CSE 143
Lecture 11

More Linked Lists

reading: 16.2 - 16.3

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Conceptual questions

- What is the difference between a `LinkedIntList` and a `ListNode`?
- What is the difference between an empty list and a `null` list?
  - How do you create each one?
- Why are the fields of `ListNode` public? Is this bad style?
- What effect does this code have on a `LinkedIntList`?

```
ListNode current = front;
current = null;
```

Conceptual answers

- A list consists of 0 to many node objects.
  - Each node holds a single data element value.

- null list: `LinkedIntList list = null;`
  empty list: `LinkedIntList list = new LinkedIntList();`

- It's okay that the node fields are public, because client code never directly interacts with `ListNode` objects.

- The code doesn't change the list.
  You can change a list only in one of the following two ways:
  - Modify its `front` field value.
  - Modify the `next` reference of a node in the list.

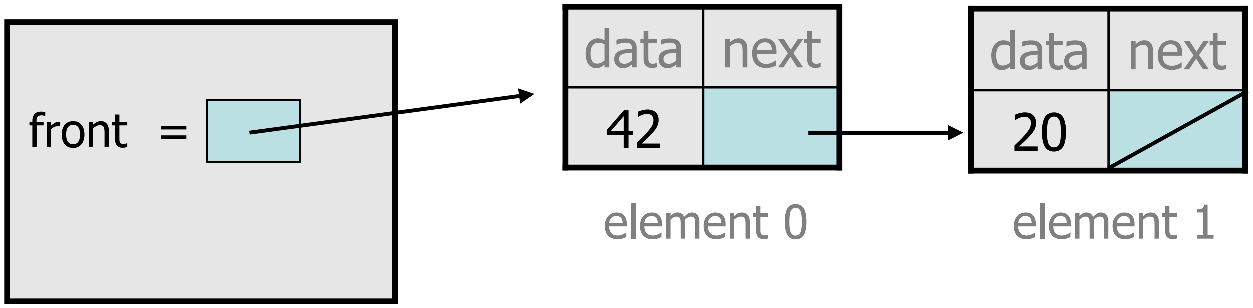
Implementing `remove`

```
// Removes and returns the list's first value.
public int remove() {
    ...
}
```

- How do we remove the front node from a list?
- Does it matter what the list's contents are before the remove?

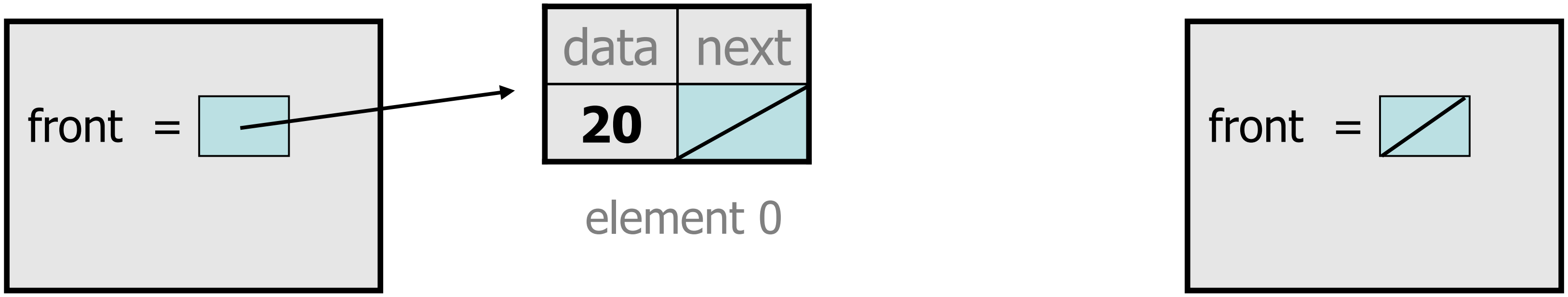
Removing front element

- Before removing front element:



- After first removal:

After second removal:



`remove` solution

```
// Removes and returns the first value.
// Throws a NoSuchElementException on empty list.
public int remove() {
    if (front == null) {
        throw new NoSuchElementException();
    } else {
        int result = front.data;
        front = front.next;
        return result;
    }
}
```

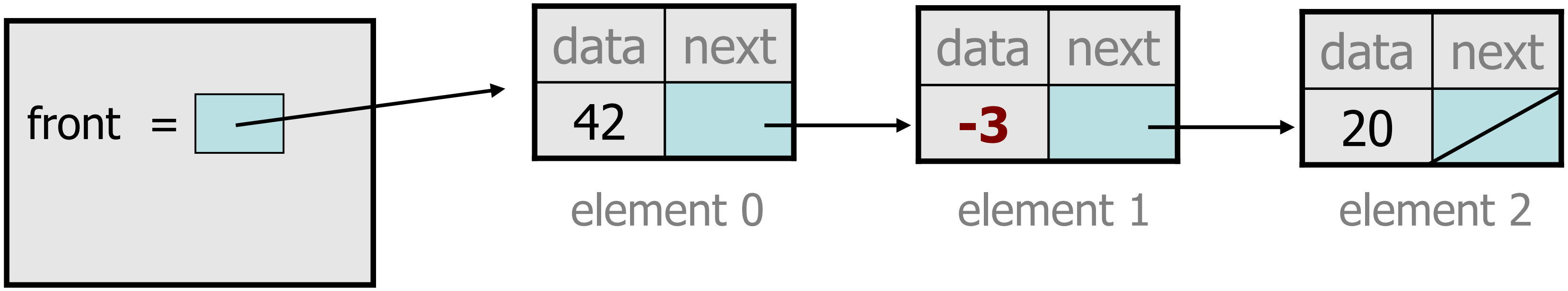
Implementing `remove` (2)

```
// Removes value at given index from list.
// Precondition: 0 <= index < size
public void remove(int index) {
    ...
}
```

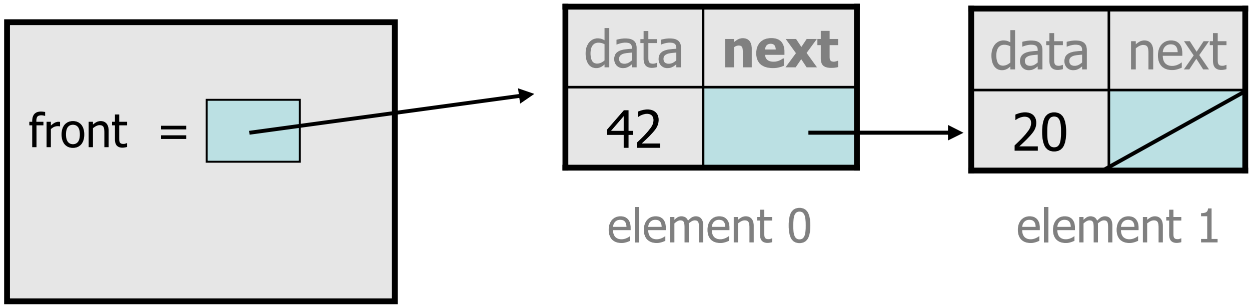
- How do we remove any node in general from a list?
- Does it matter what the list's contents are before the remove?

Removing from a list

- Before removing element at index 1:

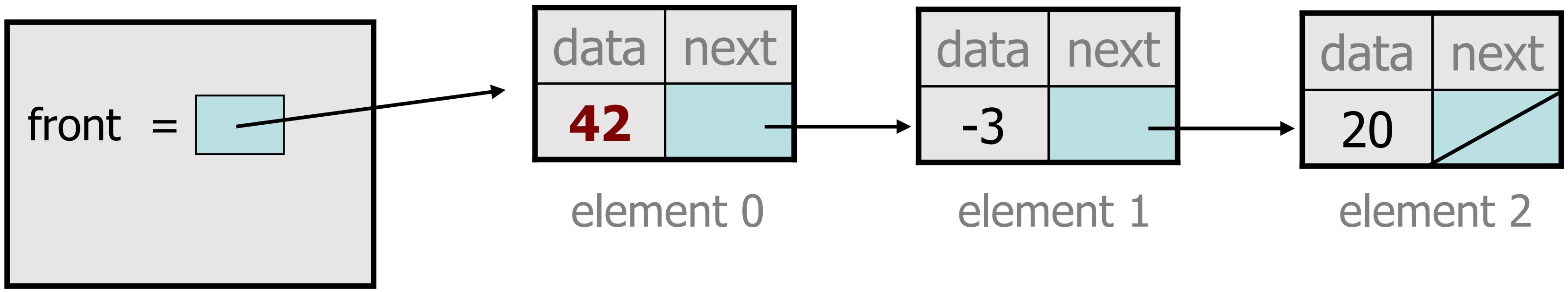


- After:

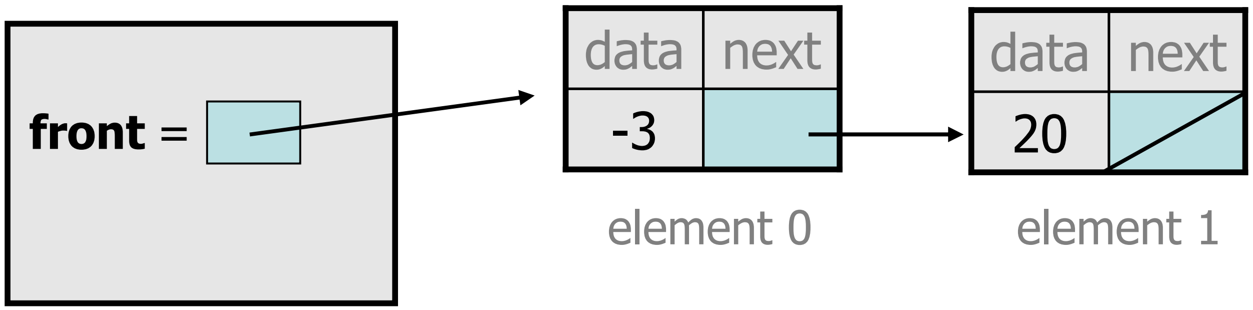


Removing from the front

- Before removing element at index 0:

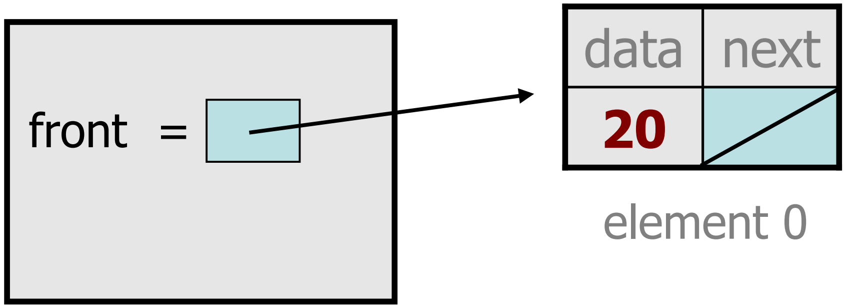


- After:

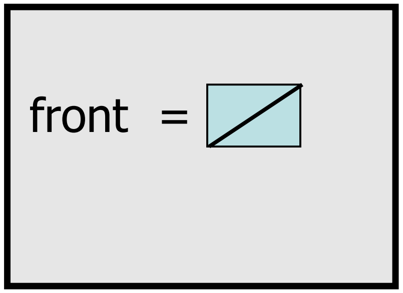


Removing the only element

- Before:



After:



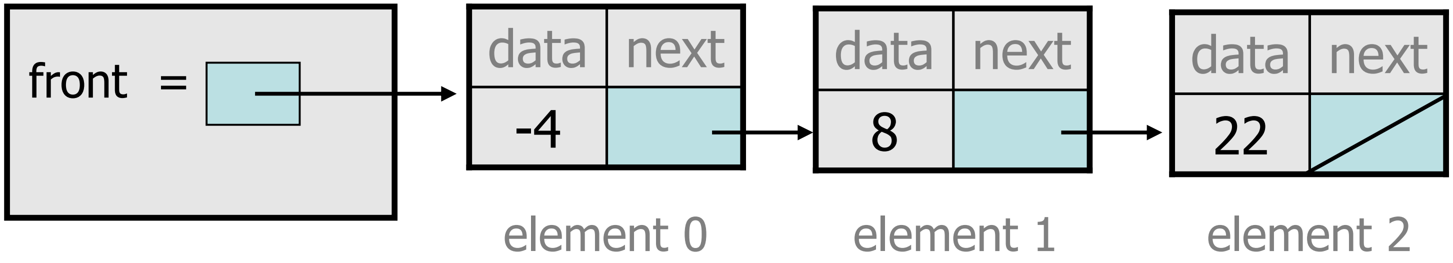
  - We must change the front field to store `null` instead of a node.
  - Do we need a special case to handle this?

remove (2) solution

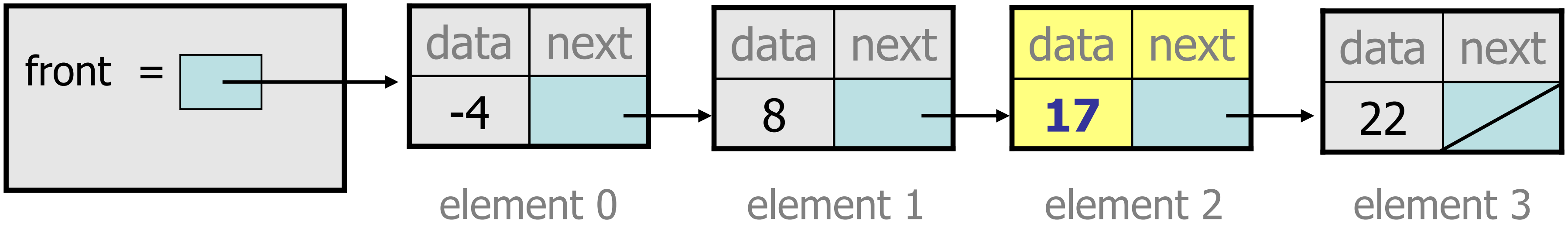
```
// Removes value at given index from list.
// Precondition: 0 <= index < size()
public void remove(int index) {
    if (index == 0) {
        // special case: removing first element
        front = front.next;
    } else {
        // removing from elsewhere in the list
        ListNode current = front;
        for (int i = 0; i < index - 1; i++) {
            current = current.next;
        }
        current.next = current.next.next;
    }
}
```

Exercise

- Write a method `addSorted` that accepts an integer value as a parameter and adds that value to a sorted list in sorted order.
  - Before `addSorted(17)` :



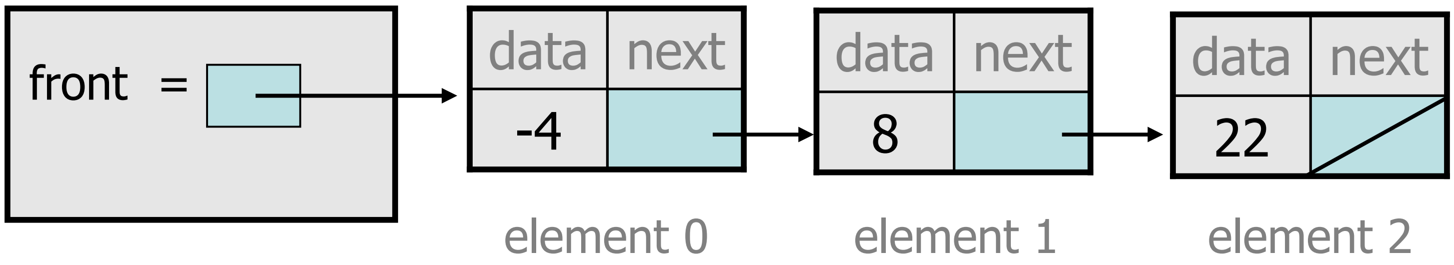
  - After `addSorted(17)` :



The common case

- Adding to the middle of a list:

```
addSorted(17)
```

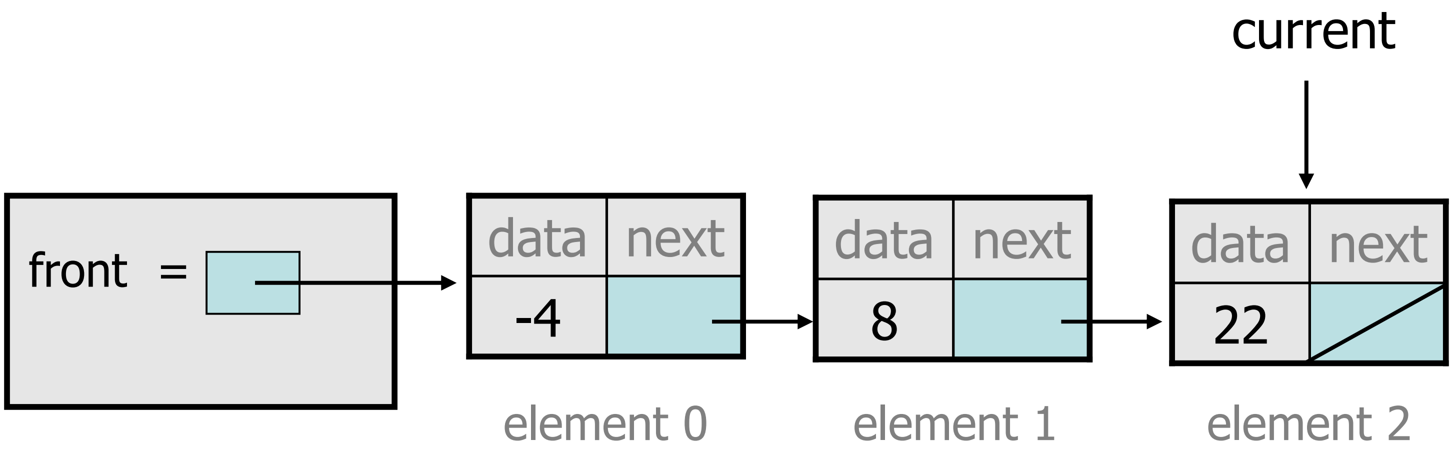


  - Which references must be changed?
  - What sort of loop do we need?
  - When should the loop stop?

First attempt

- An incorrect loop:

```
ListNode current = front;
while (current.data < value) {
    current = current.next;
}
```

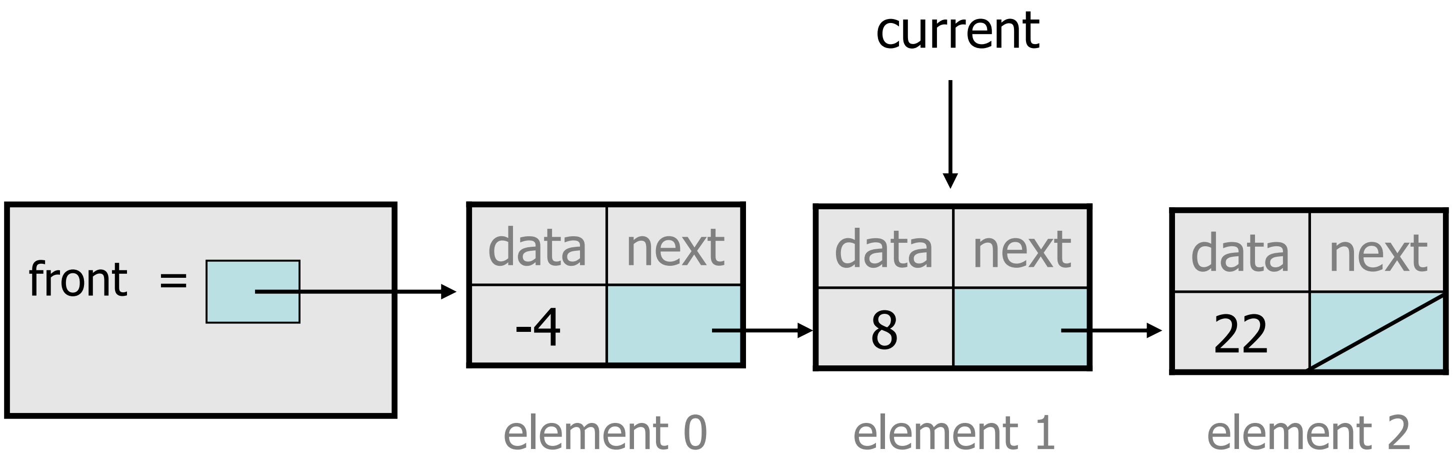


- What is wrong with this code?
  - The loop stops too late to affect the list in the right way.

Key idea: peeking ahead

- Corrected version of the loop:

```
ListNode current = front;
while (current.next.data < value) {
    current = current.next;
}
```

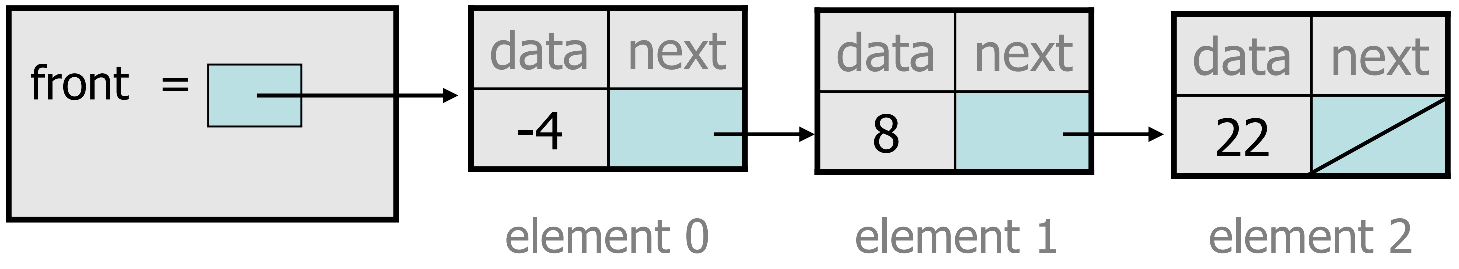


  - This time the loop stops in the right place.

Another case to handle

- Adding to the end of a list:

```
addSorted(42)
```



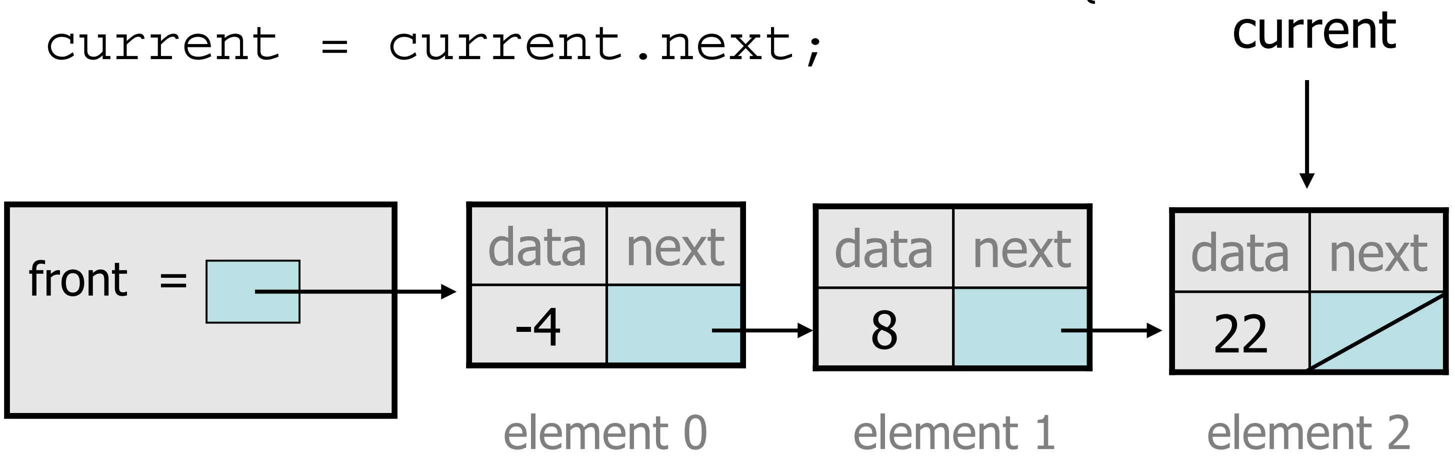
```
Exception in thread "main": java.lang.NullPointerException
```

– Why does our code crash?
– What can we change to fix this case?

Multiple loop tests

- A correction to our loop:

```
ListNode current = front;
while (current.next != null &&
       current.next.data < value) {
    current = current.next;
}
```

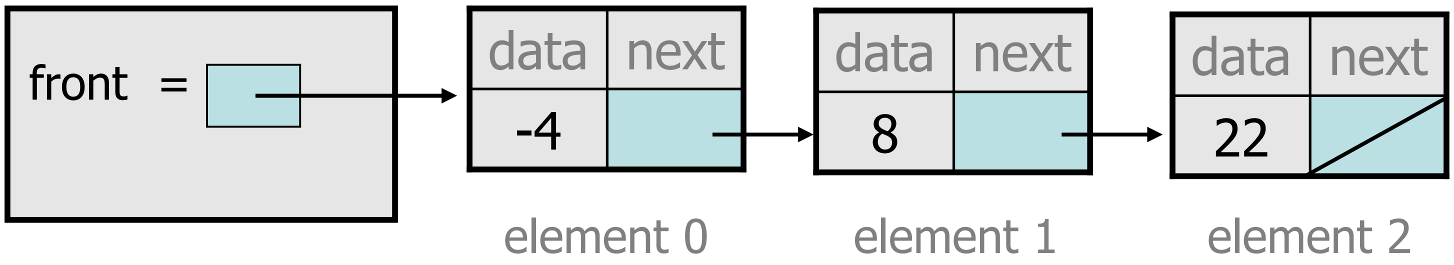


  - We must check for a `next` of `null` *before* we check its `.data`.

Third case to handle

- Adding to the front of a list:

  `addSorted(-10)`



  - What will our code do in this case?
  - What can we change to fix it?

Handling the front

- Another correction to our code:

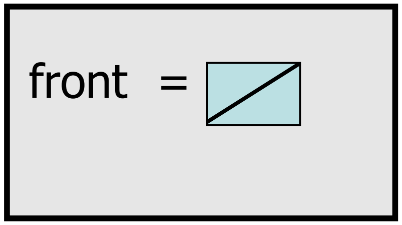
```
if (value <= front.data) {
    // insert at front of list
    front = new ListNode(value, front);
} else {
    // insert in middle of list
    ListNode current = front;
    while (current.next != null &&
           current.next.data < value) {
        current = current.next;
    }
}
```

  – Does our code now handle every possible case?

Fourth case to handle

- Adding to (the front of) an empty list:

```
    addSorted(42)
```



  - What will our code do in this case?
  - What can we change to fix it?

Final version of code

```
// Adds given value to list in sorted order.
// Precondition: Existing elements are sorted
public void addSorted(int value) {
    if (front == null || value <= front.data) {
        // insert at front of list
        front = new ListNode(value, front);
    } else {
        // insert in middle of list
        ListNode current = front;
        while (current.next != null &&
                current.next.data < value) {
            current = current.next;
        }
    }
}
```

Other list features

- Add the following methods to the `LinkedIntList`:
  - `size`
  - `isEmpty`
  - `clear`
  - `toString`
  - `indexOf`
  - `contains`

- Add a `size` field to the list to return its size more efficiently.

- Add preconditions and exception tests to appropriate methods.