CSE 331 Spring 2021 Example Final Exam

Name _____________________ Solution _____________________

The exam should only take about 1 hour.

Score: _________________ / 60

1. _____________ / 12
2. _____________ / 10
3. _____________ / 10
4. _____________ / 10
5. _____________ / 10
6. _____________ / 8
Problem 1 (Reasoning)

Fill in an implementation of the method runLengthEncode on the next page. It takes as input a string, str, an array of characters, chars, and an array of ints, lens. You can assume the string and both arrays are of length at least n. You can assume that str is non-empty and that it does not contain the character '\0'.

Your method will write its output into the arrays chars and lens, and it should return a number t such that (after returning) str = chars[0] * lens[0] + ... + chars[t-1] * lens[t-1], where a char * int means a string containing that many copies of the char. For example, if str = “aaabbcccccaadd”, it would return t = 5 and leave chars[0..4] = [a, b, c, a, d] and lens[0..4] = [3, 2, 4, 2, 3].

The invariant for the loop is already provided. Do not add any additional loops.

You do not need to turn in a complete proof of correctness, but you should complete one since your code will be graded on correctness.

(Continued on the next page...)
```java
{{ P: 0 < n <= str.length, chars.length, lens.length }}
int runLengthEncode(String str, int n, char[] chars, int[] lens) {

    int i = 0;
    int j = -1;
    char cur = '\0';

    {{ Inv: P and str[0..i-1] = chars[0] * lens[0] + ... + chars[j] * lens[j] and
        chars[0] != chars[1], ..., chars[j-1] != chars[j] and
        (i = 0 or cur = str[i-1]) }}

    while (i != n) {
        if (str.charAt(i) == chr) {
            lens[j] = lens[j] + 1;
        } else {
            j = j + 1
            cur = str.charAt(i);
            chars[j] = cur;
            lens[j] = 1;
        }
        i = i + 1;
    }

    {{ str[0..n-1] = chars[0] * lens[0] + ... + chars[j] * lens[j] and
        chars[0] != chars[1], ..., chars[j-1] != chars[j]]}}
    return j+1;
}
```
Problem 2 (Testing)

Describe three test cases for the runLengthEncode method on the previous pages. The three tests should fall into different subdomains, i.e., they should be from subsets of the input where the expected or actual behavior is fundamentally different.

1. **Input:** str = __________"abc"____________ and n = _____3______
   **Output:** returns ______3_______
   chars starts with ____________ ['a', 'b', 'c'] __________
   lens starts with ____________ [1, 1, 1] __________

2. **Input:** str = __________ “aabbccc” __________ and n = _____6______
   **Output:** returns ______3_______
   chars starts with ____________ ['a', 'b', 'c'] __________
   lens starts with ____________ [2, 3, 2] __________

   If it's not obvious, why is this testing a different behavior\(^1\) from the case above?
   
   Testing cases where characters are repeated

3. **Input:** str = __________ "abc" __________ and n = _____2______
   **Output:** returns ______2_______
   chars starts with ____________ ['a', 'b'] __________
   lens starts with ____________ [1, 1] __________

   If it's not obvious, why is this testing a different behavior\(^1\) from the cases above?
   
   Testing cases where not all characters in str should be examined.

\(^1\) You can define behavior, e.g., in terms of expected (black box) or actual (clear box) execution equivalence using either implementation of runLengthEncode.
Problem 3 (ADTs)

Suppose that we created a CharList ADT whose abstract value is a string but whose concrete representation was the run-length encoding used in the previous problems:

```java
/** Represents an immutable sequence of characters like "abc" or "". */
class CharList {
    private char[] chars;
    private int[] lens;
    private int count;  // number of entries used in above arrays
    ...

    // Note: count corresponds to the return value of runLengthEncode.

What would the representation invariant be for this ADT?

chars != null and lens != null and 0 <= count <= chars.length, lens.length and chars[i-1] != chars[i] for i in 1 .. count-1

What would the abstraction function be for this ADT?


Fill in the implementation of the following method:

```java
public void checkRep() {
    assert chars != null;
    assert lens != null;
    assert 0 <= count;
    assert count <= chars.length;
    assert count <= lens.length;
}
```

While CharList uses the same representation as the runLengthEncode methods from before, you cannot use those methods to define your RI or AF here. You should define both directly in terms of the fields, as usual.
Problem 4 (Reasoning II)

Fill in the implementation of the following method:

```java
/** Returns the abstract value as a string. */
public String toString() {
    StringBuilder buf = new StringBuilder();
    for (int i = 0; i < count; i++) {
        for (int j = 0; j < lens[i]; j++) {
            buf.append(chars[i]);
        }
    }
    return buf.toString();
}
```

Fill in the implementation of the following method (include the loop invariant):

```java
/** @return Length of the list. */
public int size() {
    int s = 0;
    // s = length of chars[0]*lens[0] + ... + chars[i-1]*lens[i-1]
    for (int i = 0; i < count; i++) {
        s += lens[i];
    }
    return s;
}
```
Problem 5 (Testing II)

Describe three test cases for the CharList ADT defined on the previous pages. Each case should be described by specifying the state of the fields of CharList. The three tests should fall into different subdomains, i.e., they should be from subsets of the input where the expected or actual behavior is fundamentally different.

1. Setup: 
   chars = ['a', 'b', 'c'] 
   lens = [1, 1, 1] 
   count = 3

   Outputs: 
   toString() returns "abc"
   size() returns 3

2. Setup: 
   chars = ['a', 'c'] 
   lens = [2, 1] 
   count = 2

   Outputs: 
   toString() returns "aac"
   size() returns 3

If it’s not obvious, why is this testing a different behavior from the case above?

   Tests a case where characters are repeated.

3. Setup: 
   chars = [] 
   lens = [] 
   count = 0

   Outputs: 
   toString() returns ""
   size() returns 0

If it’s not obvious, why is this testing a different behavior from the case above?

   Test the case where the string is empty.
Problem 6 (Miscellaneous)

a. Which is the best movie by the Cohen brothers (circle one)?
   - The Big Lebowski
   - Fargo
   - Burn After Reading
   - No Country for Old Men

b. Which is the most underrated movie by the Cohen brothers (circle one)?
   - Burn After Reading
   - The Hudsucker Proxy
   - O Brother Where Art Thou
   - The Ballad of Buster Scruggs

c. O Brother Where Art Thou is a retelling of which book?
   - The Iliad
   - The Odyssey
   - The Epic of Gilgamesh
   - Beowulf

d. The main characters of The Big Lebowski enjoy which of these the most?
   - yoga
   - bowling
   - debugging
   - singing

Of course, these questions are all fake. The actual test will include a half dozen or so multiple-choice / short answer questions on the topics from the second half of the course: equals & hashCode, exceptions, subtypes, generics, event-driven programs, and design patterns.