CSC1016S Assignment 6

References and Arrays in Java

Assignment Instructions

This assignment concerns (i) the use of class or 'static' variables and methods, (ii) the use of arrays, and the general OOP in Java question.

Class variables and class methods are those prefixed by the word "static". There is no creation process involved as there is when working with objects. These components simply exist for the duration of program execution.

One use of class variables and methods is for defining collections of constants and routines – much like a Python module. The class "`java.lang.Math`" is an excellent example. It defines constants such as π, and provides routines for calculating square roots, powers etc. We don't create a 'Math' object to make use of these facilities.

Question 1 [35 marks]

This question concerns the construction of a NumberUtils class declaration that contains a collection of useful routines.

Write a class declaration that satisfies the following specification:

Class NumberUtils

The NumberUtils class contains a collection of routines for working with integers.

Instance variables

None

Constructors

```
private NumberUtils() {}
        // A private, empty-bodied constructor prevents NumberUtil objects from being created.
```

Methods

```
public static int[] toArray(int number)
        // Given a number that is n digits in length, maps the digits to an array length n.
        // e.g. given the number 5678, the result is the array {5, 6, 7, 8}.

public static int countMatches(int numberA, int numberB)
        // Given two numbers, count the quantity of matching digits – those with the same value and
        // position. For example, given 39628 and 79324, there are 2 digits in common: x9xx2x.
        // It is assumed that the numbers are the same length and have no repeating digits.

public static int countIntersect(int numberA, int numberB)
        // Count the quantity of digits that two numbers have in common, regardless of position.
        // For example, given 39628 and 97324, there are 3 digits in common: 3, 9, 2.
        // It is assumed that the numbers are the same length and have no repeating digits.
```

You should make a simple test program (which you do not need to submit) to check your code.

Question 2 [30 marks]

This question concerns the construction of a simple game called 'Cows and Bulls' that is implemented using the NumberUtils class of question one.

The game involves guessing a mystery 4 digit number. The number contains no repeat digits and no zero.

With each guess, the number of correct digits – bulls – and the number of digits that would be correct if they were in the right position – cows.

For example, say the mystery number is 8657 and the player guesses 4678, there is one bull (6), and two cows (7, 8).

Class CowsAndBulls

CowsAndBulls implements the logic for a cows and bulls guessing game the player has

Constants

```
public final static int NUM_DIGITS = 4;
public final static int MAX_VALUE = 9876;
public final static int MIN_VALUE = 1234;
public final static int MAX_GUESSES = 10;
```

Constructors

```
public CowsAndBulls(int seed)
        // Create a CowsAndBulls game using the given randomisation seed value to generate
        // a mystery number of NUM_DIGITS length, and that gives the player MAX_GUESSES guesses.

public int guessesRemaining()
        // Obtain the number of guesses remaining.

public Result guess(int guessNumber)
        // Evaluates a guess that the mystery number is guessNumber, returning the outcome in the form
        // of a Result object. Decrements guesses remaining.
        // Assumes that game is not over.

public int giveUp()
        // End the game, returning the secretNumber.

public boolean gameOver()
        // Returns true if (i) the secret number has been guessed, or (ii) there are no more guesses.
```

On the Vula web page you will find:

- A NumberPicker class that you should use in the CowsAndBulls constructor to generate a mystery number,
- A Result class that you should use to implement the CowsAndBulls guess method.
- A Game program that completes the game; implementing user interaction.

NOTE:

- the seed value supplied to the CowsAndBulls constructor should be fed to the NumberPicker object that it creates. The purpose of this value is to make the (pseudo) random number generation repeatable i.e. the same seed value causes the same mystery number to be generated.
- To generate a mystery number, create a NumberPicker with the seed value and a range 1-9 (inclusive). Get a digit, multiply by 10 and add a digit, multiply by 10 and add a digit,…

Running the Game program produces the following sorts of interaction.

Sample I/O

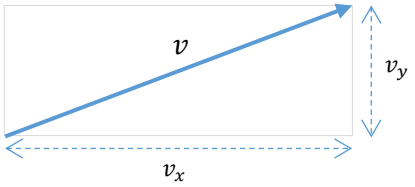
```
Your challenge is to guess a secret 4 digit number.
Enter randomisation seed value:
10
Make a guess:
5678
Sorry that's incorrect.
You have 3 cows and 1 bull.
You have 9 guesses remaining
Make a guess:
5687
Sorry that's incorrect.
You have 2 cows and 2 bulls.
You have 8 guesses remaining
Make a guess:
8657
Correct !
```

Sample I/O (abbreviated)

```
Your challenge is to guess a secret 4 digit number.
Enter randomisation seed value:
5
Make a guess:
1234
Sorry that's incorrect.
You have 0 cows and 2 bulls.
You have 9 guesses remaining
Make a guess:
…
…
4569
Sorry that's incorrect.
You have 2 cows and 0 bulls.
You have 1 guesses remaining
Make a guess:
4537
Sorry, you lose.
```

Question 3 [35 marks]

This exercise concerns the construction of a Java class to represent a vector in two dimensions. A vector has magnitude and direction. The following is a graphical depiction of a vector, v:



A vector can be represented by its horizontal and vertical components i.e. $v = (v_x, v_y)$.

There are a number of operations that can be performed on vectors:

Operation	*Description*
Obtain magnitude	The magnitude of a vector $v = (v_x, v_y)$ is $\sqrt{{v_x}^2 + {v_y}^2}$
Vector add	Given two vectors $v = (v_x, v_y)$ and $v' = (v'_x, v'_y)$, the result of adding them together is the vector $(v_x + v'_x, v_y + v'_y)$.
Scalar Multiply	The multiplication of a vector $v = (v_x, v_y)$ by a value m produces a vector $v' = (mv_x, mv_y)$.
Dot product	Given two vectors $v = (v_x, v_y)$, and $v' = (v'_x, v'_y)$, their dot product is the value of $(v_x \times v'_x, v_y \times v'_y)$.

On the Vula page you will find a test harness called *TestVector.java*. Please DO NOT modify this class.

Your task is, given the information above, to develop a Vector class that is compatible with TestVector i.e. TestVector should compile and run without modification.

Sample I/O:

```
Make a selection and press return:
(0) Quit, (1) Test getMagnitude(), (2) Test add()
(3) Test scalar multiply(), (4) Test dotProduct()
1
Enter x component and y component (separated by a space):
3 4
Created a Vector object with the given values for vx and vy.
Result of calling getMagnitude(): 5.00

Make a selection and press return:
(0) Quit, (1) Test getMagnitude(), (2) Test add()
(3) Test scalar multiply(), (4) Test dotProduct()
2
Enter x component and y component (separated by a space):
-3 3
Created Vector object: v = (-3.00, 3.00)
Enter x component and y component (separated by a space):
4 -4
Created Vector object: v = (4.00, -4.00)
Result of adding the vectors: v = (1.00, -1.00)
```

```
Make a selection and press return:
(0) Quit, (1) Test getMagnitude(), (2) Test add()
(3) Test scalar multiply(), (4) Test dotProduct()
3
Enter x component and y component (separated by a space):
-3 3
Created Vector object: v = (-3.00, 3.00)
Enter multiplier:
.5
New Vector: v = (-1.50, 1.50)

Make a selection and press return:
(0) Quit, (1) Test getMagnitude(), (2) Test add()
(3) Test scalar multiply(), (4) Test dotProduct()
4
Enter x component and y component (separated by a space):
-3 3
Created Vector object: v = (-3.00, 3.00)
Enter x component and y component (separated by a space):
4 2
Created Vector object: v = (4.00, 2.00)
Result of dot product of the vectors: -6.0

Make a selection and press return:
(0) Quit, (1) Test getMagnitude(), (2) Test add()
(3) Test scalar multiply(), (4) Test dotProduct()
0
```

NOTE: The String class 'format' method can be used to produce a string representation of a real number rounded to 2 decimal places e.g. `String.format("%.2f", 4.896)` produces the result `"4.90"`.

Marking and Submission

Submit `NumberUtils.java`, `CowsAndBulls.java` and `Vector.java` in a single .ZIP folder to the automatic marker.

The zipped folder should have the following naming convention:

yourstudentnumber.zip

END