CS 61B Homework 4
Due noon Wednesday, February 26

This homework will give you practice with writing doubly-linked lists and using subclasses. This is an individual assignment; you may not share code with other students.

Copy the Homework 4 directory by doing the following, starting from your home directory.

```
cp -r ~cs61b/hw/hw4 .
cd hw4
```

When you did Project 1, you probably noticed that the SList ADT doesn't allow you to walk through an SList and process each node as you go. Either you must violate the ADT by manipulating the SListNode pointers directly from your RunLengthEncoding class, or you must use the slow nth() method to access each successive element, thereby obtaining a toPixImage() method that runs in time proportional to N^2, where N is the size of the list. Because we didn't know about Java packages, we were unable to develop a really satisfying list ADT.

In this homework, you will implement a doubly-linked list ADT that allows an application to holdlist nodes and hop from node to node quickly. How do we make the list an ADT if applications can get access to list nodes? It's easy: we put all the list code in a package called "list", and we declare the fields of DListNode protected--except the "item" field, which is public. Applications can't access the "prev" or "next" fields of a DListNode, so they can't violate any DList invariants.

I've chosen to make the "item" field public because it doesn't take part in any invariants, so it does no harm to make it public. Applications may read and change "item" as they please. In fact, no method is provided for reading the "item" field indirectly.

Part I (6 points)
---

list/DList.java contains a skeleton of a doubly-linked list class. Fill in the method implementations.

Your DList should be circularly-linked, and its head should be a sentinel node (which holds no item) as described in Lecture 8. An empty DList is signified by a sentinel node that points to itself. Some DList methods return DListNodes; they should NEVER return the sentinel under any circumstances. Your DList should satisfy the following invariants.

1) For any DList d, d.head != null.
2) For any DListNode x in a DList, x.next != null.
3) For any DListNode x in a DList, x.prev != null.
4) For any DListNode x in a DList, if x.next == y, then y.prev == x.
5) For any DListNode x in a DList, if x.prev == y, then y.next == x.
6) For any DList d, the field d.size is the number of DListNodes, NOT COUNTING the sentinel, that can be accessed from the sentinel (d.head) by a sequence of "next" references.

The DList class includes a newNode() method whose sole purpose is to call the DListNode constructor. All of your methods that insert a new node should call this method; they should not call the DListNode constructor directly. This will help minimize the number of methods you need to override in Part III.

Do not change any of the method prototypes; as usual, our test code expects you to adhere to the interface we provide. Do not change the fields of DList or DListNode. You may add private/package helper methods as you please.

You are welcome to create a main() method with test code. It will not be graded. We'll be testing your DList class, so you should too.

A quirk of Java is that you must compile and run your code from outside the list/ directory by changing to your hw4 directory and typing the following.

```
javac -g list/*.java
java list.DList
```

Part II (1 point)

Our ADT is not as well protected as we would like. There are several ways by which a hostile (or stupid) application can corrupt our DList (i.e., make it violate an invariant) through method calls alone. Describe one in a text file named GRADER (which will be submitted with your code). Assume that the application is NOT in the list package (which would be a remarkably inappropriate place to put an application).

At the top of the GRADER file, include your name and cs61b login ID.

Part III (3 points)

Implement a "lockable" doubly-linked list ADT: a list in which any node can be "locked." A locked node can never be removed from its list. Any attempt to remove a locked node has no effect (not even an error message). Your locked list classes should be in the list package alongside DList and DListNode.

First, define a LockDListNode class that extends DListNode and carries information about whether it has been locked. LockDListNodes are not locked when they are first created. Your LockDListNode constructor(s) should call a DListNode constructor to avoid code duplication.

Second, define a LockDList class that extends DList and includes an additional method

```
public void lockNode(DListNode node) { ... }
```

that permanently locks "node".

DO NOT CHANGE THE SIGNATURE OF lockNode(). The parameter really is supposed to be of static type DListNode, not LockDListNode. I chose this signature for the convenience of the users of your LockDList. It saves them the nuisance of having to cast every node they want to lock. Instead, it's your job to take care of that cast (from DListNode to LockDListNode).

Your LockDList class should override just enough methods to ensure that
(1) LockDListNodes are always used in LockDLists (instead of DListNodes), and
(2) locked nodes cannot be removed from a list.

WARNING: To override a method, you must write a new method in the subclass with EXACTLY the same prototype. You can't change a parameter's type to a subclass. Overriding WON'T WORK if you do that.

Your overriding methods should include calls to the overridden superclass methods whenever it makes sense to do so. Unnecessary code duplication will be penalized.

Again, I recommend you write tests for your code.

```
Submitting your solution
------------------------
Change (cd) to your hw4 directory, which should contain a file called GRADER
and the list directory.  The list directory should contain DList.java,
DListNode.java, LockDList.java, LockDListNode.java, and any other .java files
required by those classes.  Make sure your code compiles and your tests run
correctly on the _lab_ machines just before you submit.

Your GRADER file should include your name, login, and answer to Part II.
Note that it's just called GRADER, with no extension.  "submit" won't take it
if you name it GRADER.txt or add some other extension.  It won't take "grader"
either; it's gotta be all-caps.

From your hw4 directory, type "submit hw4".  (Note that "submit" will not work
if you are inside the list directory!)  After submitting, if you realize your
solution is flawed, you may fix it and submit again.  You may submit as often
as you like.  Only the last version you submit before the deadline will be
graded.
```