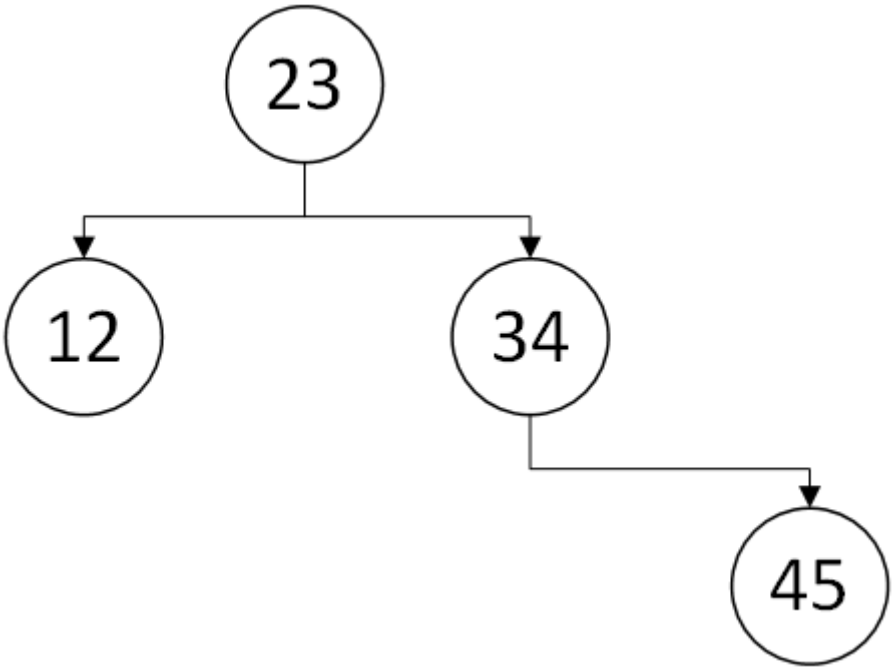
- insert 34



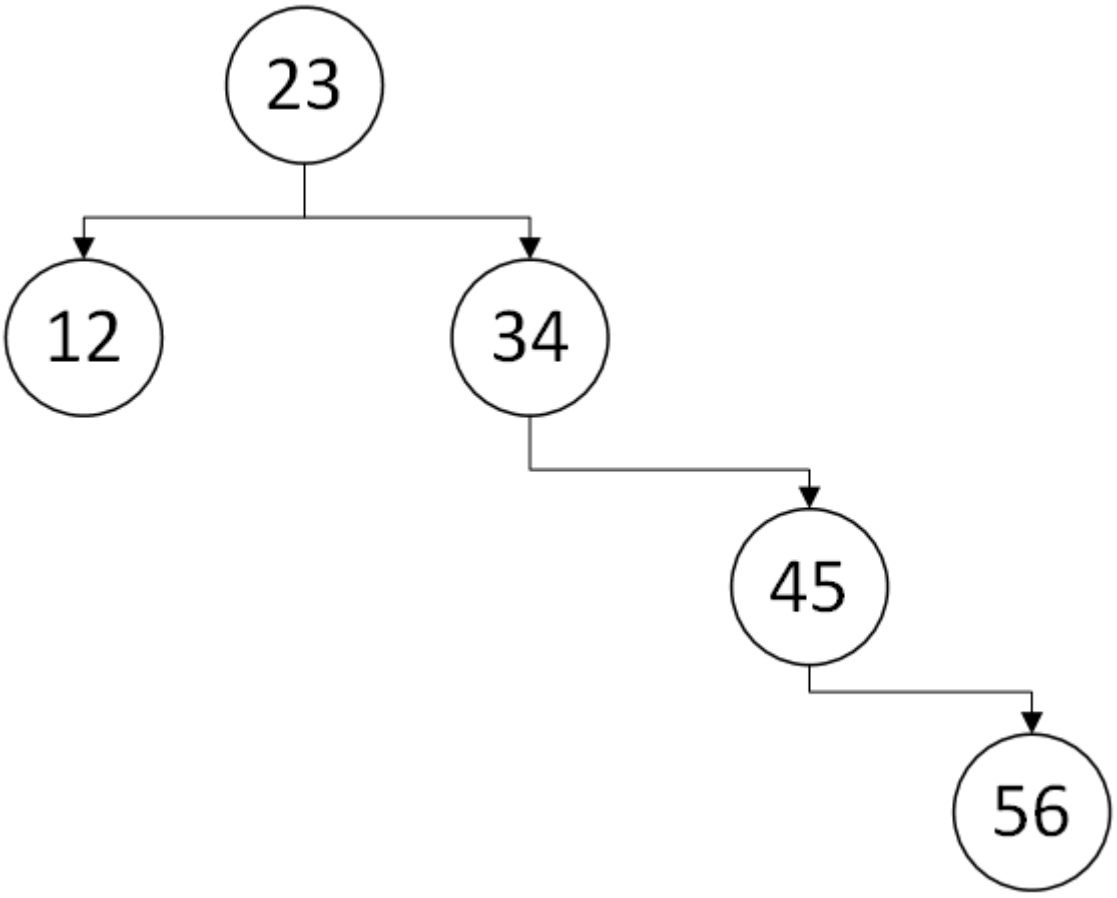
rotation



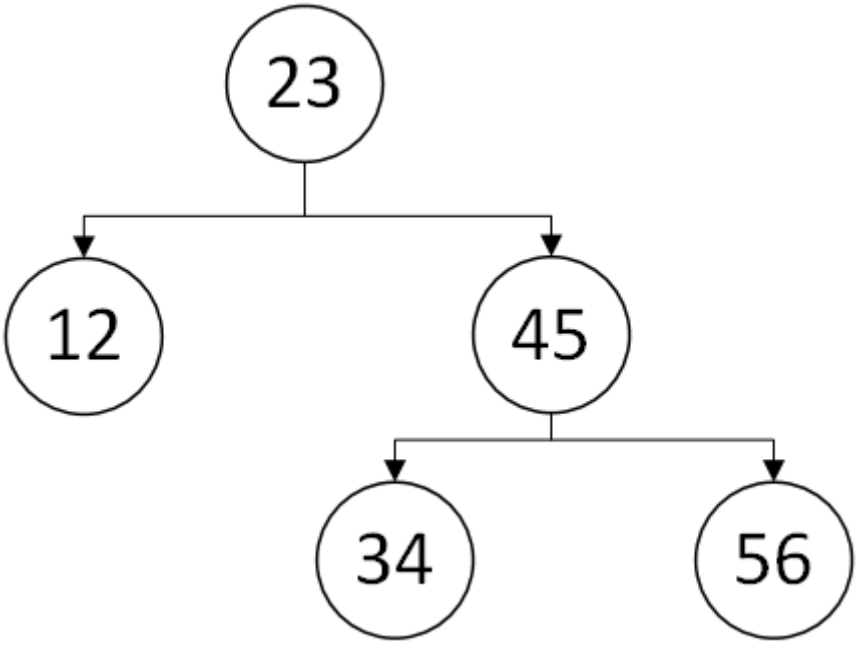
- insert 45



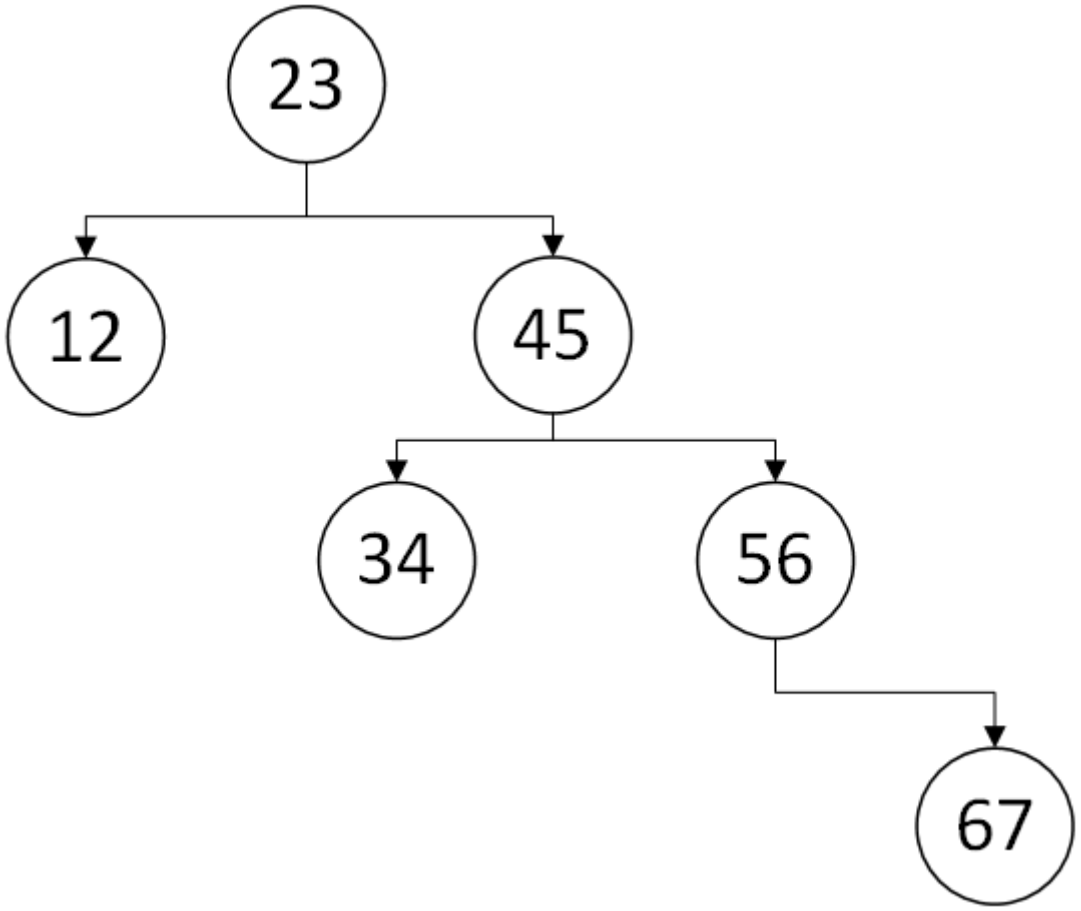
- insert 56



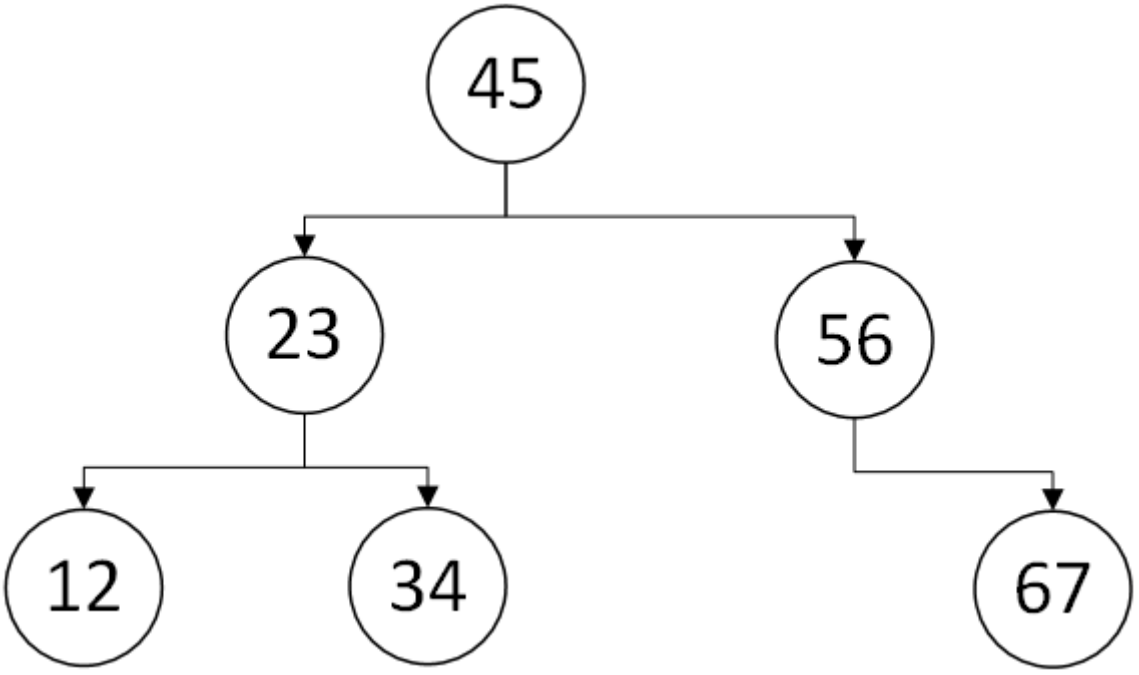
rotation



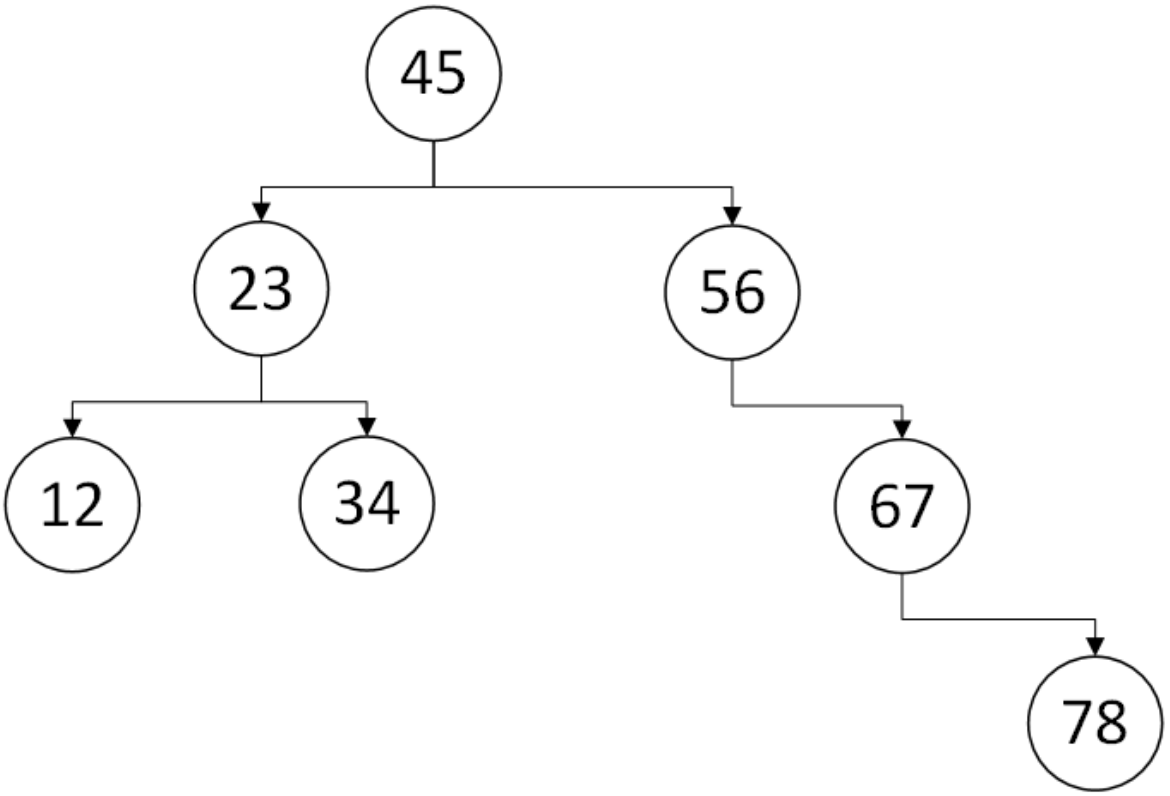
- insert 67



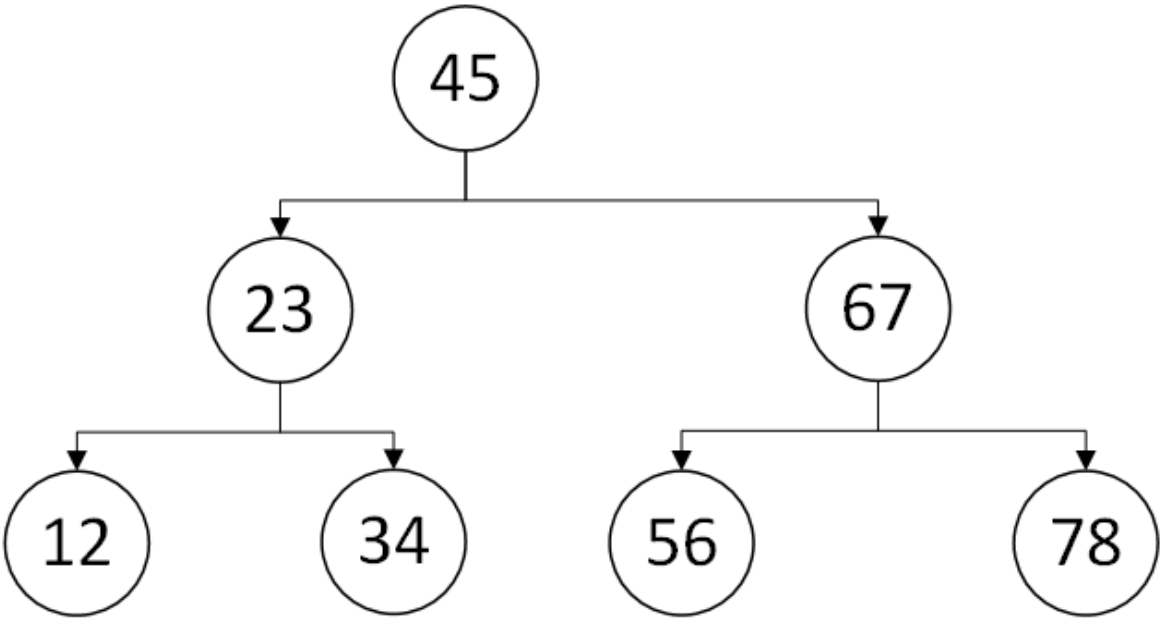
rotation



- insert 78

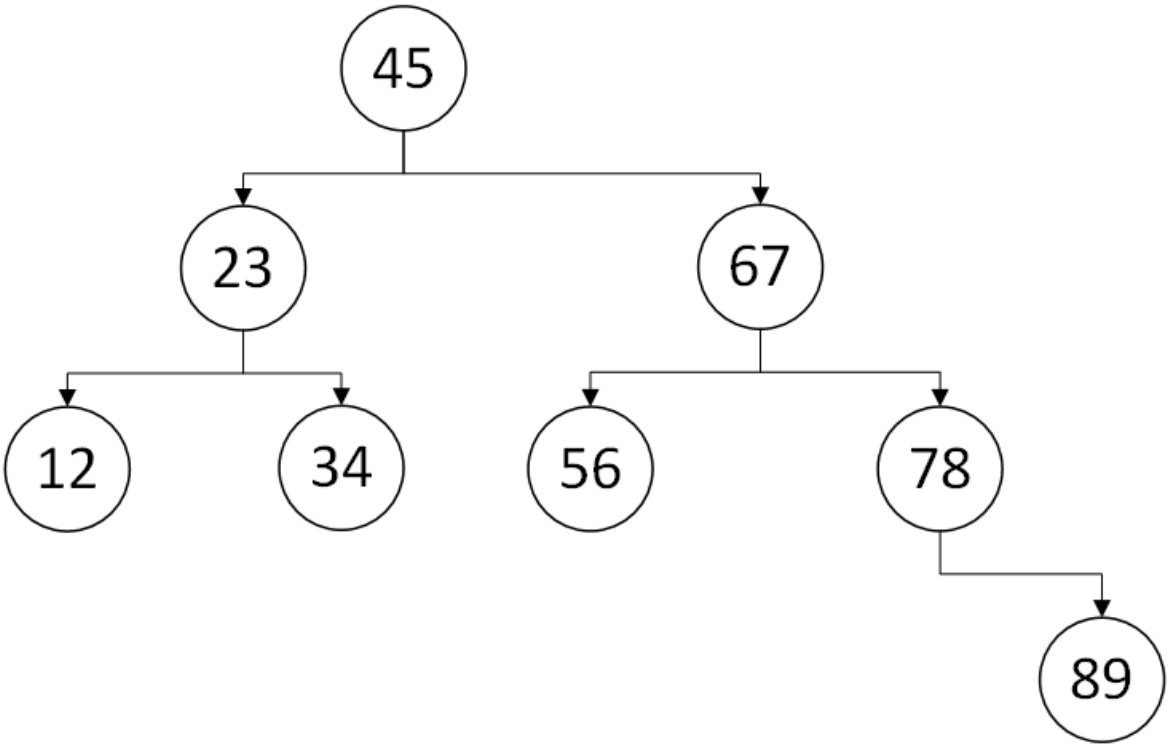


rotation



- insert 89

finally


45
23
67
12
34
56
78
89

Q2

Algorithm 1 Merge Nodes

Require: $node_{pre}$, $node_{suf}$
  insert $node_{pre}$ *before* $node_{suf}$

Algorithm 2 Merge Linked List

Require: L, R
  $node1 \leftarrow L$
  $node2 \leftarrow R$
  $head \leftarrow L$ (initialize)
  if $(L == null)$ *and* $(R == null)$ **then** ▷ check if the list is empty
    raise error
  else if $(L == null)$ **then**
    return R
  else if $(R == null)$ **then**
    return L
  end if
  while $(node2! = null)$ *and* $(node1! = null)$ **do**
    if $node1.val <= node2.val$ **then**
      $MergeNodes(node1,\ node2)$
      $node1 \leftarrow node1.next$
    else
      $node2 \leftarrow node2.next$
    end if
  end while
  $MergeNodes(node2,\ node1)$ ▷ merge the rest of list 1
  while $head.pre! = null$ **do** ▷ find head node
    $head \leftarrow head.pre$
  end while
    return *head*

```python
class Node:
    def __init__(self, val=None, pre=None, nex=None):
        self.val = val
        self.pre = pre
        self.nex = nex

def merge_nodes(node_pre: Node, node_suf: Node):
    if not node_pre and not node_suf:
        return
    if not node_pre:
        node_suf.pre = None
    elif not node_suf:
        node_pre.nex = None
```

```
    elif not node_suf.pre:
        node_pre.nex, node_suf.pre = node_suf, node_pre
    else:
        node_suf.pre.nex = node_pre
        node_pre.pre = node_suf.pre
        node_suf.pre = node_pre
        node_pre.nex = node_suf

def merge_linked_list(head1: Node, head2: Node) ->
Node:
    head = head1
    if not head1 and not head2:
        return None
    if not head1:
        return head2
    if not head2:
        return head1
    node1, node2 = head1, head2
    while node1 and node2:
        if node1.val < node2.val:
            tmp = node1.nex
            merge_nodes(node1, node2)
            node1 = tmp
        else:
            if not node2.nex:
                break
            node2 = node2.nex

    merge_nodes(node2, node1)
    while head.pre:
        head = head.pre
    return head

def print_linked_list(head: Node):
    while head:
        print(head.val, end=' ')
        head = head.nex

def array_to_linked_list(arr: list[int]) -> Node:
    head = Node()
```

```
    node = head
    for val in arr:
        new_node = Node(val)
        node.nex, new_node.pre = new_node, node
        node = new_node
    ret, head.nex.pre = head.nex, None
    return ret

def main():
    L = array_to_linked_list([1, 3, 5, 7, 9, 11])
    R = array_to_linked_list([2, 4, 6, 8, 10])
    head = merge_linked_list(L, R)
    print_linked_list(head)

main()
```

Q3

since

$$\lim_{n\to\infty} \frac{3n^3+20n^2+5}{n^3} = 3$$

we have $\forall \epsilon > 0,\ \exists n_0 > 0,\ s.t. \forall n > n_0,$

$$|\frac{3n^3+20n^2+5}{n^3} - 3| < \epsilon$$

we can find a specific coefficients satisfying formula above,

if $\epsilon = 1$, $n_0 = 100$, then $c = 4$.

```
import matplotlib.pyplot as plt
import numpy as np

x = np.arange(0, 200, 1)
y1 = np.power(x, 3)*3 + 20*np.power(x, 2) + 5*x
y2 = np.power(x, 3)*4
y3 = np.power(x, 3)*2
plt.figure(figsize=(10, 6))
plt.plot(x, y1, label='y')
```

```
plt.plot(x, y2, label='upper bound')
plt.plot(x, y3, label='lower bound')
plt.xlabel('n')
plt.legend()
plt.show()
```