2017

AP Computer Science A

Free-Response Questions

COMPUTER SCIENCE A
SECTION II

Time—1 hour and 30 minutes

Number of questions—4

Percent of total score—50

Directions: SHOW ALL YOUR WORK. REMEMBER THAT PROGRAM SEGMENTS ARE TO BE WRITTEN IN JAVA.

Notes:

- Assume that the interface and classes listed in the Java Quick Reference have been imported where appropriate.
- Unless otherwise noted in the question, assume that parameters in method calls are not `null` and that methods are called only when their preconditions are satisfied.
- In writing solutions for each question, you may use any of the accessible methods that are listed in classes defined in that question. Writing significant amounts of code that can be replaced by a call to one of these methods will not receive full credit.

1. This question involves identifying and processing the digits of a non-negative integer. The declaration of the `Digits` class is shown below. You will write the constructor and one method for the `Digits` class.

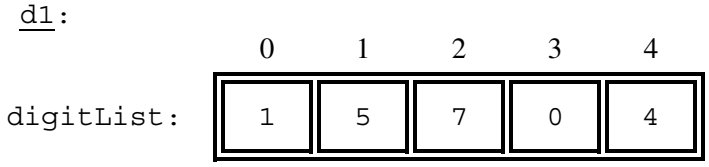
```
public class Digits
{
    /** The list of digits from the number used to construct this object.
     *  The digits appear in the list in the same order in which they appear in the original number.
     */
    private ArrayList<Integer> digitList;

    /** Constructs a Digits object that represents num.
     *  Precondition: num >= 0
     */
    public Digits(int num)
    {  /* to be implemented in part (a) */  }

    /** Returns true if the digits in this Digits object are in strictly increasing order;
     *          false otherwise.
     */
    public boolean isStrictlyIncreasing()
    {  /* to be implemented in part (b) */  }
}
```

Part (a) begins on page 4.

(a) Write the constructor for the `Digits` class. The constructor initializes and fills `digitList` with the digits from the non-negative integer `num`. The elements in `digitList` must be `Integer` objects representing single digits, and appear in the same order as the digits in `num`. Each of the following examples shows the declaration of a `Digits` object and the contents of `digitList` as initialized by the constructor.

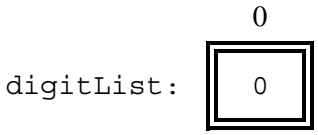
Example 1

```
Digits d1 = new Digits(15704);
```



Example 2

```
Digits d2 = new Digits(0);
```



WRITE YOUR SOLUTION ON THE NEXT PAGE.

Complete the `Digits` constructor below.

```
/** Constructs a Digits object that represents num.
 *  Precondition: num >= 0
 */
public Digits(int num)
```

Part (b) begins on page 6.

(b) Write the `Digits` method `isStrictlyIncreasing`. The method returns `true` if the elements of `digitList` appear in strictly increasing order; otherwise, it returns `false`. A list is considered strictly increasing if each element after the first is greater than (but not equal to) the preceding element.

The following table shows the results of several calls to `isStrictlyIncreasing`.

Method call	Value returned
`new Digits(7).isStrictlyIncreasing()`	`true`
`new Digits(1356).isStrictlyIncreasing()`	`true`
`new Digits(1336).isStrictlyIncreasing()`	`false`
`new Digits(1536).isStrictlyIncreasing()`	`false`
`new Digits(65310).isStrictlyIncreasing()`	`false`

WRITE YOUR SOLUTION ON THE NEXT PAGE.

Complete method `isStrictlyIncreasing` below.

```
/** Returns true if the digits in this Digits object are in strictly increasing order;
 *          false otherwise.
 */
public boolean isStrictlyIncreasing()
```

2. This question involves the design of a class that will be used to produce practice problems. The following `StudyPractice` interface represents practice problems that can be used to study some subject.

```
public interface StudyPractice
{
    /** Returns the current practice problem. */
    String getProblem();

    /** Changes to the next practice problem. */
    void nextProblem();
}
```

The `MultPractice` class is a `StudyPractice` that produces multiplication practice problems. A `MultPractice` object is constructed with two integer values: *first integer* and *initial second integer*. The first integer is a value that remains constant and is used as the first integer in every practice problem. The initial second integer is used as the starting value for the second integer in the practice problems. This second value is incremented for each additional practice problem that is produced by the class.

For example, a `MultPractice` object created with the call `new MultPractice(7, 3)` would be used to create the practice problems `"7 TIMES 3"`, `"7 TIMES 4"`, `"7 TIMES 5"`, and so on.

In the `MultPractice` class, the `getProblem` method returns a string in the format of `"`*first integer* `TIMES` *second integer*`"`. The `nextProblem` method updates the state of the `MultPractice` object to represent the next practice problem.

The following examples illustrate the behavior of the `MultPractice` class. Each table shows a code segment and the output that would be produced as the code is executed.

Example 1

Code segment	Output produced
`StudyPractice p1 = new MultPractice(7, 3);` `System.out.println(p1.getProblem());`	`7 TIMES 3`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 4`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 5`
`p1.nextProblem();` `System.out.println(p1.getProblem());`	`7 TIMES 6`

Example 2

Code segment	Output produced

`StudyPractice p2 = new MultPractice(4, 12);`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
`System.out.println(p2.getProblem());`
	`4 TIMES 13`
	`4 TIMES 13`

`p2.nextProblem();`
`p2.nextProblem();`
`System.out.println(p2.getProblem());`
	`4 TIMES 15`

`p2.nextProblem();` `System.out.println(p2.getProblem());`	`4 TIMES 16`

Question 2 continues on page 10.

Interface information for this question

```
public interface StudyPractice

String getProblem()
void nextProblem()
```

Write the complete `MultPractice` class. Your implementation must be consistent with the specifications and the given examples.

3. This question involves analyzing and modifying a string. The following `Phrase` class maintains a phrase in an instance variable and has methods that access and make changes to the phrase. You will write two methods of the `Phrase` class.

```
public class Phrase
{
   private String currentPhrase;

   /** Constructs a new Phrase object. */
   public Phrase(String p)
   {  currentPhrase = p;  }


   /** Returns the index of the nth occurrence of str in the current phrase;
    *  returns -1 if the nth occurrence does not exist.
    *  Precondition: str.length() > 0 and n > 0
    *  Postcondition: the current phrase is not modified.
    */
   public int findNthOccurrence(String str, int n)
   {  /* implementation not shown */  }


   /** Modifies the current phrase by replacing the nth occurrence of str with repl.
    *  If the nth occurrence does not exist, the current phrase is unchanged.
    *  Precondition: str.length() > 0 and n > 0
    */
   public void replaceNthOccurrence(String str, int n, String repl)
   {  /* to be implemented in part (a) */  }


   /** Returns the index of the last occurrence of str in the current phrase;
    *  returns -1 if str is not found.
    *  Precondition: str.length() > 0
    *  Postcondition: the current phrase is not modified.
    */
   public int findLastOccurrence(String str)
   {  /* to be implemented in part (b) */  }


   /** Returns a string containing the current phrase. */
   public String toString()
   {  return currentPhrase;  }
}
```

Part (a) begins on page 12.

(a) Write the `Phrase` method `replaceNthOccurrence`, which will replace the `nth` occurrence of the string `str` with the string `repl`. If the `nth` occurrence does not exist, `currentPhrase` remains unchanged.

Several examples of the behavior of the method `replaceNthOccurrence` are shown below.

Code segments	Output produced

`Phrase phrase1 = new Phrase("A cat ate late.");`
`phrase1.replaceNthOccurrence("at", 1, "rane");`
`System.out.println(phrase1);`
	`A crane ate late.`

`Phrase phrase2 = new Phrase("A cat ate late.");`
`phrase2.replaceNthOccurrence("at", 6, "xx");`
`System.out.println(phrase2);`
	`A cat ate late.`

`Phrase phrase3 = new Phrase("A cat ate late.");`
`phrase3.replaceNthOccurrence("bat", 2, "xx");`
`System.out.println(phrase3);`
	`A cat ate late.`

`Phrase phrase4 = new Phrase("aaaa");`
`phrase4.replaceNthOccurrence("aa", 1, "xx");`
`System.out.println(phrase4);`
	`xxaa`

`Phrase phrase5 = new Phrase("aaaa");`
`phrase5.replaceNthOccurrence("aa", 2, "bbb");`
`System.out.println(phrase5);`
	`abbba`

Class information for this question

```
public class Phrase

private String currentPhrase
public Phrase(String p)
public int findNthOccurrence(String str, int n)
public void replaceNthOccurrence(String str, int n, String repl)
public int findLastOccurrence(String str)
public String toString()
```

The `Phrase` class includes the method `findNthOccurrence`, which returns the `nth` occurrence of a given string. You must use `findNthOccurrence` appropriately to receive full credit.

Complete method `replaceNthOccurrence` below.

```
/** Modifies the current phrase by replacing the nth occurrence of str with repl.
 *  If the nth occurrence does not exist, the current phrase is unchanged.
 *  Precondition: str.length() > 0 and n > 0
 */
public void replaceNthOccurrence(String str, int n, String repl)
```

Part (b) begins on page 14.

(b) Write the `Phrase` method `findLastOccurrence`. This method finds and returns the index of the last occurrence of a given string in `currentPhrase`. If the given string is not found, `-1` is returned. The following tables show several examples of the behavior of the method `findLastOccurrence`.

```
Phrase phrase1 = new Phrase("A cat ate late.");
```

Method call	Value returned
`phrase1.findLastOccurrence("at")`	`11`
`phrase1.findLastOccurrence("cat")`	`2`
`phrase1.findLastOccurrence("bat")`	`-1`

Class information for this question

```
public class Phrase

private String currentPhrase
public Phrase(String p)
public int findNthOccurrence(String str, int n)
public void replaceNthOccurrence(String str, int n, String repl)
public int findLastOccurrence(String str)
public String toString()
```

WRITE YOUR SOLUTION ON THE NEXT PAGE.

You must use `findNthOccurrence` appropriately to receive full credit.

Complete method `findLastOccurrence` below.

```
/** Returns the index of the last occurrence of str in the current phrase;
 *  returns -1 if str is not found.
 *  Precondition: str.length() > 0
 *  Postcondition: the current phrase is not modified.
 */
public int findLastOccurrence(String str)
```

4. This question involves reasoning about a two-dimensional (2D) array of integers. You will write two static methods, both of which are in a single enclosing class named `Successors` (not shown). These methods process a 2D integer array that contains consecutive values. Each of these integers may be in any position in the 2D integer array. For example, the following 2D integer array with 3 rows and 4 columns contains the integers 5 through 16, inclusive.

2D Integer Array

	0	1	2	3
0	15	5	9	10
1	12	16	11	6
2	14	8	13	7

The following `Position` class is used to represent positions in the integer array. The notation `(r,c)` will be used to refer to a `Position` object with row `r` and column `c`.

```
public class Position
{
    /** Constructs a Position object with row r and column c. */
    public Position(int r, int c)
    {  /* implementation not shown */  }

    // There may be instance variables, constructors, and methods that are not shown.
}
```

(a) Write a `static` method `findPosition` that takes an integer value and a 2D integer array and returns the position of the integer in the given 2D integer array. If the integer is not an element of the 2D integer array, the method returns `null`.

For example, assume that array `arr` is the 2D integer array shown at the beginning of the question.

- The call `findPosition(8, arr)` would return the `Position` object `(2,1)` because the value `8` appears in `arr` at row 2 and column 1.
- The call `findPosition(17, arr)` would return `null` because the value `17` does not appear in `arr`.

Complete method `findPosition` below.

```
/** Returns the position of num in intArr;
 *  returns null if no such element exists in intArr.
 *  Precondition: intArr contains at least one row.
 */
public static Position findPosition(int num, int[][] intArr)
```

Part (b) begins on page 18.

(b) Write a `static` method `getSuccessorArray` that returns a 2D successor array of positions created from a given 2D integer array.

The *successor* of an integer value is the integer that is one greater than that value. For example, the successor of 8 is 9. A 2D *successor array* shows the position of the successor of each element in a given 2D integer array. The 2D successor array has the same dimensions as the given 2D integer array. Each element in the 2D successor array is the position (row, column) of the corresponding 2D integer array element's successor. The largest element in the 2D integer array does not have a successor in the 2D integer array, so its corresponding position in the 2D successor array is `null`.

The following diagram shows a 2D integer array and its corresponding 2D successor array. To illustrate the successor relationship, the values 8 and 9 in the 2D integer array are shaded. In the 2D successor array, the shaded element shows that the position of the successor of 8 is `(0,2)` in the 2D integer array. The largest value in the 2D integer array is 16, so its corresponding element in the 2D successor array is `null`.

2D Integer Array

	0	1	2	3
0	15	5	9	10
1	12	16	11	6
2	14	8	13	7

2D Successor Array

	0	1	2	3
0	(1,1)	(1,3)	(0,3)	(1,2)
1	(2,2)	null	(1,0)	(2,3)
2	(0,0)	(0,2)	(2,0)	(2,1)

Class information for this question

```
public class Position

public Position(int r, int c)

public class Successors

public static Position findPosition(int num, int[][] intArr)
public static Position[][] getSuccessorArray(int[][] intArr)
```

Assume that `findPosition` works as specified, regardless of what you wrote in part (a). You must use `findPosition` appropriately to receive full credit.

Complete method `getSuccessorArray` below.

```
/** Returns a 2D successor array as described in part (b) constructed from intArr.
 *  Precondition: intArr contains at least one row and contains consecutive values.
 *                Each of these integers may be in any position in the 2D array.
 */
public static Position[][] getSuccessorArray(int[][] intArr)
```

STOP

END OF EXAM