CMSC 206: Data Structures
Lab 7: Linked Lists & Iterators

For this lab, you will be writing an iterator for the `SingleLinkedList` class, as adapted from our textbook. You will then use this iterator to conduct a few performance experiments comparing `KWArrayList` and `SingleLinkedList`.

Part I.

1. Make a new project for this lab. Copy the `SingleLinkedList` and `KWArrayList` classes into it.

2. In the `SingleLinkedList` class, make an private `SLLIterator` class. Here is how to start it (the bold part is what you have to write; the rest is just for context):

```
public class SingleLinkedList<E>
{
     private static class Node<E> { … }

     private static class SLLIterator<E>
       implements Iterator<E>
     {

     }

     private Node<E> head = null;
     …
}
```

   Although in homework, exams, etc., you won't have to write classes inside of others, we need to do so here in order to access the `Node` class within `SingleLinkedList`.

3. The definition above will not compile, because the concrete `SLLIterator` inherits abstract methods from `Iterator`. Look up the `Iterator` documentation. (It's in `java.util`.) You will have to override the methods `hasNext` and `next` to get this to work.

4. Your iterator will need to store information to keep track of where in the list it is. For an array, storing an index is appropriate, but doing so for a linked list would be inefficient (every access of the list would require walking down the list from the head). So, we will use a `Node` field in the `SLLIterator` class:

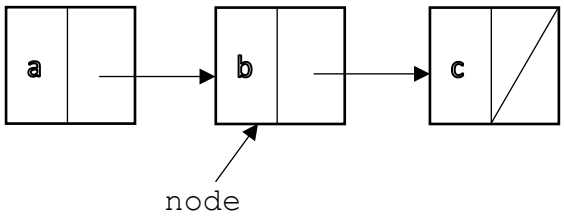
```
     private Node<E> node;
```

5. Write a constructor as follows:

```
/** Creates this iterator at the beginning of the
 *  given list
 *  @param list The list to iterate down
 */
private SLLIterator(SingleLinkedList<E> list)
{
     // you write the code here
}
```

   This must initialize the one field of your `SLLIterator` class to refer to the head of the provided list. It's only one line of code!

6. The `node` field of `SLLIterator` will refer to the node whose data will next be returned by the `next` method.



   In the scenario pictured here, `hasNext()` should return `true`, and `next()` should return `"b"` while advancing the `node` to refer to the node containing `"c"`.

   What will `node` be when it's at the end of the list (i.e., there are no more elements to return)?

7. Write the `hasNext()` and `next()` methods for `SLLIterator`. Make sure that the `next()` method throws a `new NoSuchElementException` if `next()` is called when there are no more elements. (If you don't handle this explicitly, your method will likely throw a `NullPointerException` in the no-more-elements case.)

8. Now, you need to make it possible for a user to obtain this iterator. Add the following method to the `SingleLinkedList` class (not the `SLLIterator` class!):

```
/** @return an iterator over this list */
public Iterator<E> iterator()
```

   This method should be about one line, and it will use the keyword `this`. Note that the return type is `Iterator<E>`, even though you will return a `SLLIterator<E>` object. This is OK because `SLLIterator` inherits from `Iterator`.

9. In order for the `SingleLinkedList` class to work with the "foreach" loop, it needs to implement the `Iterable` interface. Modify `SingleLinkedList` to implement this interface by changing the header line to look like this:

```
public class SingleLinkedList<E>
  implements Iterable<E>
```

   You shouldn't need to make any more changes, because the `Iterable` interface defines only the `iterator` method, which you've already written.

10. Make a separate `Main` class, with the following `main` method:

```
public class Main
{
     public static void main(String[] args)
     {
          SingleLinkedList<String> list =
            new SingleLinkedList<>();

          list.addFirst("snow");
          list.addFirst("it");
          list.addFirst("let");

          for(String s : list)
          {
               System.out.println(s);
          }
     }
}
```

   This uses the fact that the type of `list` is something that implements `Iterable` to call the `iterator` method and then uses `hasNext` and `next` to iterate through the list.

   Run this method and confirm it works.

   Why does it use `addFirst` to build up the list instead of `add`?

11. Add `System.out.println` statements to `iterator`, `hasNext`, and `next` to demonstrate that the "foreach" loop really does call these methods.

Part II.

Similar to how we did so in class, you will measure the performance of the two collections you have.

12. Add a field to the `SingleLinkedList` class to track how many times the `node = node.next` line in `getNode` is called. That field should start out at 0 and be incremented every time the loop in `getNode` is run. (Note that this loop is the *only* loop in `SingleLinkedList`.) You will also have to add a getter for this field so that a `main` method can print it.

13. Write a new `main` method (in a new class) that builds a list by successively `add`ing new elements to the end. Have it build lists of length 10, 20, 40, and 80. For each list, print out how many times the `node = node.next` line in `getNode` was called. How does this growth depend on the length of the list?

14. Change your `main` method to use `addFirst` instead of `add`. (This will build the lists in reverse order.) How many times does the loop get run now?

15. Change your `main` method to use `KWArrayList` instead of `SingleLinkedList`. Find the loops in `KWArrayList` and track how many times they run. You'll also have to change `addFirst` to use the two-parameter `add` method of `KWArrayList`. How many times do the loops run now?