

COMP 2231 Assignment 3

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## 1. Stack using Linked List

```
jsjf/driverOne.java - Eclipse IDE
Navigate Search Project Run Window Help

driverOne.java × driverThree.java DriverFour.java DriverTwo.java
1 package jsjf;
2
3 public class driverOne {
4
5     public static void main(String[] args) {
6         LinkStack<String> list = new LinkStack<String>();
7
8
9         list.push("tolga");
10        list.push("olcay");
11        list.push("zoo");
12        list.push("beehive");
13        list.push("1");
14        list.push("2");
15        list.push("monkey");
16        System.out.println("peek: " + list.peek() + "\n");
17
18        list.pop();
19
20
21        System.out.println(list);
22    }
23 }
24
```

```
@ Javadoc Declaration Console ×
<terminated> driverOne [Java Application] C:\Users\Tolga\.p2\pool\plugins\org.eclipse.justj.openjdk.hotspot.jre.full.win:
peek: monkey

2
1
beehive
zoo
olcay
tolga
```

Here is the result of a stack using a linked list. I use the same instructions for all the drivers that use stacks.

As you can see, when we peek, the string is monkey because that was the last value pushed on the stack.

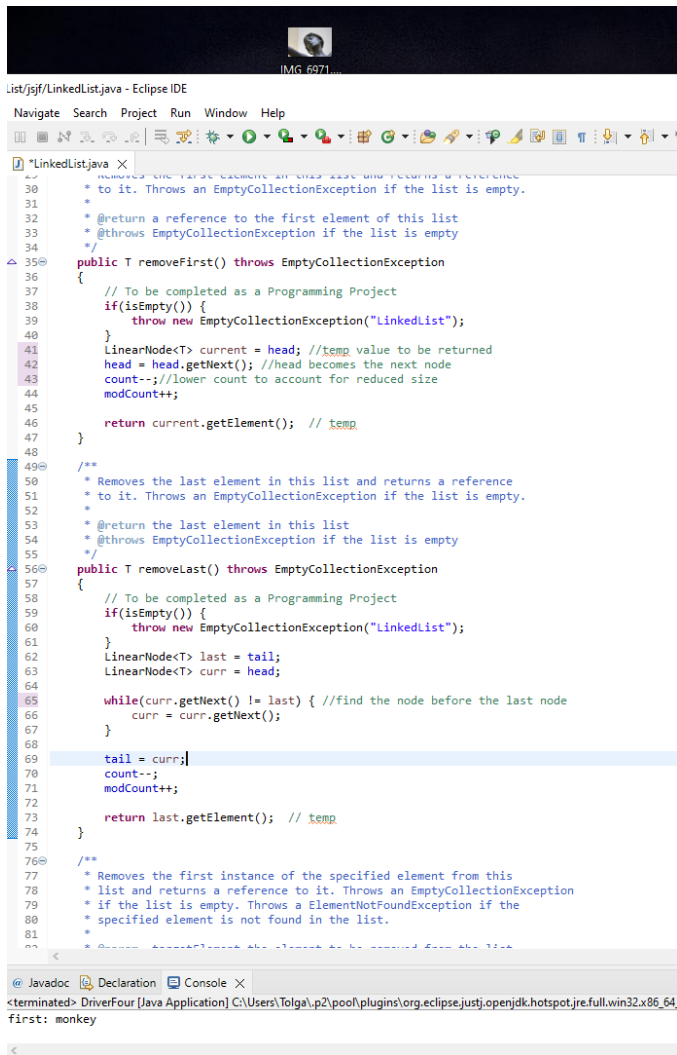
When we pop and then print the stack, we can notice that monkey is removed from the stack.

Now let me demonstrate how this works:

First Lets look at LinkStack

```
1 package isjf;
2
3 public class LinkStack<T> implements StackADT<T> {
4     LinkedUnorderedList<T> stack = new LinkedUnorderedList<T>();
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```

By using functions from the LinkedList and the LinkedUnorderedList, we can implement the methods of the LinkStack via encapsulation. Lets look at LinkedUnorderedList, LinkStack, and I will also show you LinkOrderedList (even though it is not necessary)



```
30  * Removes the first element in this list and returns a reference
31  * to it. Throws an EmptyCollectionException if the list is empty.
32  *
33  * @return a reference to the first element of this list
34  * @throws EmptyCollectionException if the list is empty
35  */
36  public T removeFirst() throws EmptyCollectionException
37  {
38  // To be completed as a Programming Project
39  if(isEmpty()) {
40  throw new EmptyCollectionException("LinkedList");
41  }
42  LinearNode<T> current = head; //temp value to be returned
43  head = head.getNext(); //head becomes the next node
44  count--; //lower count to account for reduced size
45  modCount++;
46  return current.getElement(); // temp
47  }
48
49  /**
50  * Removes the last element in this list and returns a reference
51  * to it. Throws an EmptyCollectionException if the list is empty.
52  *
53  * @return the last element in this list
54  * @throws EmptyCollectionException if the list is empty
55  */
56  public T removeLast() throws EmptyCollectionException
57  {
58  // To be completed as a Programming Project
59  if(isEmpty()) {
60  throw new EmptyCollectionException("LinkedList");
61  }
62  LinearNode<T> last = tail;
63  LinearNode<T> curr = head;
64
65  while(curr.getNext() != last) { //find the node before the last node
66  curr = curr.getNext();
67  }
68
69  tail = curr;
70  count--;
71  modCount++;
72  return last.getElement(); // temp
73  }
74
75  /**
76  * Removes the first instance of the specified element from this
77  * list and returns a reference to it. Throws an EmptyCollectionException
78  * if the list is empty. Throws a ElementNotFoundException if the
79  * specified element is not found in the list.
80  *
81  * @param element the element to be removed from the list
82  * @return a reference to the element to be removed from the list
83  * @throws EmptyCollectionException if the list is empty
84  * @throws ElementNotFoundException if the element is not found in the list
85  */
86  T removeElement(E element) throws EmptyCollectionException, ElementNotFoundException
87  {
88  // To be completed as a Programming Project
89  if(isEmpty()) {
90  throw new EmptyCollectionException("LinkedList");
91  }
92  LinearNode<T> current = head;
93  while(current != null) {
94  if(current.getElement().equals(element)) {
95  // Found the element to be removed
96  // Remove the element
97  if(current == head) {
98  head = current.getNext();
99  }
100  if(current == tail) {
101  tail = current.getPrevious();
102  }
103  current = current.getNext();
104  count--;
105  modCount++;
106  return current.getElement();
107  }
108  current = current.getNext();
109  }
110  return null;
111  }
```

Here you can see the RemoveFirst() function. It is used in the LinkStack in the pop() method. As you can see I have also completed the removeLast() function even though it is not needed for the LinkStack.

```
Navigate Search Project Run Window Help
LinkedList.java x
133 public T first() throws EmptyCollectionException
134 {
135     // To be completed as a Programming Project
136     if(isEmpty()) {
137         throw new EmptyCollectionException("LinkedList");
138     }
139     return head.getElement(); // temp
140 }
141
142
143 /**
144  * Returns the last element in this list without removing it.
145  *
146  * @return the last element in this list
147  * @throws EmptyCollectionException if the list is empty
148  */
149 public T last() throws EmptyCollectionException
150 {
151     // To be completed as a Programming Project
152     if(isEmpty()) {
153         throw new EmptyCollectionException("LinkedList");
154     }
155     return tail.getElement(); // temp
156 }
157
158
159 /**
160  * Returns true if the specified element is found in this list and
161  * false otherwise. Throws an EmptyCollectionException if the list
162  * is empty.
163  *
164  * @param targetElement the element that is sought in the list
165  * @return true if the element is found in this list
166  * @throws EmptyCollectionException if the list is empty
167  */
168 public boolean contains(T targetElement) throws EmptyCollectionException
169 {
170     // To be completed as a Programming Project
171     if(isEmpty()) {
172         throw new EmptyCollectionException("LinkedList");
173     }
174     int size = size();
175     LinearNode<T> curr = head;
176
177     for(int i = 0; i < size; i++) { //loop thru the list, if the target element is in the list, return true
178         if (targetElement == curr.getElement() ) {
179             return true;
180         }
181         curr = curr.getNext();
182     }
183 }
184
185
```

The first() function in the LinkedList class is very useful for the pop() and peek() function in the LinkStack. (I probably should have used the contains() function in the LinkedUnorderedList for the addAfter() function, but I just thought of that now!)

```

r Navigate Search Project Run Window Help
*LinkedList.java x
186     return false; // temp
187 }
188
189 /**
190  * Returns true if this list is empty and false otherwise.
191  *
192  * @return true if the list is empty, false otherwise
193  */
194 public boolean isEmpty()
195 {
196     // To be completed as a Programming Project
197     if(head != null) {
198         return false;
199     }
200     return true; // temp
201 }
202
203 /**
204  * Returns the number of elements in this list.
205  *
206  * @return the number of elements in the list
207  */
208 public int size()
209 {
210     // To be completed as a Programming Project
211
212     return count; // temp
213 }
214
215 /**
216  * Returns a string representation of this list.
217  *
218  * @return a string representation of the list
219  */
220 public String toString()
221 {
222     // To be completed as a Programming Project
223     if(isEmpty()) {
224         return "";
225     }
226
227     LinearNode<T> curr = head;
228     String result = "";
229     int size = size();
230
231     for(int i = 0; i < size; i++) { //loop thru the list, add the each nodes value to a string, return the string
232         result = (result + curr.getElement() + "\n";
233         curr = curr.getNext();
234     }
235
236     return result; // temp
237 }

```

@ Javadoc Declaration Console x

```

<terminated> DriverFour [Java Application] C:\Users\Tolga\.p2\pool\plugins\org.eclipse.justj.openjdk.hotspot.jre.full.win32.x86_64_17.0.2.v20220201-1208\jre\bin\javaw.exe (May 24, 2022, 12:33:33 AM - 1
first: monkey

```

The isEmpty, size, and toString functions in the LinkedList class are all used in the LinkStack class to find out if the stack is empty, find the size, and to print the stack.

Now lets look at the LinkUnorderedList:

```

27  /*
28  public void addToFront(T element)
29  {
30  // To be completed as a Programming Project
31  LinearNode<T> elementNode = new LinearNode(element);
32
33  if(isEmpty() == true) { //if there are no elements in the list, add the element to the head
34  head = elementNode;
35  }else {
36
37  elementNode.setNext(head); //set the new element to point to the head node, then make the head the new element node
38  head = elementNode;
39
40  }
41
42
43
44  //find tail
45  LinearNode<T> tailNode = head;
46  while(tailNode.getNext() != null) {
47  tailNode = tailNode.getNext();
48  }
49  tail = tailNode;
50
51
52  count++;
53  modCount++;
54  }
55
56  /**
57   * Adds the specified element to the rear of this list.
58   *
59   * @param element the element to be added to the list
60   */
61  public void addToRear(T element)
62  {
63  // To be completed as a Programming Project
64
65
66  LinearNode<T> elementNode = new LinearNode(element);
67
68  if(isEmpty() == true) {
69  head = elementNode;
70  }else {
71
72  tail.setNext(elementNode);
73  tail = elementNode;
74
75
76  }
77
78  //find tail
79  LinearNode<T> tailNode = head;

```

The addToFront and addToRear methods were both required to be completed as part of the programming project, however, ONLY THE addToFront() function was used for the LinkStack.

```

/**
 * Adds the specified element to this list after the given target.
 *
 * @param element the element to be added to this list
 * @param target the target element to be added after
 * @throws ElementNotFoundException if the target is not found
 */
public void addAfter(T element, T target)
{
    if(isEmpty())
        throw new EmptyCollectionException("LinkedList");
    // To be completed as a Programming Project
    int size = size();
    LinearNode<T> elementNode = new LinearNode(element);
    LinearNode<T> curr = head;
    int countNode = 1;
    String name = target.toString(); //name used for element not found exception

    while(curr != null && curr.getElement() != target) { //loop through the list to find the target
        curr = curr.getNext();
        countNode++;
    }

    if(countNode == 1) { //if the target is the head then add the element after the head and make the element point to the node that is after the head
        LinearNode<T> after = curr.getNext();
        elementNode.setNext(after);
        head.setNext(elementNode);
        count++;
        modCount++;
    }else if(countNode == size) { //if target is the tail, set the tail next to point to the element
        tail.setNext(elementNode);
        tail = elementNode;
        count++;
        modCount++;
    }else if(curr != null) { //if the target is not the head or not the tail, yet still exists within the list
        LinearNode<T> after = curr.getNext();
        elementNode.setNext(after);
        curr.setNext(elementNode);
        count++;
        modCount++;
    }else {
        throw new ElementNotFoundException(name); //target is not in the list
    }
}
}

```

The AddAfter() function was also required to be completed as part of the programming project, however it was not used for the LinkStack.

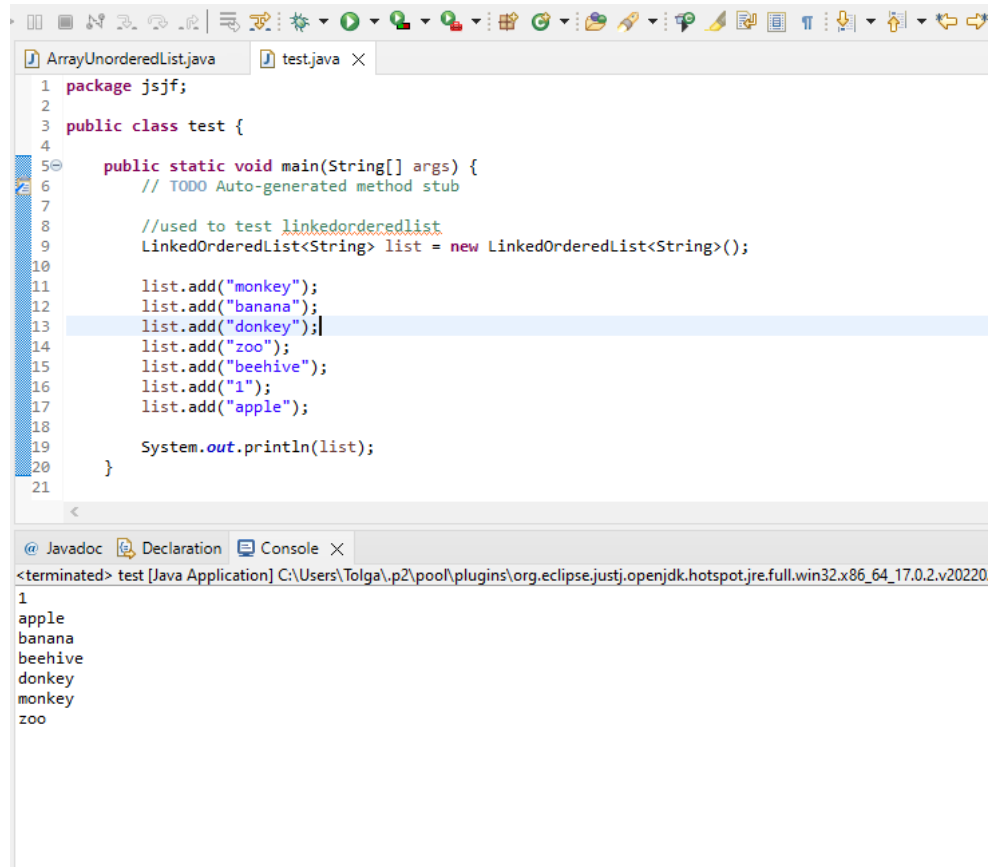
Now let me show you the HARDEST part of the assignment WHICH was not even used for the LinkStack!:

## THE LinkOrderedListClass!

```
st/jgf/LinkOrderedList.java - Eclipse IDE
Navigate Search Project Run Window Help
LinkOrderedList.java
28 * @param element the element to be added to this list
29 * @throws NonComparableElementException if the element is not comparable
30 */
31 public void add(T element)
32 {
33     // To be completed as a Programming Project
34     if (!(element instanceof Comparable))
35         throw new NonComparableElementException("OrderedList");
36     Comparable<T> comparableElement = (Comparable<T>)element;
37     LinearNode<T> elementNode = new LinearNode<T>(element);
38
39
40
41     if (isEmpty() == true) {
42         head = elementNode;
43     }
44
45     else {
46         LinearNode<T> curr = head;
47         LinearNode<T> prev = head;
48
49
50
51         //If there is only one element in the list then we just compare that element and swap positions in the list as needed
52         if (curr.getNext() == null) {
53             if (comparableElement.compareTo(curr.getElement()) > 0) {
54                 curr.setNext(elementNode);
55             }
56             else {
57                 elementNode.setNext(curr);
58                 head = elementNode;
59             }
60         }
61         //If there are more than one element in the list
62         while (curr.getNext() != null && comparableElement.compareTo(curr.getElement()) > 0) { //travel through the list until we find the correct spot where we can swap
63             curr = curr.getNext();
64         }
65
66         if (comparableElement.compareTo(curr.getElement()) > 0) { //if the new element belongs after the current element, make the new element point to the node that is after curr.
67             LinearNode<T> after = curr.getNext();
68             curr.setNext(elementNode);
69             elementNode.setNext(after); //thus the order is curr -> new element -> node that was previously after curr.
70         }
71         //If the new element belongs before the current node
72         //find the previous node
73         if (prev != curr) { //if the prev and curr aren't the same node, loop through the list to find the node that is before curr
74             while (prev.getNext() != curr) {
75                 prev = prev.getNext();
76             }
77             //prev is now the node that is before curr
78             prev.setNext(elementNode); //sandwich the new element between prev and curr
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```



The add() function for this class was by far the hardest part. Below is a test driver used to test out the ListOrderedList because I want to show you the extent of how it works:



The screenshot shows an IDE with two windows. The top window, titled 'test.java', contains the following Java code:

```
1 package jsjf;
2
3 public class test {
4
5     public static void main(String[] args) {
6         // TODO Auto-generated method stub
7
8         //used to test linkedorderedlist
9         LinkedListOrderedList<String> list = new LinkedListOrderedList<String>();
10
11         list.add("monkey");
12         list.add("banana");
13         list.add("donkey");
14         list.add("zoo");
15         list.add("beehive");
16         list.add("1");
17         list.add("apple");
18
19         System.out.println(list);
20     }
21 }
```

The bottom window, titled 'Console', shows the output of the program:

```
<terminated> test [Java Application] C:\Users\Tolga\.p2\pool\plugins\org.eclipse.justj.openjdk.hotspot.jre.full.win32.x86_64_17.0.2.v20220
1
apple
banana
beehive
donkey
monkey
zoo
```

As you can see it places the values in the List where they belong.

## 2. Stack using ArrayList

```
t/jsjf/DriverTwo.java - Eclipse IDE
Navigate Search Project Run Window Help
driverOne.java driverThree.java DriverFour.java DriverTwo.java X
1 package jsjf;
2
3 public class DriverTwo {
4
5
6
7
8     public static void main(String[] args) {
9         ArrayStack<String> list = new ArrayStack<String>();
10
11         list.push("tolga");
12         list.push("olcay");
13         list.push("zoo");
14         list.push("beehive");
15         list.push("1");
16         list.push("2");
17         list.push("monkey");
18         System.out.println("peek: " + list.peek() + "\n");
19
20         list.pop();
21
22         System.out.println(list);
23     }
24
25
@ Javadoc Declaration Console X
<terminated> DriverTwo [Java Application] C:\Users\Tolga\.p2\pool\plugins\org.eclipse.justj.openjdk.hotspot.jr
peek: monkey
2
1
beehive
zoo
olcay
tolga
```

As you can see, this driver is very similar to driver one. The main difference is that instead of creating a LinkStack, we created an ArrayStack! As you can see, monkey is not there when we print the stack because, it was popped.

Now let me demonstrate how this works:

Lets look at the ArrayStack:

```
rrayStack.java - Eclipse IDE
jate Search Project Run Window Help
driverOne.java driverThree.java DriverFour.java DriverTwo.java LinkStack
1 package jsjf;
2
3 public class ArrayStack<T> implements StackADT<T> {
4
5
6     ArrayUnorderedList<T> stack = new ArrayUnorderedList<T>();
7
8
9     @Override
10    public void push(T element) {
11        // TODO Auto-generated method stub
12        stack.addToFront(element);
13    }
14
15    @Override
16    public T pop() {
17        // TODO Auto-generated method stub
18        T result = stack.first();
19        stack.removeFirst();
20        return result;
21    }
22
23    @Override
24    public T peek() {
25        // TODO Auto-generated method stub
26        T result = stack.first();
27        return result;
28    }
29
30    @Override
31    public boolean isEmpty() {
32        // TODO Auto-generated method stub
33        boolean result = stack.isEmpty();
34        return result;
35    }
36
37    @Override
38    public int size() {
39        // TODO Auto-generated method stub
40        int size = stack.size();
41        return size;
42
43    }
44
45
46    public String toString() {
47        String result = stack.toString();
48        return result;
49    }
50
51
```

We use functions from the ArrayList and ArrayUnoredredList classes in our methods. As you can see, these methods don't really show much how these work because it is encapsulated by the ArrayUnorderedList class which extends the ArrayList Class. I will be showing you how both of those classes work.

## ArrayUnorderedList extends the ArrayList class and is part of the programming Project

```
ArrayList.java - Eclipse IDE
r Navigate Search Project Run Window Help
ArrayUnorderedList.java X
35     * @param element the element to be added to the front of the list
36     */
37     public void addToFront(T element)
38     {
39
40
41
42         if (size() == list.length)
43             expandCapacity();
44
45         int scan = 0;
46
47         // shift existing elements up one
48         for (int shift = rear; shift > scan; shift--)
49             list[shift] = list[shift - 1];
50
51         // insert element
52         list[scan] = element;
53         rear++;
54         modCount++;
55
56
57         // To be completed as a Programming Project
58     }
59
60     /**
61     * Adds the specified element to the rear of this list.
62     *
63     * @param element the element to be added to the list
64     */
65     public void addToRear(T element)
66     {
67         // To be completed as a Programming Project
68
69
70
71
72         if (size() == list.length)
73             expandCapacity();
74         if (isEmpty()) {
75             list[rear] = element;
76             rear++;
77             modCount++;
78         }
79         else {
80             list[rear] = element;
81             rear++;
82             modCount++;
83         }
84     }
85 }
86
```

Our ArrayStack uses the addToFront method to add our objects to the front of the stack. This other functions from the ArrayUnorderedList and ArrayStack use methods from the ArrayList class:

```
ArrayList.java X
Search Project Run Window Help
ArrayList.java X
protected void expandCapacity()
{
    // To be completed as a Programming Project
    list = Arrays.copyOf(list, list.length * 2); //double the size by creating a copy with twice the length
}

/**
 * Removes and returns the last element in this list.
 *
 * @return the last element in the list
 * @throws EmptyCollectionException if the element is not in the list
 */
public T removeLast() throws EmptyCollectionException
{
    // To be completed as a Programming Project
    if (isEmpty()) {
        throw new EmptyCollectionException("ArrayList");
    }
    T result;
    rear--; //move the rear back to account for the size
    result = list[rear];
    list[rear] = null;
    modCount++;

    return result;
}

/**
 * Removes and returns the first element in this list.
 *
 * @return the first element in the list
 * @throws EmptyCollectionException if the element is not in the list
 */
public T removeFirst() throws EmptyCollectionException
{
    // To be completed as a Programming Project
    if (isEmpty()) {
        throw new EmptyCollectionException("ArrayList");
    }
    T result = list[0];
    rear--;
    for (int i = 0; i < rear; i++) { //loop thru the list to advance all the rest of the elements by one to make room for the new element in the front
        list[i] = list[i+1];
    }
    list[rear] = null;
    modCount++;

    return result;
}
}
```

For example, the `expandCapacity` function is used by functions which add items to the list, so that the list does not run out of space. If you noticed, `removeFirst()` is used in the `pop()` function in `ArrayStack`.

```
/**
 * Returns a reference to the element at the front of this list.
 * The element is not removed from the list. Throws an
 * EmptyCollectionException if the list is empty.
 *
 * @return a reference to the first element in the list
 * @throws EmptyCollectionException if the list is empty
 */
public T first() throws EmptyCollectionException
{
    // To be completed as a Programming Project
    if(isEmpty()) {
        throw new EmptyCollectionException("ArrayList");
    }

    return list[0]; // temp
}

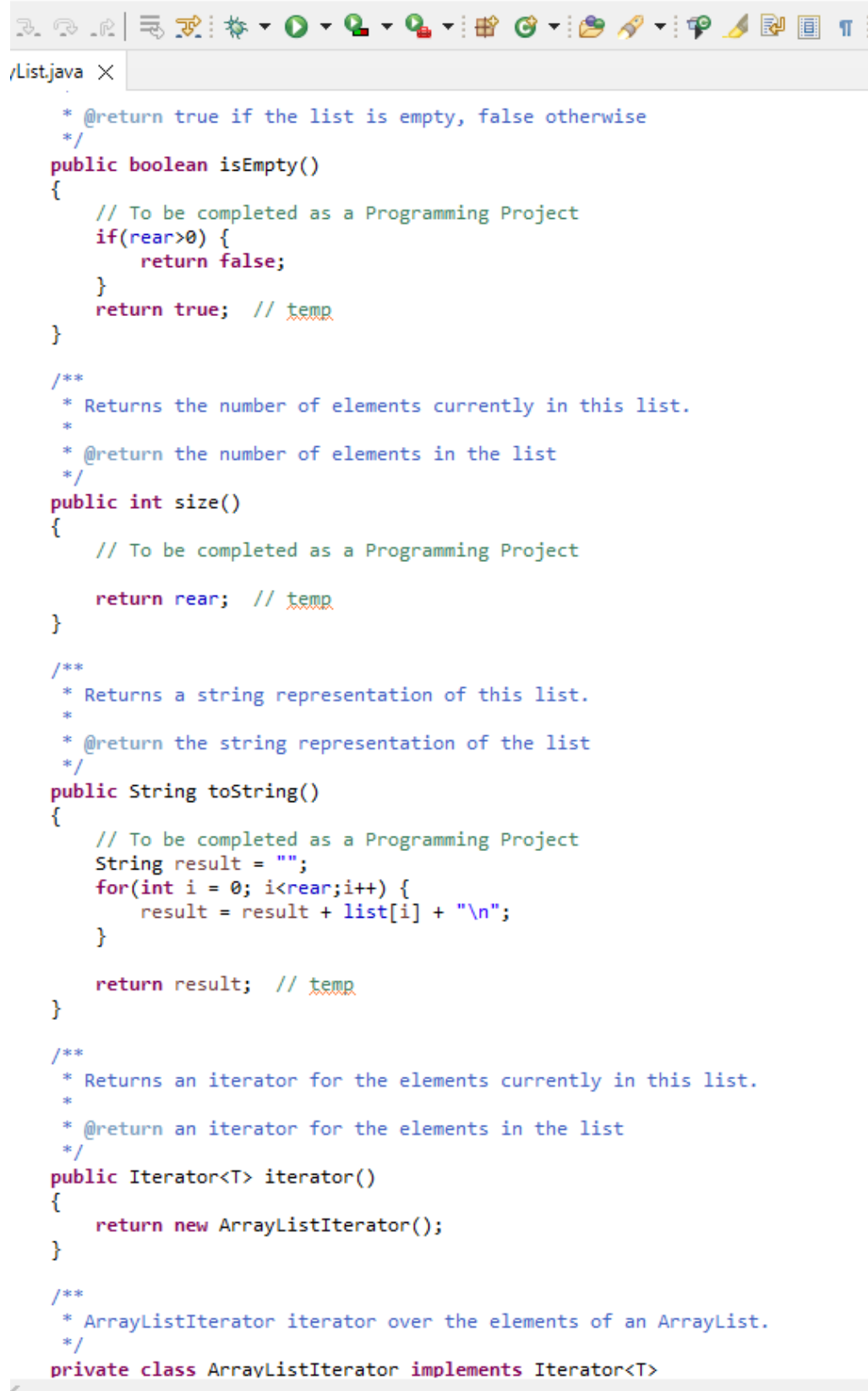
/**
 * Returns a reference to the element at the rear of this list.
 * The element is not removed from the list. Throws an
 * EmptyCollectionException if the list is empty.
 *
 * @return a reference to the last element of this list
 * @throws EmptyCollectionException if the list is empty
 */
public T last() throws EmptyCollectionException
{
    // To be completed as a Programming Project
    if(isEmpty()) {
        throw new EmptyCollectionException("ArrayList");
    }

    return list[rear-1]; // temp
}

/**
 * Returns true if this list contains the specified element.
 *
 * @param target the target element
 * @return true if the target is in the list, false otherwise
 */
public boolean contains(T target)
{
    return (find(target) != NOT_FOUND);
}
```

---

The `first()` function is used in the `peek()`, and also the `pop()` method in the `ArrayStack`, allowing us to save the value which is in the top of the stack and return.



```
.
 * @return true if the list is empty, false otherwise
 */
public boolean isEmpty()
{
    // To be completed as a Programming Project
    if(rear>0) {
        return false;
    }
    return true; // temp
}

/**
 * Returns the number of elements currently in this list.
 *
 * @return the number of elements in the list
 */
public int size()
{
    // To be completed as a Programming Project

    return rear; // temp
}

/**
 * Returns a string representation of this list.
 *
 * @return the string representation of the list
 */
public String toString()
{
    // To be completed as a Programming Project
    String result = "";
    for(int i = 0; i<rear;i++) {
        result = result + list[i] + "\n";
    }

    return result; // temp
}

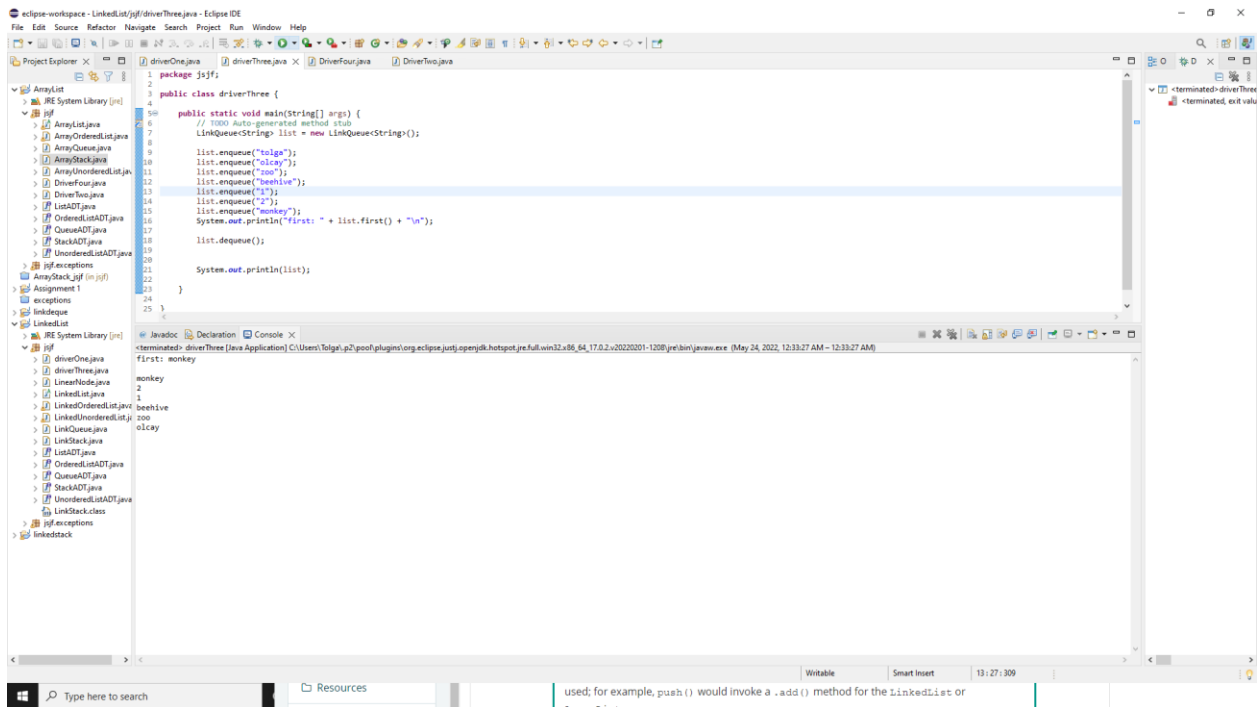
/**
 * Returns an iterator for the elements currently in this list.
 *
 * @return an iterator for the elements in the list
 */
public Iterator<T> iterator()
{
    return new ArrayListIterator();
}

/**
 * ArrayListIterator iterator over the elements of an ArrayList.
 */
private class ArrayListIterator implements Iterator<T>
```

The isEmpty and the toString functions from ArrayList are used in the ArrayStack to check the size of the stack and to print the stack.

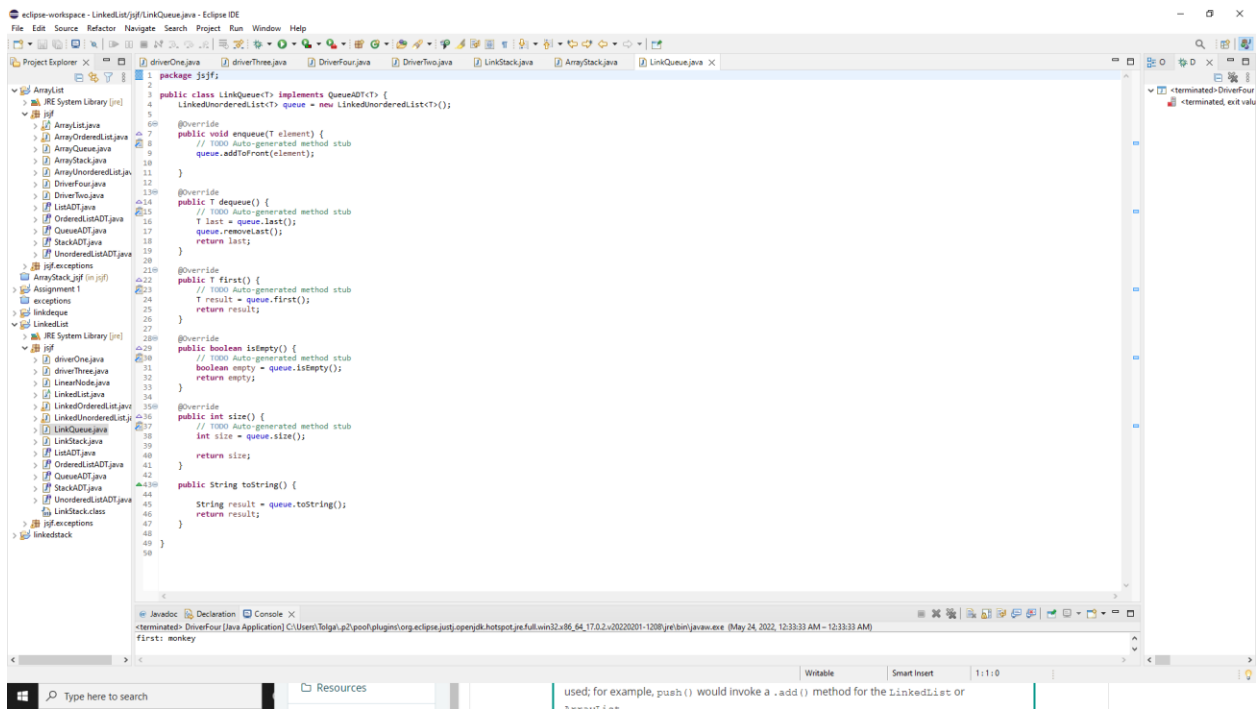
Now you understand how we can use the ArrayList and ArrayUnorderedList to create an ArrayStack.

### 3. Linked Queue



As you can see with our linkQueue driver, the string “tolga” is no longer in the queue when we print the queue. That’s because “tolga” was the first string that was enqueued, so when we dequeue(), tolga is removed from the queue.

Now, Lets view the LinkQueue class.

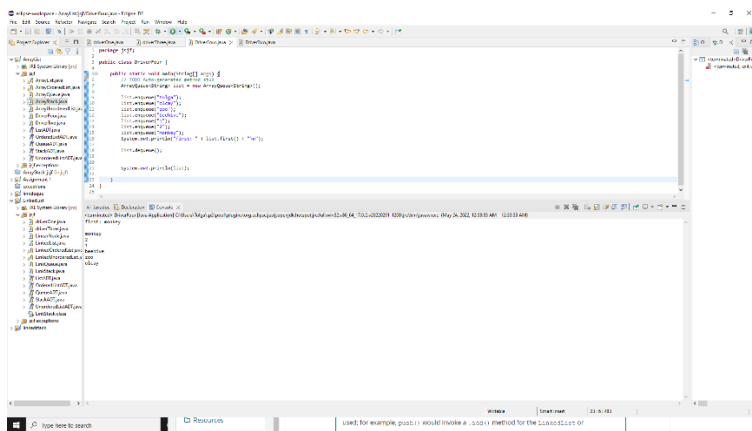


As you can see, just like LinkStack, LinkQueue uses functions from the LinkList and the LinkUnorderedList classes. I am able to re-use these classes for my LinkStack and my LinkQueue via encapsulation.

As you can see when we dequeue, instead of using the removeFirst() function like we did for our stack, we instead do removeLast(); since by doing so, we are removing the first value added to the list.

Since I already showed you how the LinkedList and the LinkUnorderedList classes work, I will not be pasting the screenshots again. (just scroll up)

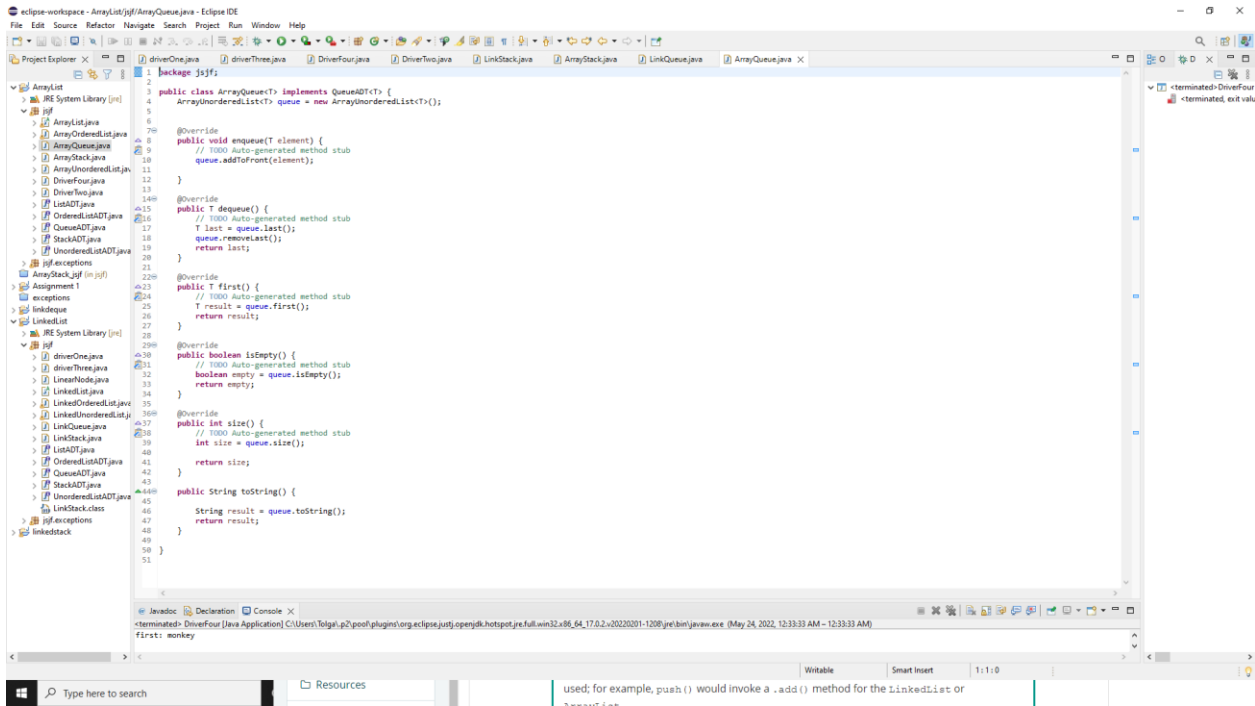
#### 4. ArrayQueue





As you can see, driver Four creates a Arrayqueue and pushes strings onto the queue. Just like driver three, we can notice that the string “tolga” is not present when we print the queue. That’s because it was the first value to be enqueued, thus making it the first value to be dequeued.

Now lets look at the ArrayQueue class



As you can see, this is very similar to the LinkQueue class, however the difference is that it creates an ArrayList and uses functions from the arrayList and ArrayUnorderedList to create the ArrayStack.

Since we already went into detail on how ArrayList and ArrayUnorderedList classes work, you can scroll up and compare the methods that are used for the queue.

You now have an idea of how ArrayQueue, LinkQueue, ArrayStack, and LinkStack work by implanting LinkedLists, Linkunorderedlists, and ArrayLists and ArrayUnorderedLists!