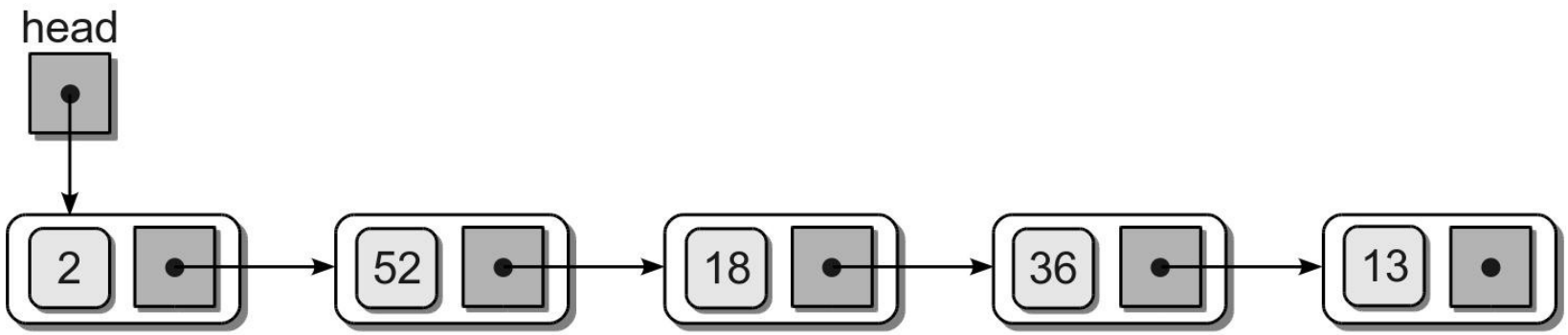
Linked Structures

Chapter 6

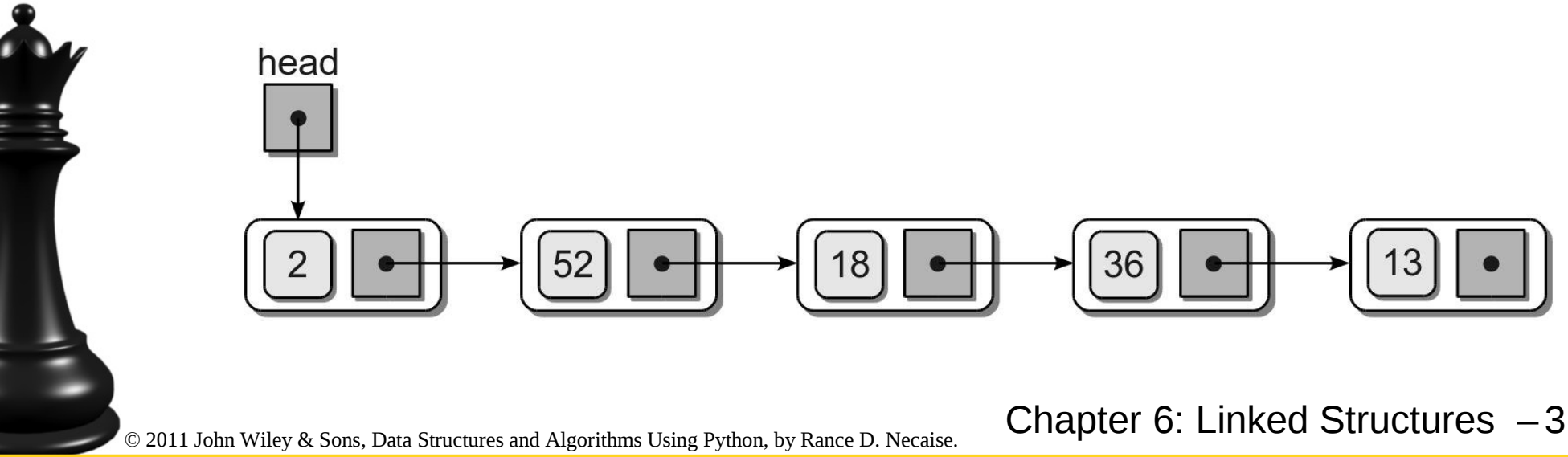
Linked Structure

- Constructed using a collection of objects called **nodes**.
- Each node contains data and at least one reference or **link** to another node.
- **Linked list** – a linked structure in which the nodes are linked together in linear order.



Linked List

- Terms:
  - **head** – first node in the list.
  - **tail** – last node in the list; link field has a null reference.



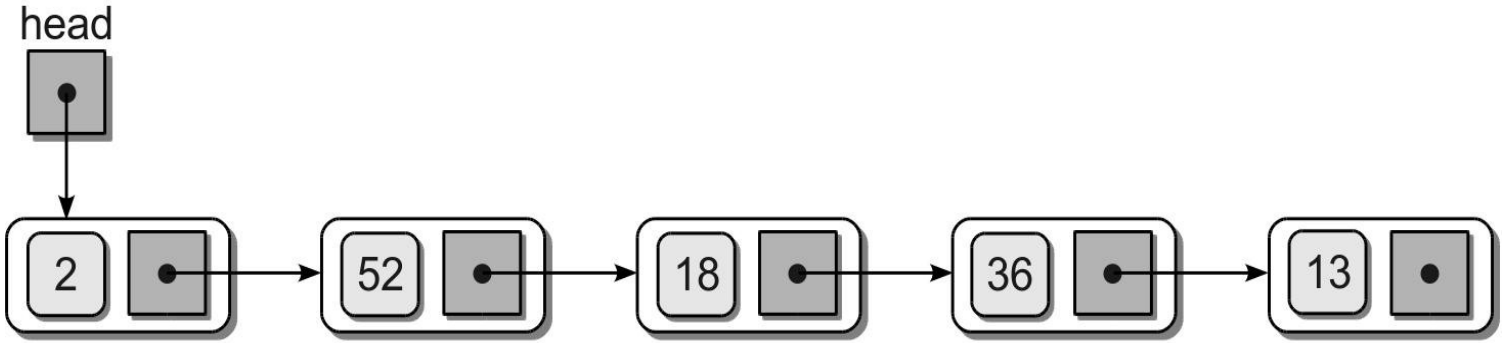
Node Definition

- The nodes are constructed from a simple storage class:

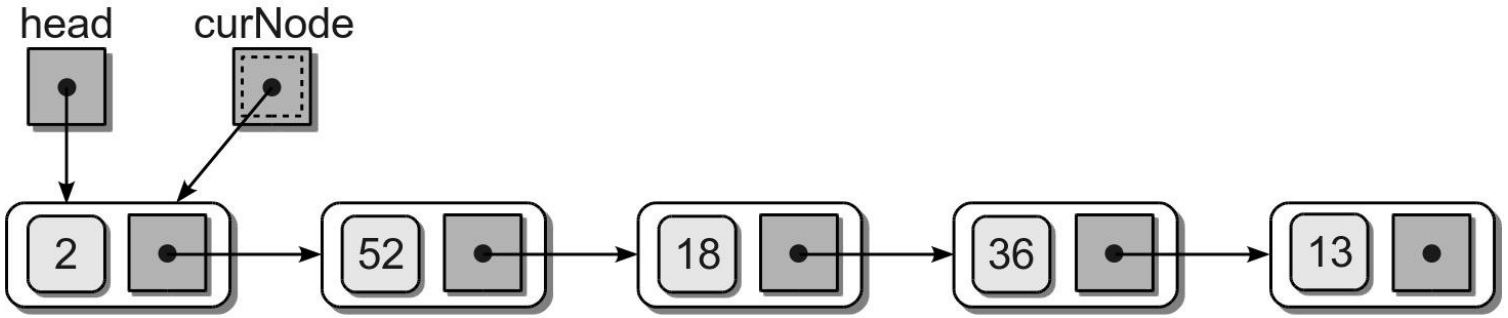
```
class _ListNode:
  def __init__( self, data ):
    self.data = data
    self.next = None
```

Traversing the Nodes

- We can traverse the nodes using a temporary external reference variable.



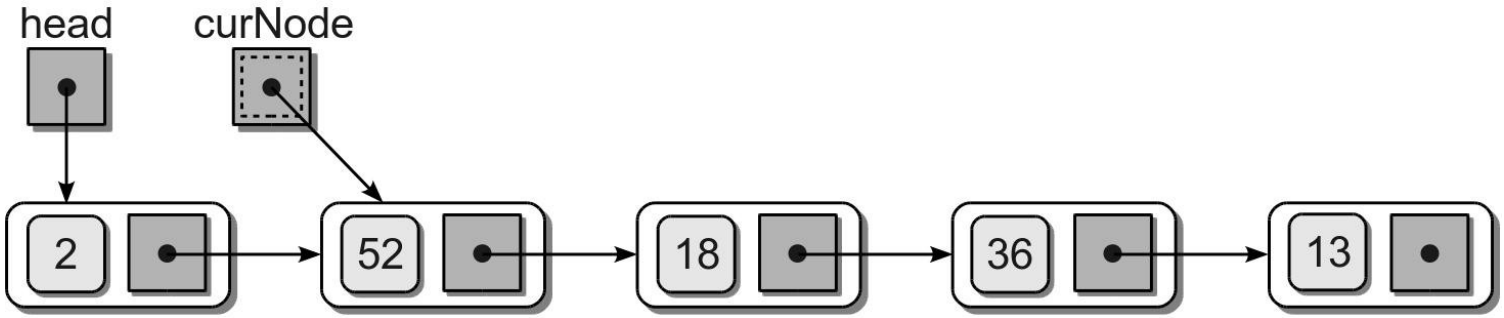
  - Initialize a temporary reference to the head node.



  - Visit the node.

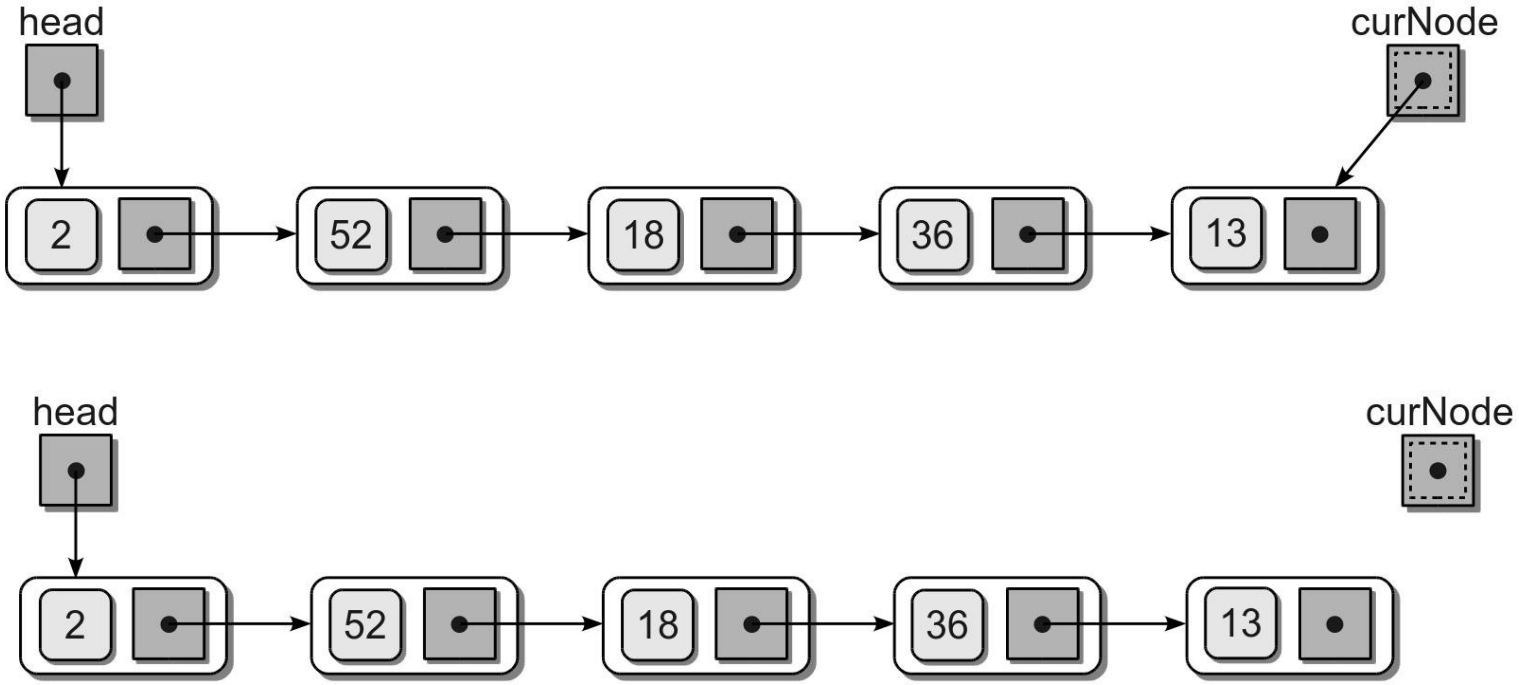
Traversing the Nodes

- Advance the temporary reference to the next node using the link field and visit that node.



Traversing the Nodes

- Repeat the process until the reference falls off the end of the list.

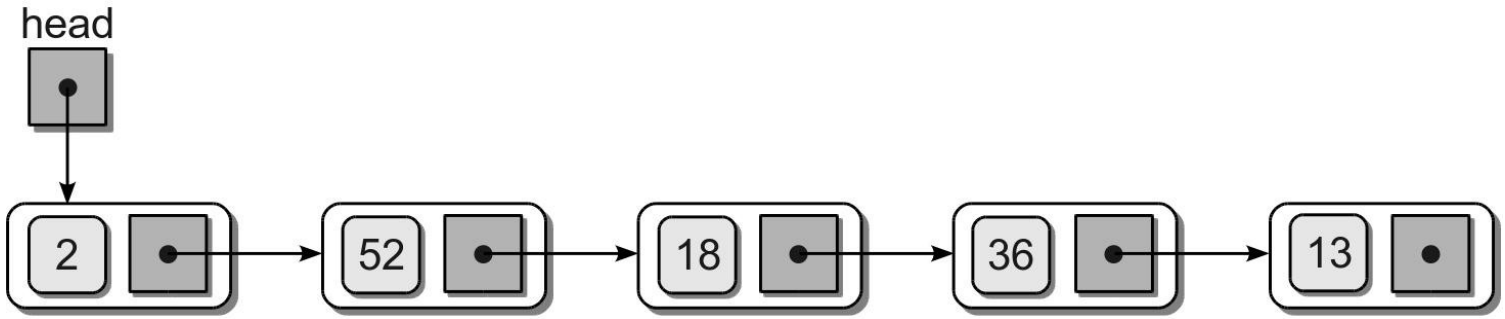


Searching

- We can perform a linear search to determine if the list contains a specific data item.

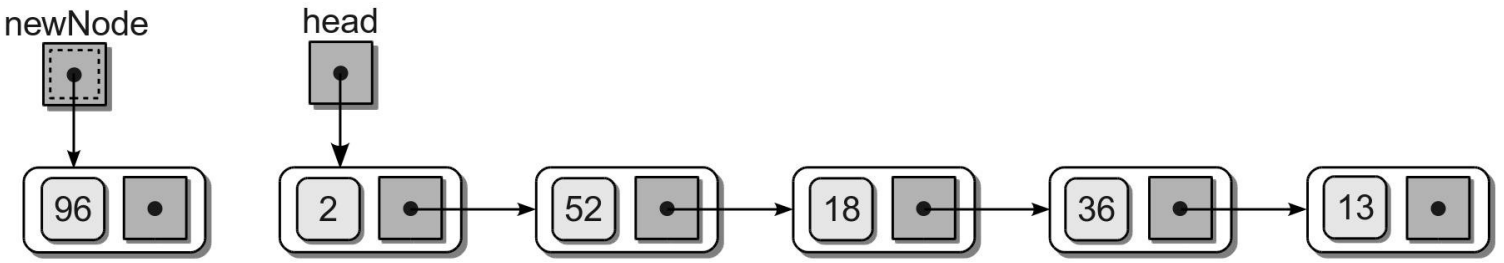
Prepending Nodes

- When working with an unsorted linked list, new values can be inserted at any point.
- We can prepend new items with little effort.
- **Example:** add value 96 to the sample list.

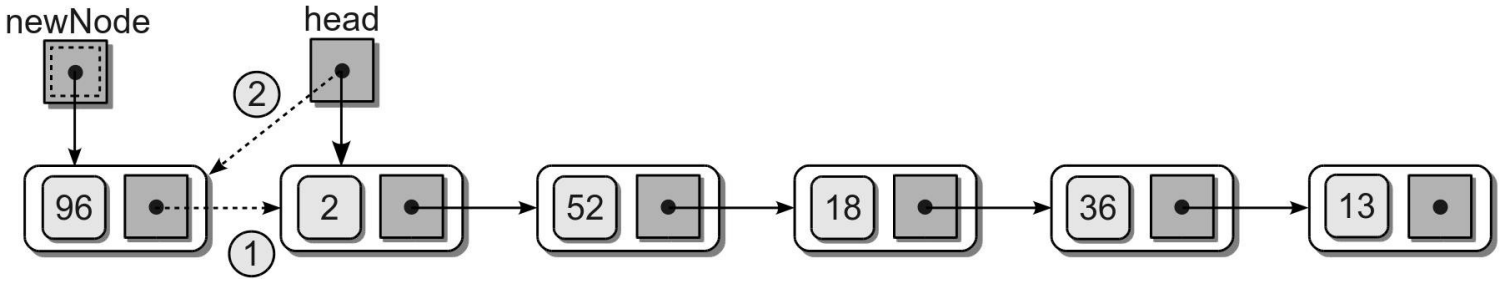


Prepending Nodes

- Create a new node for the new item.

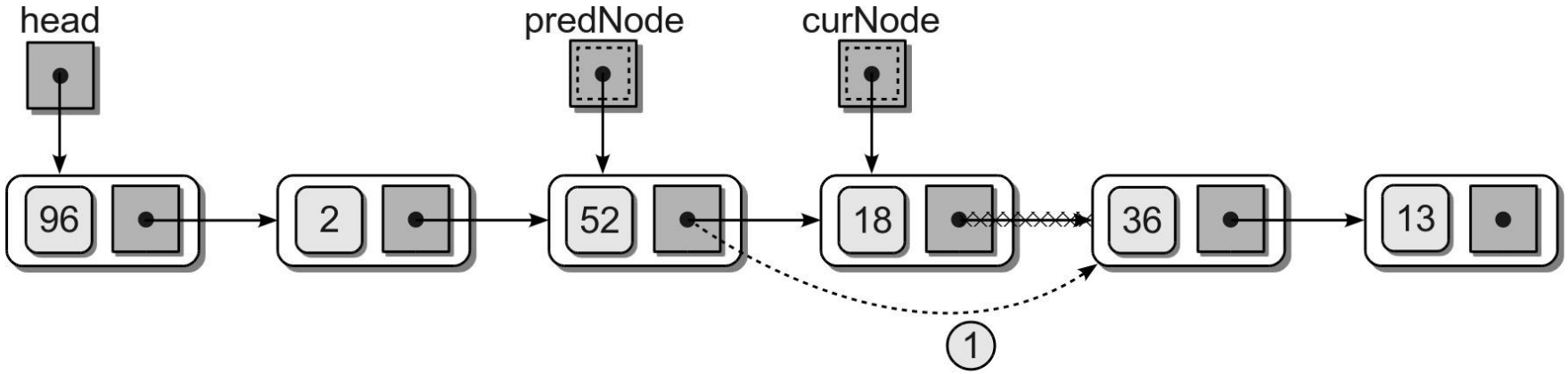


- Connect the new node to the list.

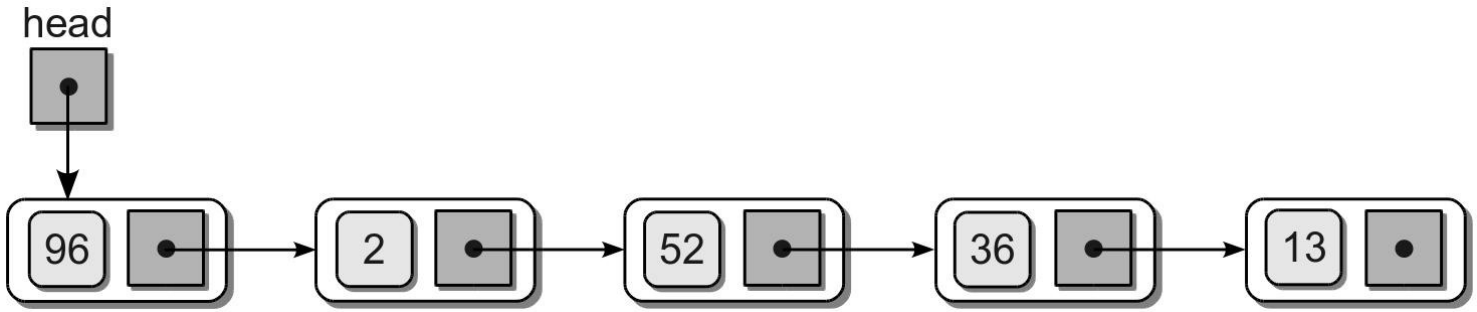


Removing Nodes

- Removing a node from the middle of the list requires a second external reference.

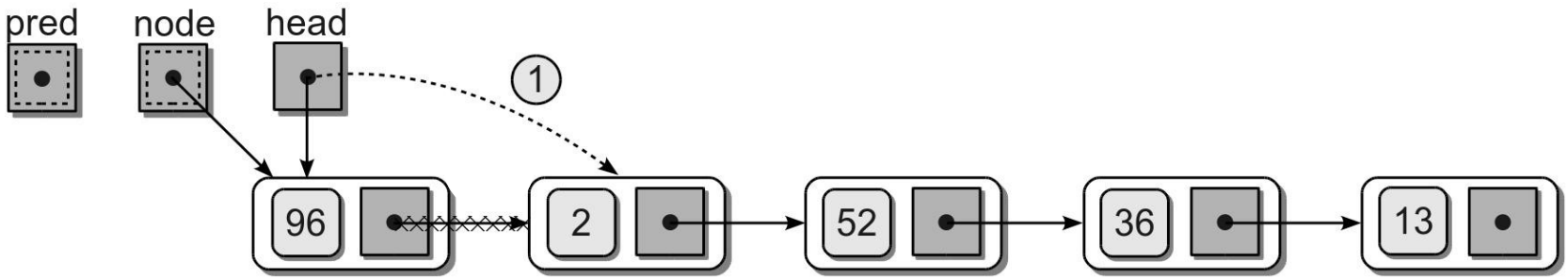


- Resulting list.



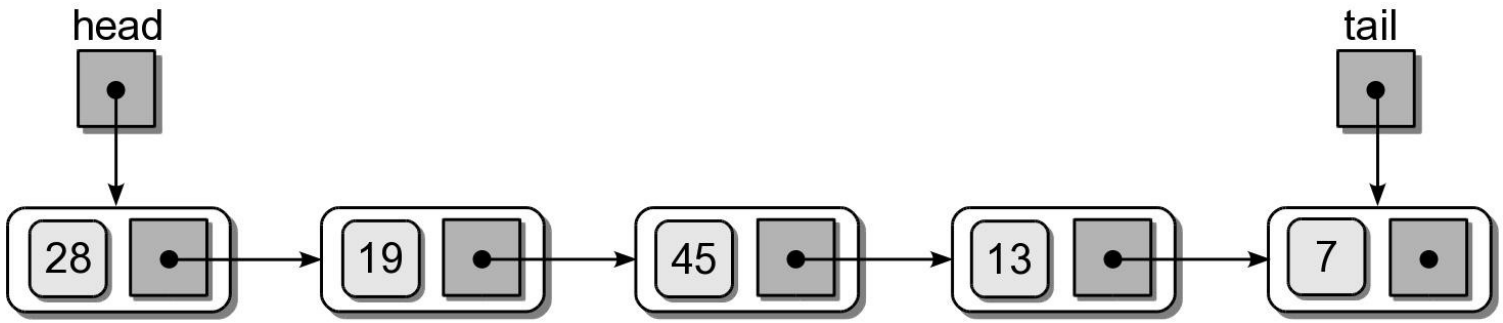
Removing Nodes

- Removing the first node is a special case.
- The head reference must be reposition to reference the next node in the list.



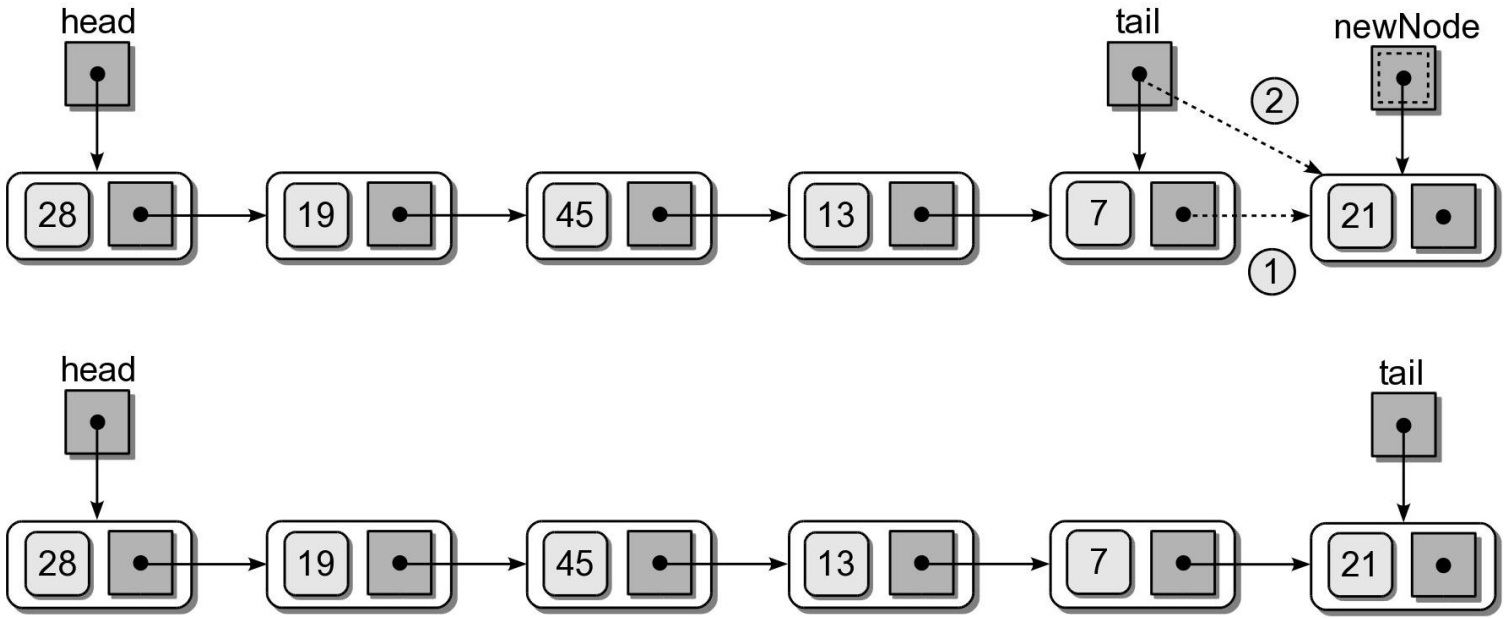
Using a Tail Reference

- Some applications require items be appended to the end of the linked list.
  - **tail reference** – a second external reference indicating the tail or last node in the list.



Appending Nodes

- Must manage the tail reference as nodes are added/removed.
  - **Example**: append 21 to the list.



Appending Nodes

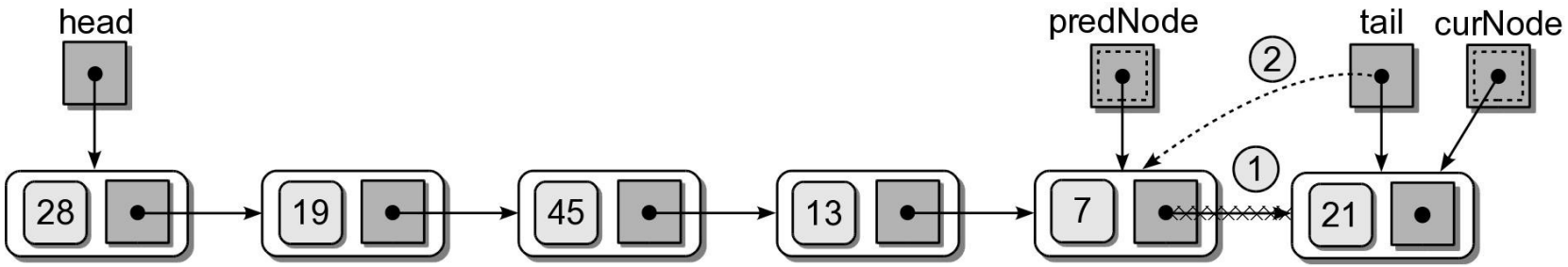
- Given the head and tail reference, we can add an item to a linked list.

```
newNode = ListNode( item )
if self._head is None :
  self._head = newNode
  self._tail = newNode
else :
  self._tail.next = newNode
  self._tail = newNode
```

What is the time complexity to append a node to a linked list, if no tail reference is used?

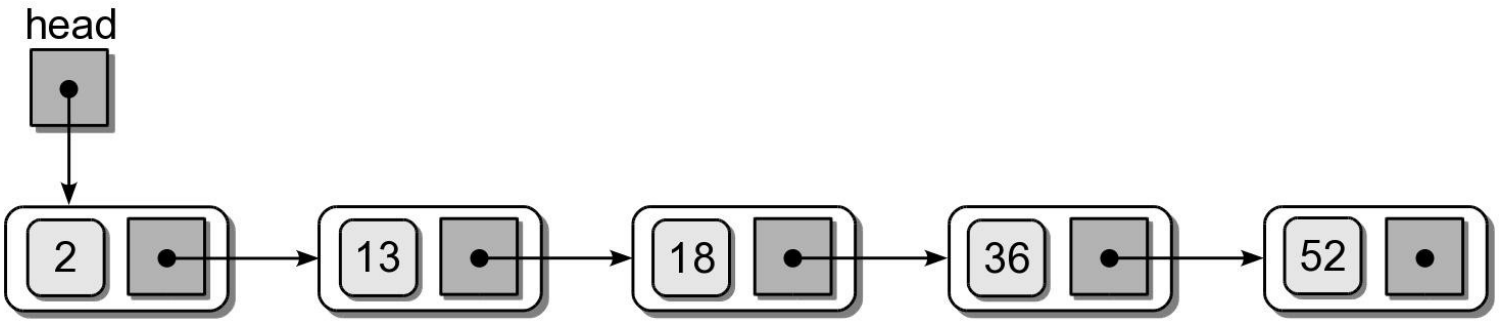
Removing Nodes

- If the tail node is removed, the tail reference has to be adjusted.



The Sorted Linked List

- The items in a linked list can be maintained in sorted order.



Sorted List: Searching

- Searching a sorted list is similar to that of an unsorted list.

```
def sortedSearch( head, target ):
  curNode = head

   # Stop early when a larger value is encountered.
  while curNode is not None and \
        target <= curNode.data :
    if curNode.data == target :
      return True
    else :
      curNode = node.next

  return False
```

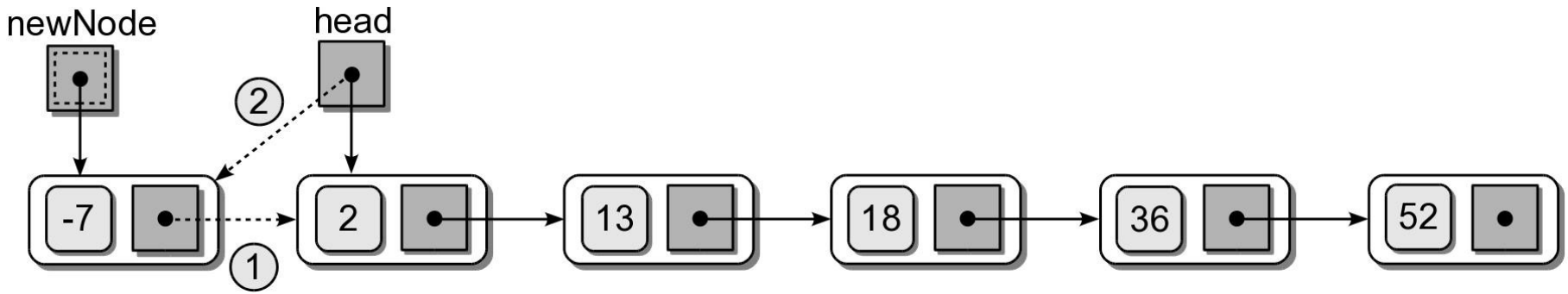
Sorted List: Insert

- Adding a new node to a sorted list requires locating the correct position within the list.
  - Locating the position is similar to the removal operation.
  - Use a second temporary reference for the predecessor.

- There are 3 possible cases.
  - front
  - middle
  - back

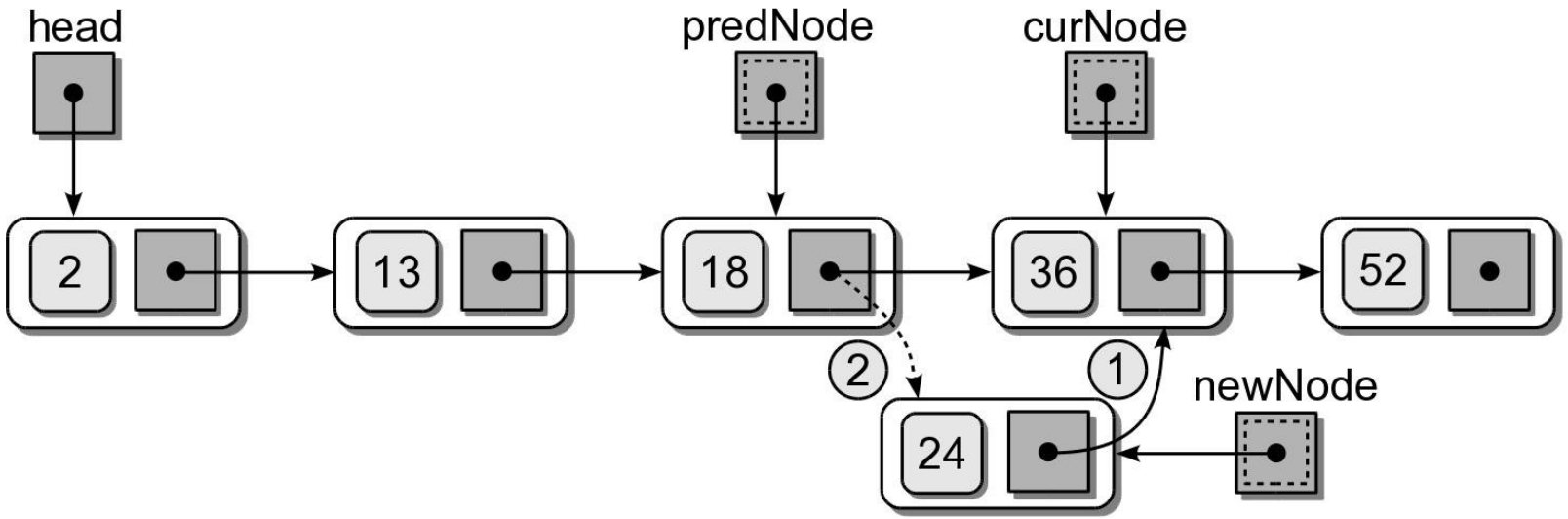
Sorted List: Insert

- (1) Insert at the front.



Sorted List: Insert

- (2) Insert in the middle.



Singly Linked List / Python List Comparison

Operation	Linked List	Python List
append(item)		
insert(0, item)		
pop(0)		
pop(i)		
__getitem__(i)		
__setitem__(i, item)		

- When does a Linked List make more sense than a contiguous representation?

Singly Linked List / Python List Comparison

Operation	Linked List	Python List
append(item)	O(n)	O(1)*
insert(0, item)	O(1)	O(n)
pop(0)	O(1)	O(n)
pop(i)	O(n)	O(n)
__getitem__(i)	O(n)	O(1)
__setitem__(i, item)	O(n)	O(1)

- When does a Linked List make more sense than a contiguous representation?

* Amortized