Quiz 1 (October 24, 2016)

Your name:_____

Your Athena username:_____

You have 50 minutes to complete this quiz. It contains 10 pages (including this page) for a total of 100 points.

The quiz is closed-book and closed-notes, but you are allowed one two-sided page of notes.

Please check your copy to make sure that it is complete before you start. Turn in all pages, together, when you finish. Before you begin, write your name on the top of every page.

Please write neatly. **No credit will be given if we cannot read what you write.**

For questions which require you to choose your answer(s) from a list, do so clearly and unambiguously by circling the letter(s) or entire answer(s). Do not use check marks, underlines, or other annotations – they will not be graded.

Good luck!

DO NOT WRITE BELOW THIS LINE

Problem	Points	Grade	Grader
1: Specifications	18		
2: Testing	28		
3: Debugging	12		
4: ADTs	28		
5: Multiple Choice	14		
Total	100		

Problem 1 (Specifications) (**18 points**).

Consider this partial specification:

```
/**
 * Shift the values in inputs, wrapping around the ends of the array.
 * For example, [2, 4, 6, 8, 10] shifted by 2 to the right is [8, 10, 2, 4, 6].
 *
 * @param inputs array to shift, ...
 * @param delta amount to shift by, ...
 * @return inputs shifted by ...
 */
public static int[] shiftArray(int[] inputs, int delta)
```

Here are two versions of this specification that fill in the missing pieces:

Specification **A**:

```
@param inputs array to shift, must be non-empty
@param delta amount to shift by, must be a positive integer
@return inputs shifted by delta units to the right
```

Specification **B**:

```
@param inputs array to shift, must be non-empty
@param delta amount to shift by
@return inputs shifted by delta units,
        to the right if positive, to the left if negative
```

For each question, answer by filling in the blanks. You may leave blanks empty if desired, and you may use the same answers more than once.

(a) Complete a specification that is weaker than **A**:

@param inputs array to shift, _____

@param delta amount to shift by, _____

@return inputs shifted by _____

_____

(b) Complete a specification that is stronger than **A** and weaker than **B**:

@param inputs array to shift, _____

@param delta amount to shift by, _____

@return inputs shifted by _____

_____

 (c) Complete a specification that is stronger than **A** but neither stronger nor weaker than **B**:

`@param inputs array to shift,` ——————————————————————————————

`@param delta amount to shift by,` ————————————————————————

`@return inputs shifted by` ————————————————————————————————

——

Problem 2 (Testing) (**28 points**).
Given this specification:

```
/**
 * If text contains bound, split into two substrings a and b, where:
 * - a ends with bound, b starts with bound, and
 * - if a = a_begin + bound, and b = bound + b_end, then
 *      text = a_begin + bound + b_end.
 * Otherwise, don't split.
 *
 * For example: splitWithBound("1a2", 'a') is { "1a", "a2" }
 *              splitWithBound("123", 'a') is { "123" }
 *
 * @param text text to split
 * @param bound character to split on
 * @return a set containing some a and b as defined above, if any,
 *         or just text if none
 */
public static Set<String> splitWithBound(String text, char bound)
```

(a) For each test case below, **write YES or NO** in the first box to say whether the test is a valid test for
`splitWithBound`. If the test is not valid, **explain why** or provide a corrected test.

1. "zaz" × 'a' → { "az", "za" }

   Valid? [   ]   Reason if invalid: [   ]

2. "az" × 'a' → { "a", "az" }

   Valid? [   ]   Reason if invalid: [   ]

3. "zaaz" × 'a' → { "za", "aaz" }

   Valid? [   ]   Reason if invalid: [   ]

4. "aa" × 'a' → { "a" }

   Valid? [   ]   Reason if invalid: [   ]

5. "a" × 'a' → { "a" }

   Valid? [   ]   Reason if invalid: [   ]

6. "" × 'a' → { "a" }

   Valid? [   ]   Reason if invalid: [   ]

(b) Start implementing a systematic testing strategy for this function by writing **one good partitioning** of the input space on **input `text` alone**. Your partitions for this question should not mention `bound`. In addition, the subdomains in your partitioning **must not overlap**.

```



```

(c) Now, write **one good partitioning** of the input space on **location(s) where `bound` appears in `text`**. In addition, the subdomains in your partitioning **must not overlap**.

```



```

(d) Suppose we instead make this function an instance method of an immutable class `Splitter`.

An instance of `Splitter` uses a fixed `bound`:

```java
public class Splitter {
    // Make a Splitter that uses the given bound
    public Splitter(char bound) { ... }

    // Split with bound, as above
    public Set<String> splitWithBound(String text) { ... }
}
```

Which of the following are true? (choose all that apply)

  A. Unit tests of `Splitter(char)` should not call `splitWithBound(String)`

  B. Unit tests of `splitWithBound(String)` should not call `Splitter(char)`

  C. This immutable class doesn't make sense, because `splitWithBound` can be called with different values of `text`

  D. The `splitWithBound` operation of `Splitter` is an *observer* according to our classification

  E. *none of the above*

Problem 3 (Debugging) (**12 points**).
You've written the following program:

```java
 1  public class Sentences {
 2
 3      public static void main(String[] args) {
 4          String s = "no sentence. Sentence. also no sentence";
 5          System.out.println(findSentence(s.toCharArray()));
 6      }
 7
 8      // Return the text (without period) of the first sentence in chars.
 9      // A sentence begins with a capital letter, ends with a period, and
10      //   doesn't contain any other periods.
11      public static char[] findSentence(char[] chars) {
12          int start = 0;
13          boolean scanning = false;
14          for (int i = 0; i < chars.length; i++) {
15              if (Character.isUpperCase(chars[i]) && ! scanning) {
16                  start = i;
17                  scanning = true;
18              }
19              if (chars[i] == '.' && scanning) {
20                  return ArrayUtils.copySubarray(chars, start, i);
21              }
22          }
23          return new char[0];
24      }
25  }
```

You run it, and the output is:

```
Sentence. also no sen
```

But you expected the output to be just:

```
Sentence
```

It's broken!

Just then, your boss shows up at your desk: *We can't afford all these CPU cycles you're burning! Run your program one more time, then just fix it already!*

 (a) Choose your own adventure!

Option 1	Option 2	Option 3
Run again with input: `21.Abc.`	Run again with input: `Abc.123`	Run again with input: `21.Abc.123`

Raise your hand and quietly inform the responding TA that you would like to explore **Option 1, 2, or 3**. The TA will highlight your chosen option and the corresponding output on the next page.

You may not change your choice or ask again.

```
21.Abc

1.Abc

Abc

Abc.

Abc.1

Abc.12

Abc.123

Exception in thread "main" java.lang.ArrayIndexOutOfBoundsException
    at Sentences.findSentence(Sentences.java:15)
    at Sentences.main(Sentences.java:5)

Exception in thread "main" java.lang.IndexOutOfBoundsException
    at ArrayUtils.copySubarray(ArrayUtils.java:18)
    at Sentences.findSentence(Sentences.java:20)
    at Sentences.main(Sentences.java:5)

Exception in thread "main" java.lang.IllegalArgumentException
    at ArrayUtils.copySubarray(ArrayUtils.java:15)
    at Sentences.findSentence(Sentences.java:20)
    at Sentences.main(Sentences.java:5)
```

> Only the output highlighted by the TA is produced by your chosen input.
> You may ignore all the other possibilities.

(b) Given all the information you have, what is the bug? Write your single best hypothesis clearly and succinctly, giving evidence to support it.

(c) Propose a fix. If you can, identify a line or lines of code, and say how they should be changed.

Problem 4 (ADTs) (**28 points**).

Consider this abstraction function, rep invariant, and argument for safety from rep exposure for a class `Document` to represent immutable text documents with section headings, where each heading is a single line, followed by a single line of text:

AF

represents the document heading $headings_0$, then text $contents_0$, then heading $headings_1$, then text $contents_1$, ..., up to `length`-1; where $headings_i$ is the ith element in `headings`, and similarly for `contents`

RI

`length = headings.size() = contents.size()`

none of the elements in `headings` or `contents` contain newlines

Safety from rep exposure

all fields are final

`length` is primitive

`headings` and `contents` are created in constructors, never returned directly to clients, and contain immutable objects

(a) What is the rep of `Document`? Use the most reasonable choices from the standard library, and write valid lines of Java.

```
```

(b) Draw a snapshot diagram, including as much information as you can, for the concrete representation of the abstract value:

Hello
Greetings!

Goodbye
Farewell.
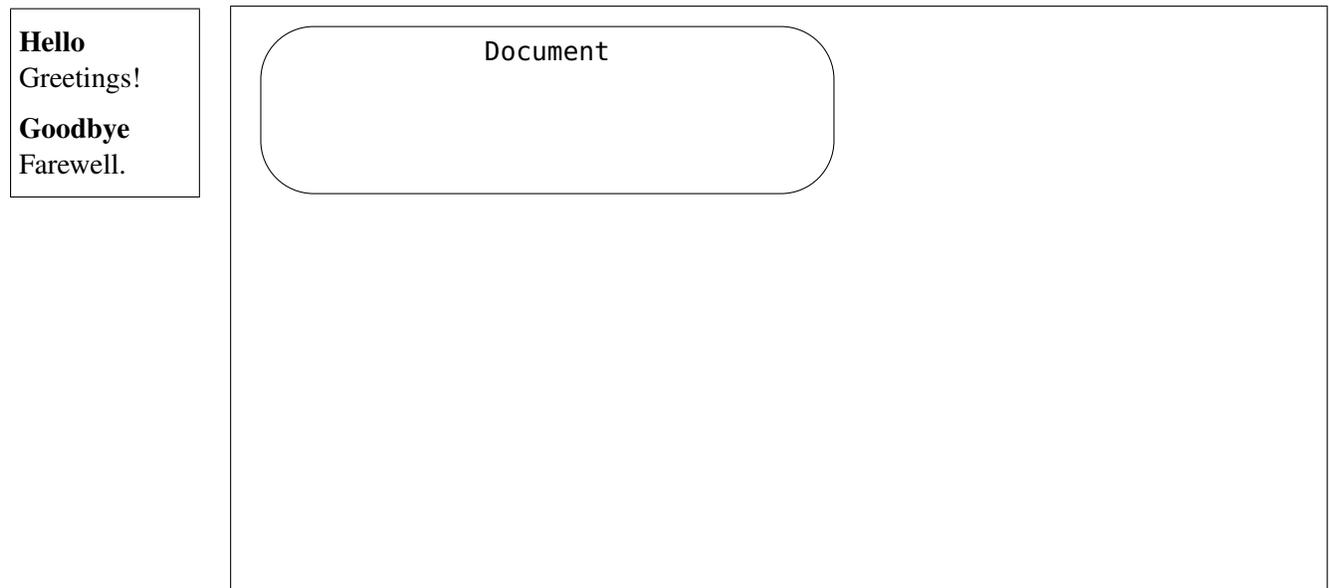
Document

(c) If all arrays, collections, and strings in the rep (if any) are empty, all primitive values (if any) are their default value, and all other objects (if any) are **null**, what is the abstract value? If none, explain why.

```
```

(d) Suppose we implement `Document` with a different representation. Here are the rep invariant and safety from rep exposure argument:

RI
`length*2 = pieces.size()`
none of the elements in `pieces` contain newlines

Safety from rep exposure
all fields are final
`length` is primitive
`pieces` is created in constructors, never returned directly to clients, and contains immutable objects

Write an abstraction function that works with this rep and rep invariant:

AF

(e) Write a **recursive datatype definition** for `Document` that uses **two** concrete variants, one of which must be **Empty**, to represent the same abstract values as above using a recursive structure:

Document =

            +

Problem 5 (Multiple Choice) (**14 points**).

(a) Which of the following statements about equality are true? (choose all that apply)

A. If you override the `equals()` method for an immutable ADT, you should also override `hashCode()`

B. You should implement observational equality for all ADTs

C. Returning a constant integer is a valid implementation of `hashCode()` because the spec of `hashCode()` specifically allows magic number implementations.

D. Using the abstraction function AF, we can define equality as: a equals b if and only if $AF(a) = AF(b)$

E. Unless we override it, `equals()` implements reference equality

(b) Which of the following best describes the benefit of declaring a variable using an interface type, as in this example:

```
List<String> words = new ArrayList<>();
```

(choose **one** best answer)

A. SFB: the `List` interface isolates our code from bugs in `ArrayList`

B. SFB: this requires `ArrayList` methods to meet specifications in `List`

C. ETU: readers may not know what an `ArrayList` is, but they will recognize `List`

D. RFC: we can change the code to use, *e.g.*, `LinkedList` instead of `ArrayList`

(c) You are implementing a `Building` ADT. Buildings have a list of rooms, which you represent with:

```
private final List<Room> rooms;
```

`Room` is immutable. Which of the following implementations for a `getRooms()` method will avoid rep exposure? (choose all that apply)

```
public List<Room> getRooms() { return ???; }
```

A. `rooms`

B. `Collections.ummodifiableList(rooms)`

C. `new ArrayList<>(this.rooms)`

D. `Optional.of(this.rooms)`

E. `this.rooms`