

# 파이썬으로 배우는 데이터 구조



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# 학습 목표

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ListSorted와 ListUnsorted 의 시간복잡도를  
비교하고, 반복자(Iterator) 사용법을 익힌다

## **Data Structures in Python**

### **Chapter 3 - 3**

- Linked List
- OOP Inheritance
- ListUnsorted Class
- **ListSorted Class & Iterator**

# Agenda

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- The ListSorted Class
  - Linked List - Review
  - Implementation
    - `push()`, `pop()`, `find()`
  - Time Complexity
- Iterator
  - Adding Count
  - Adding Iterator

## The ListSorted Class

- Sorted linked-list example:



# Linked List ADT

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- `LinkedList()`
  - Creates a new list that is empty and returns an empty list.
- `is_empty()`
  - Tests to see whether the list is empty and **returns** a Boolean value.
- `size()` and `__len__()`
  - Returns the number of nodes in the list.
- `__str__()`
  - Returns contents of the list in human readable format.
- `push(data)`
  - Pushes a new node with the data to the list.
- `pop(data)`
  - Removes the node from the list.
- `find(data)`
  - Searches for the data in the list and **returns** a Boolean value.

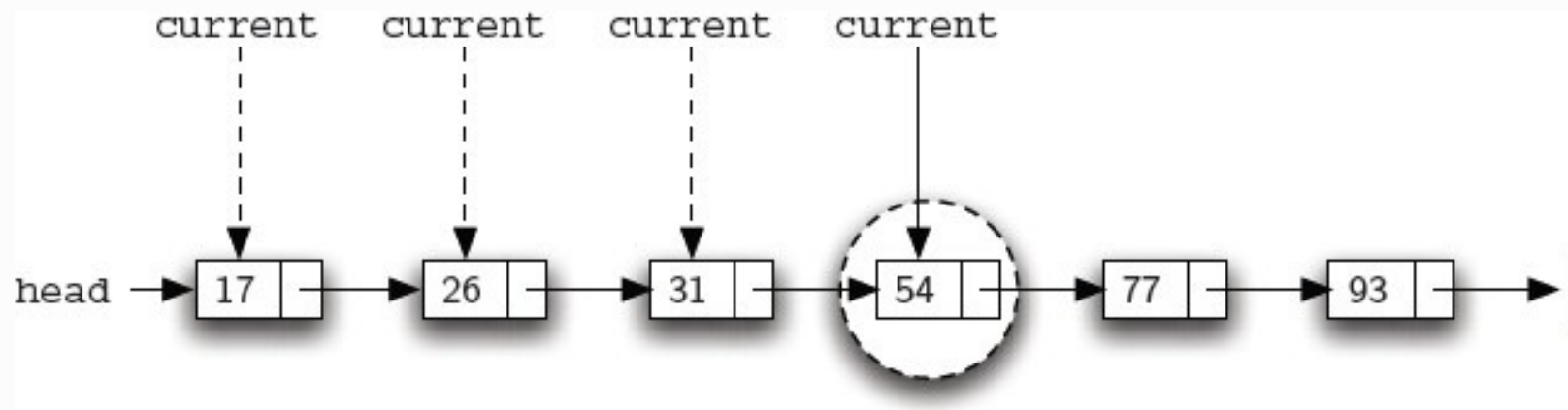
} abstract methods

## The ListSorted Class - push()

- push(data) the new node with data in sorted list.
- Determine the point of insertion.
  - Starting point:
    - curr = self.head
    - prev = None
    - stop = False

```
curr = self.head
prev = None
stop = False
while curr != None and not stop:
    if curr.get_data() > data:
        stop = True
    else:
        prev = curr
        curr = curr.get_next()
```

```
mylist.push(49)
```

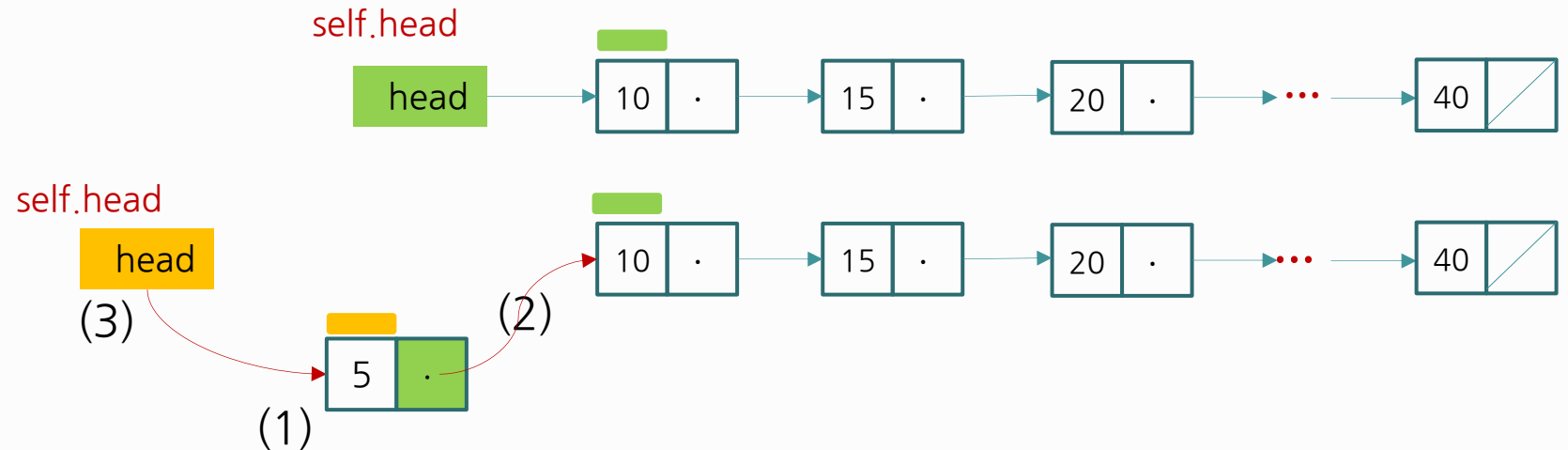
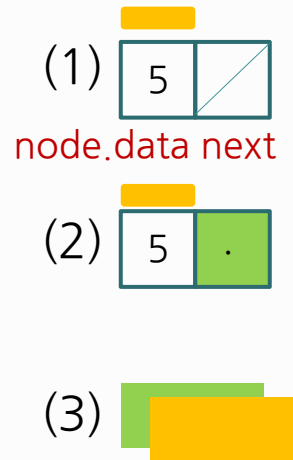


# The ListSorted Class - push()

- Insert at the beginning of a linked list

```
(1) node = Node(5)
(2) node.set_next(self.head)
(3) self.head = node
```

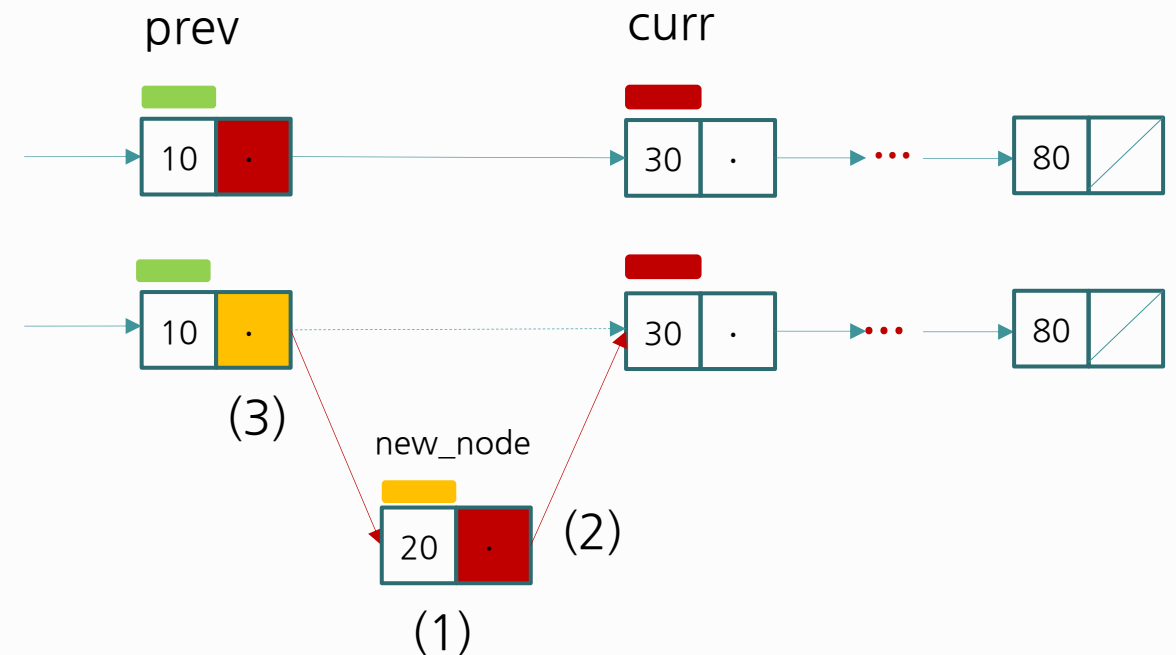
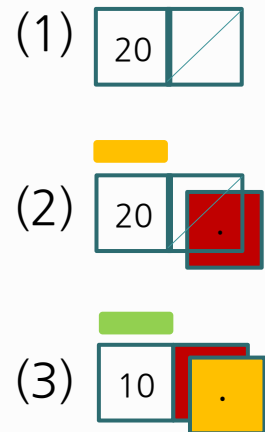
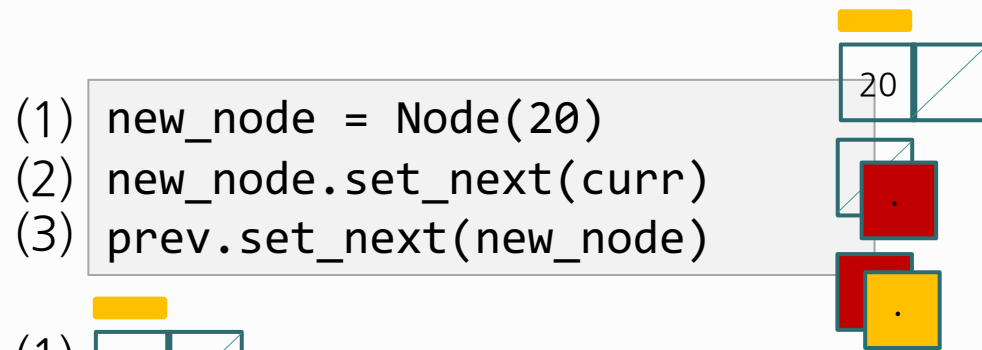
```
curr = self.head
prev = None
stop = False
while curr != None and not stop:
    if curr.get_data() > data:
        stop = True
    else:
        prev = curr
        curr = curr.get_next()
```





# The ListSorted Class - push()

- push(data) inserts at the middle of a sorted linked list.
  - Change the next reference of the new node to refer to the current node of the list.
  - Modify the next reference of the previous node to refer to the new node.

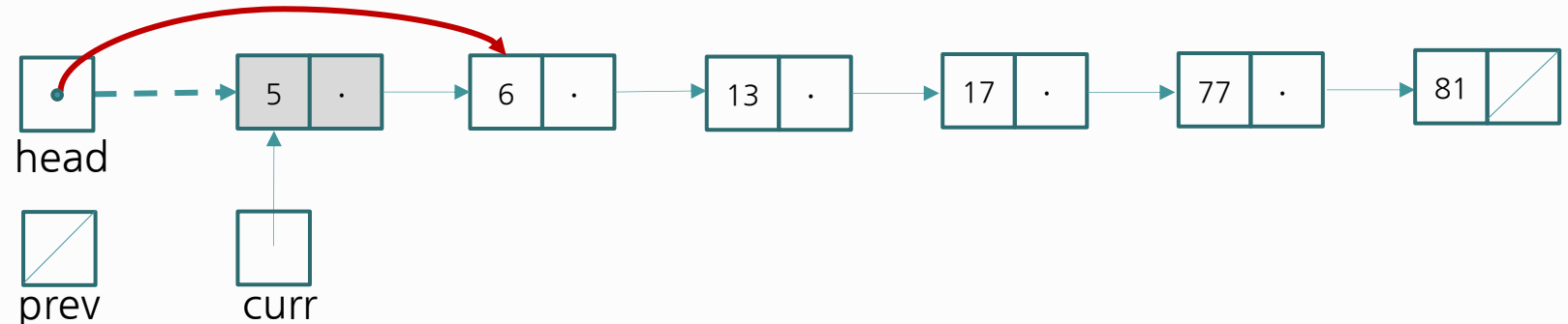


## The ListSorted Class - pop()

- ▶ pop(data) removes a node with data from the list.
  - ▶ What is different from pop() of ListUnsorted class?
- ▶ Examples:
  - ▶ Delete the first node.

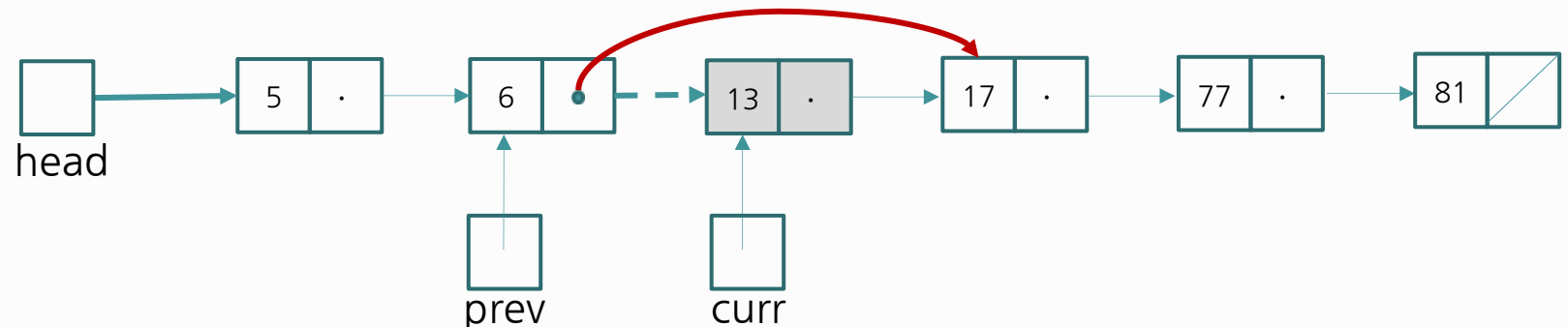
```
mylist.pop(5)
```

```
mylist.pop_front()
```



- ▶ Delete a node in the middle of the list with **prev** and **curr** references.

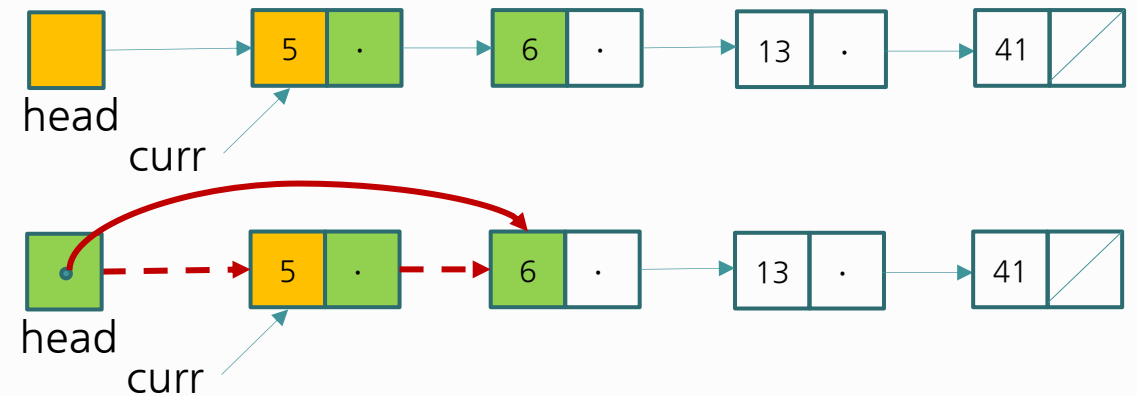
```
mylist.pop(13)
```



## The ListSorted Class - pop()

- ▶ To delete a node from a linked list
  - ▶ Locate the node that you want to delete (**curr**)
  - ▶ **Disconnect** this node from the linked list by changing references.
- ▶ Two situations:
  - ▶ (1) To delete the **first** node,
    - ▶ Modify head to refer to the node after the current node

```
self.head = curr.get_next()
```

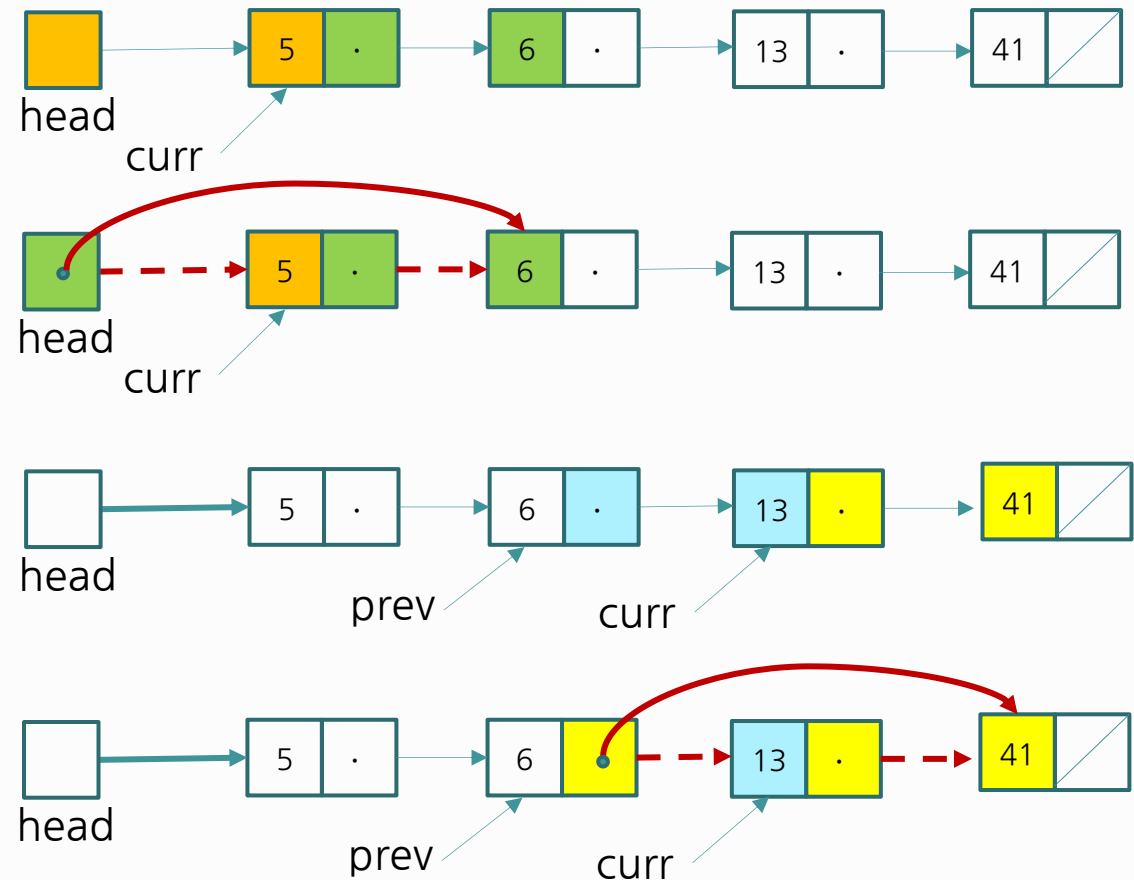


# The ListSorted Class - pop()

- ▶ To delete a node from a linked list
  - ▶ Locate the node that you want to delete (**curr**)
  - ▶ **Disconnect** this node from the linked list by changing references.
- ▶ Two situations:
  - ▶ (1) To delete the **first** node,
    - ▶ Modify head to refer to the node after the current node
  - ▶ (2) To delete a node in the **middle**,
    - ▶ Set next of the **prev** node to refer to the node **after the current node**.

```
self.head = curr.get_next()
```

```
prev.set_next(curr.get_next())
```

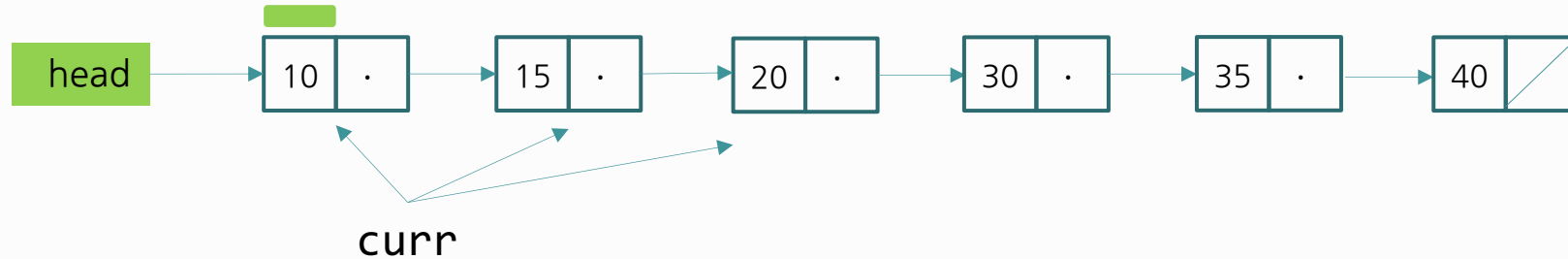


# The ListSorted Class - find()

- find(data) searches for the node with data in the list.
  - Returns a Boolean
  - Examples:

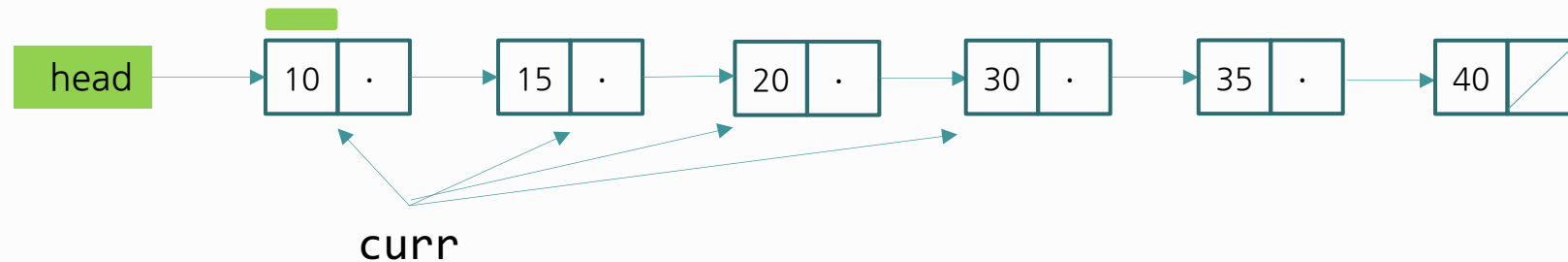
```
print(mylist.find(20))
```

True



```
print(mylist.find(25))
```

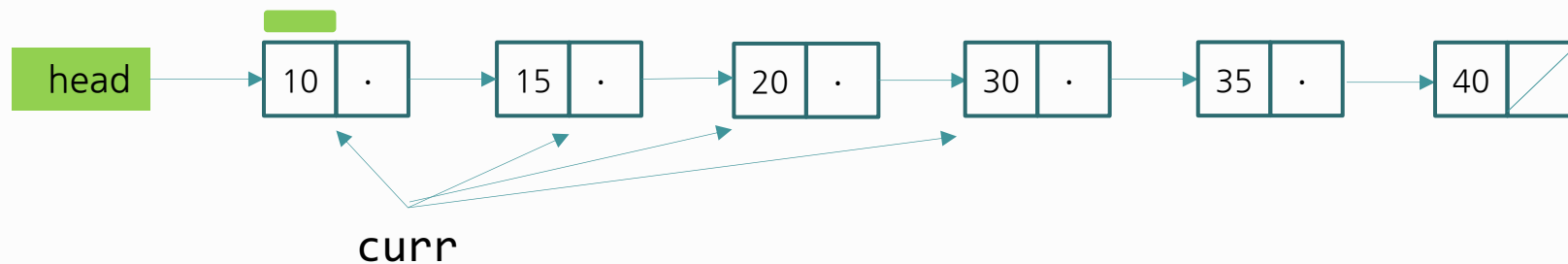
False



## The ListSorted Class - find()

- find(data) searches for the node with data in the list.
  - Set a pointer to be the same address as head, process the data in the node, (search) move the pointer to the next node, and so on.
  - Loop stops either
    - Found the item
    - The next pointer is None
    - The value in the node is greater than the item that we are searching

```
curr = self.head
while curr != None:
    if curr.get_data() == data:
        return True
    elif curr.get_data() > data:
        return False
    curr = curr.get_next()
return False
```



# The ListSorted Class - Time Complexity

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- Summary:

	ListUnsorted	ListSorted
is_empty	$O(1)$	$O(1)$
size	$O(n)$	$O(n)$
push	$O(1)$	$O(n)$
pop	$O(n)$	$O(n)$
find	$O(n)$	$O(n)$

# Iterator

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- Enhancements of LinkedList Classes (LinkedList, ListUnSorted, ListSorted)
  - Adding Count
  - Adding Iterator



## The ListUnsorted Class - adding count

- We can add a count variable to count the number of nodes in the list.

```
class ListUnsorted(LinkedList):  
    def __init__(self):  
        ...  
  
    def push(self, data):  
        new_node = Node(data)  
        ...  
        self.count += 1  
  
    def pop(self, data):  
        current = self.head  
        ...  
        self.count -= 1  
  
    def size(self):  
        return self.count  
  
    def is_empty(self):  
        return self.count == 0
```

Time complexity:  $O(1)$



# The ListUnsorted Class - Time Complexity

- Summary

	Python List		ListUnsorted
<code>if len(mylist) == 0: ...</code>	$O(1)$	<code>__len().__</code>	$O(1)$
<code>len</code>	$O(1)$	<code>size</code>	$O(1)$ with <i>count</i> variable $O(n)$ <i>without</i> count variable
<code>push()</code> <code>insert(i, data)</code>	$O(1)$ $O(n)$	<code>push</code>	$O(1)$ (beginning of the linked list)
<code>pop</code> <code>del</code>	$O(n)$ $O(n)$	<code>pop</code>	$O(n)$
<code>in</code>	$O(n)$	<code>find</code>	$O(n)$

# Iterators

- **Traversals** are very common operations, especially on containers.
- Python's for loop allows programmer to traverse items in strings, lists, tuples, and dictionaries:

- Lists

```
for item in [1, 2, 3, 4]:  
    print(item)
```

- Tuples

```
for item in (1, 2, 3, 4):  
    print(item)
```

- Dictionaries:

```
for key in {'a': 1, 'b':2, 'c':3}:  
    print(key)
```

- Strings:

```
for ch in 'hello':  
    print(ch)
```

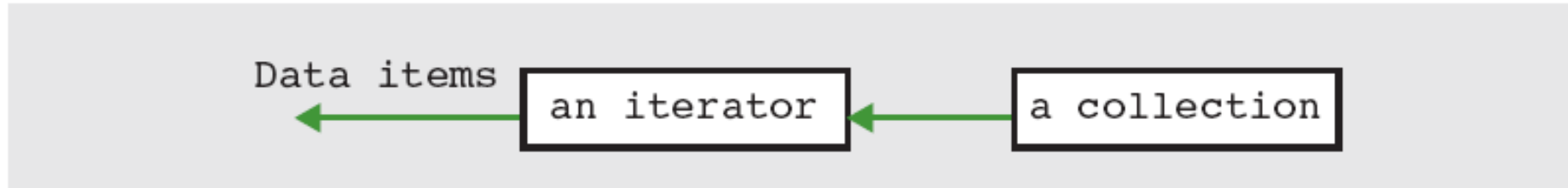
```
for <eachItem> in <collection>:  
    <do something with eachItem>
```

iterable object



# Iterators

- Python compiler translates for loop to code that uses a special type of object called an **iterator**.



- An iterator guarantees that each element is visited exactly **once**.
  - It is useful to be able to traverse an ListUnsorted or an ListSorted, i.e., visit each element exactly once.
- To explicitly create an iterator, use the built-in **iter** function:

```
it = iter([1, 2, 3])  
print(next(it))  
print(next(it))
```

1  
2

```
>>> it = iter([1, 2, 3])  
>>> print(next(it))  
1  
>>> print(next(it))  
2
```

# Iterators

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- You can create your own iterators if you write a function to generate the next item.
- You need to add:
  - Constructor
  - The `__iter__()` method, which must return the iterator object.
  - The `__next__()` method, which returns the next element from a sequence.
- For example:

```
obj = MyIterObj(5, 10)
for num in obj:
    print(num, end=" ")
```

5 6 7 8 9 10

# Iterators

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- Define the `MyIterObj` class which is **iterable**:

```
class MyIterObj:
    def __init__(self, low, high):
        self.curr = low
        self.high = high

    def __iter__(self):
        return self

    def __next__(self):
        if self.curr > self.high:
            raise StopIteration
        else:
            self.curr += 1
            return self.curr - 1
```

## Iterators - Linked List Traversals

- Now, we would like to traverse an `ListUnsorted` or an `ListSorted` using a for-loop, i.e., visit each element exactly once.

```
for num in mylist:  
    print(num, end=" ")
```

- However, we will get the following error:

```
for num in mylist:  
    print(num, end=" ")
```

```
for num in mylist:  
TypeError: 'ListUnsorted' object is not iterable
```

- Solution:
  - Create an iterator class for the linked list
  - Add the `__iter__()` method to returns an instance of the `LinkedListIterator` class

## Iterators - The LinkedListIterator

- Define `LinkedListIterator` class that defines an iterator object of the `LinkedList`.
  - The object stores the head of the list.
  - It implements `__next__()` method that returns data of the current node and advances to the next node.
  - It maintains the reference of the current node.

```
#!/usr/bin/env python3
# %%writefile linkedlistIterator.py
class LinkedListIterator:
    def __init__(self, head):
        self.head = head
        self.curr = head
    def __next__(self):
        if self.curr != None:
            data = self.curr.get_data()
            self.curr = self.curr.get_next()
            return data
        else:
            raise StopIteration
```



## Iterators - The LinkedListIterator

- Define `__iter__()` method that returns an iterator object of the LinkedList.
  - The iterator has the head of LinkedList and knows how to traverse the list.

```
from linkedlistIterator import LinkedListIterator

class ListUnsorted(LinkedList):
    ...
    def __iter__(self):
        return LinkedListIterator(self.head)
    ...

class ListSorted(LinkedList):
    ...

    def __iter__(self):
        return LinkedListIterator(self.head)
    ...
```

```
#!/usr/bin/env python
# %%writefile linkedlistIterator.py
class LinkedListIterator:
    def __init__(self, head):
        self.head = head
        self.curr = head
    def __next__(self):
        if self.curr != None:
            data = self.curr.get_data()
            self.curr = self.curr.get_next()
            return data
        else:
            raise StopIteration
```

## Iterators - The LinkedListIterator

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- Adding LinkedListIterator in ListUnsorted/ListSorted classes as needed:

```
...  
  
class ListUnsorted(LinkedList):  
    ...  
    def __iter__(self):  
        return LinkedListIterator(self.head)  
    ...  
  
class LinkedListIterator(LinkedList):  
    def __init__(self, head):  
        self.head = head  
        self.curr = head  
    def __next__(self):  
        if self.curr != None:  
            data = self.curr.get_data()  
            self.curr = self.curr.get_next()  
            return data  
        else:  
            raise StopIteration
```

# Iterators - The LinkedListIterator

- Example:

```
if __name__ == '__main__':  
    mylist = ListUnsorted()  
    num_list = [24, 65, 12]  
    for num in num_list:  
        mylist.push(num)  
  
    for num in mylist:  
        print(num, end=" ")
```

12 65 24

## Exercise - get\_sum() function

- Write a function that returns the sum of the list data.

```
def get_sum(node):  
    sum = 0  
  
    # your code here  
  
    return sum
```

```
if __name__ == '__main__':  
    mylist = ListSorted()  
    num_list = [1, 3, 5]  
  
    for num in num_list:  
        mylist.push(num)    # pushing numbers to the linked list  
  
    print(mylist)  
    print('sum =', get_sum(mylist.head))
```

[5, 3, 1]  
sum = 9

## Summary

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- Different implementations may have different time and space complexity.
- The linked-list can be sorted.
- Adding a simple count let `size()` operate in  $O(1)$  instead of  $O(n)$ .
- Adding `__iter__()` function let the user traverse the list using for-loop.

# 학습 정리

- 1) ListSorted는 노드를 push()할 때부터 순서를 맞추어 정렬한다
- 2) 반복자(Iterator)를 사용하여 LinkedList를 순회할 수 있다
- 3) \_\_iter\_\_(), \_\_next\_\_()를 재정의(override)함으로  
반복자를 자유롭게 만들고 활용할 수 있다

# 파이썬으로 배우는 데이터 구조

수고했습니다  
곧 다음 시간에  
다시 뵙겠습니다

