Note to the 2017 class: the exam was a week later in 2014 so it covered lab 4, in which you will implement "iterators". There will be nothing about iterators on next week's exam.

CS 151
Exam 1
October 8, 2014

There are 7 questions with 100 possible points. Don't forget to sign the Honor Pledge at the end.

1. [10 points] Here is the Fisher-Yates algorithm for shuffling the entries of an array. If the random number generator is good this will give every possible ordering of the array, with each ordering equally likely.

```
public static void shuffle(int [] A) {
      Random rand = new Random();
      for (int i = A.length-1; i > 0; i--) {
            int k = rand.nextInt(i+1);
            int temp = A[i];
            A[i] = A[k];
            A[k] = temp;
      }
}
```

Give a Big-Oh estimate of the worst-case running time of this algorithm on an array of size n.

2. [20 points] Suppose you need to create a Stack of ints and you decide to do it with a linked structure.

   a) Draw a picture of your stack after you push data elements 1 and then 3. Include in your picture any labels you refer to in your code.

   b) Give code for methods

      void push(int x)

      int pop( )

   You can make any assumptions you want about the Node class for your structure. The pop method should throw an EmptyStackException if you try to pop an empty stack.

3. [15 points] Suppose you have a rectangular array A of ints with 6 rows and 6 columnns. Write a method

    ArrayList<Integer> neighbors(int row, int col)

that returns a list of the data values in the neighboring cells. Note that the potential neighbors are at locations (row-1, col), (row, col-1), (row+1, col), and (row, col+1). For example, if A is the array

row\col	0	1	2	3	4	5
0	23	34	12	8	5	7
1	9	14	23	11	32	17
2	5	4	33	2	12	66
3	3	42	87	33	15	27
4	33	2	22	16	34	33
5	23	21	5	54	38	31

then neighbors(0, 3) would return a list with data {12, 11, 5}

4. [10 points] Interfaces and Abstract Classes are two different ways to describe functionality that needs to be implemented in a class. When should you use an interface and when should you use an abstract class? You can answer this in two sentences; don't write a lengthy essay.

5. [15 points] Here is a new operation with lists. Method increment(L) works with lists of integers by adding 1 to the value of each element. If L is a list with values {4, 8, 10}, increment(L) changes those values to {5, 9, 11}. Give Big-Oh estimates for the time it takes to run increment(L) on

   i) An ArrayList of size n using list methods L.get(i) and L.set(i, e)

   ii) A LinkedList of size n using list methods L.get(i) and L.set(i, e)

   iii) A LinkedList of size n with an iterator, using the iterator's next( ) and set(e) methods.

6. [15 points] Here is a complete Java program with a curious recursive function:

```
public class Foobar {

	public static int H(int n) {
		if (n == 0)
			return 0;
		else if (n == 1)
			return 1;
		else if (n%2 == 1) // that is, if n is odd
			return H(n+1) + H(n-1);
		else
			return 2*H(n/2);
	}

	public static void main(String[] args) {
		System.out.println( H(10) );

	}
```

Use dynamic programming to rewrite this function so it is more efficient. If you should happen to use an array for this, say (in English or code) how it is initialized. The largest value of n I will call H with is 100.

7. [15 points] You implemented iterators in Lab 4. Can you use them?
   a) Use an iterator to write method

      public boolean isSorted(LinkedList<Integer> L)

   Naturally, this method returns true if L is sorted – each element is greater than or equal to the previous number.

   b) Why would we use an iterator for this method rather than the get(i) LinkedList method?

This won't get you any extra credit, but if you are done early here's something to do. The worst algorithm I know that actually works is the "VegasSort" for an array. Use the Fisher-Yates algorithm (Question 1) to shuffle the array. Test to see if it is sorted. If not, continue shuffling until it is sorted. What is the worst-case running time of this algorithm on an array of size n?

Please write and sign the Honor Pledge when you are finished with the exam.