XCS10111

UNIVERSITY OF DUBLIN
TRINITY COLLEGE

Faculty of Engineering, Mathematics & Science

School of Computer Science & Statistics

B.A. (Mod.) Computer Science
B.A. (Mod.) Computer Science Linguistics & Language
B.A. (Mod.) Business & Computing
B.A. (Mod.) Management Science and Information Systems Studies
Junior Freshman Examination

Trinity Term 2011

CS1011 Introduction to Programming I & II

Thursday, 5th May 2011 RDS-MAIN 14:00 – 17:00

Prof. Vinny Cahill and Dr. Arthur Hughes

Instructions to Candidates:

Attempt **four** questions.
All questions carry equal marks.
Answer each question in a separate answer book.

Materials permitted for this examination:

None required.

Q1. A polygon can be defined by a set of points. For example, a single triangle can be defined by three points, a single square by four points, or a pentagon by five points, etc. Write a Java application that reads a description of a set of three or more points from its user and returns the length of the perimeter of the polygon described by those points.

Hint: write a class whose instances represent points in two-dimensional space and remember that the distance between two points (x_1, y_1) and (x_2, y_2) is:

$$\sqrt{(x_2 - x_1)^2 + (y_2 - y_1)^2}$$

Q2. Dr. Sheldon Cooper in The Big Bang Theory considers 73 to be the best number because of its many mathematical properties. Sheldon claims that 73 is the twenty first (21^{st}) prime number and that if we take the mirrors of 73 and 21, which are 37 and 12 respectively, we find that 37 is the twelfth (12^{th}) prime number.

Write a Java class `SheldonsFavouriteNumber` which should contain the following methods allowing the machine verification of Dr. Sheldon Cooper's claims about the number 73:

(i) a method `isPrime` which determines if a given integer is a prime number;

(ii) a method `findNextPrime` which takes an integer and which returns the first prime number greater than the given integer, i.e., the smallest prime number which is greater than the given integer. For example, the next prime number after the number 2 is 3 and the next prime number after the number 8 is 11;

(iii) a method `nthPrime` which takes a positive integer n and which returns the nth prime number in the prime number sequence where 2 is the first (1^{st}) prime number, 3 is the second (2^{nd}) prime number, 5 is the third (3^{rd}) prime number, 7 is the fourth (4^{th}) prime number, 11 is the fifth (5^{th}) prime number, etc.;

(iv) a method `mirror` which return a non-negative integer value which is the mirror of given non-negative integer parameter, i.e., the mirror is formed by reversing the order of the digits in the given non-negative integer. For example, the mirror of the number 1234 is the number 4321 and the mirror of the number 100 is 1;

(v) a method `isSheldonCorrect` which determines using the method above if Sheldon's claims about the number 73 are correct, i.e., 73 is the twenty first (21^{st}) prime number and is the mirror of the twenty first (21^{st}) prime number equal to the twelfth (12^{th}) prime number?

Q3. Consider an $n \times n$ array in which each element contains one of the n different integers $1 \ldots n$ with each number occurring exactly once in each row and exactly once in each column. For example, for $n = 3$ such an array might be:

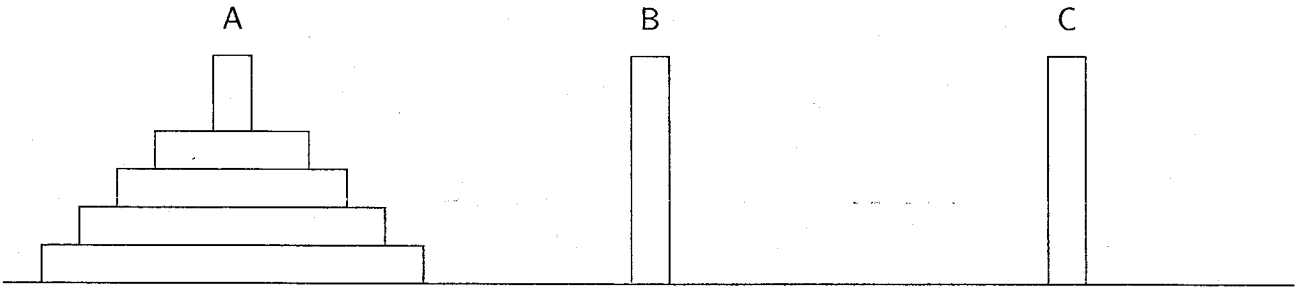
1	3	2
2	1	3
3	2	1

and for $n = 4$ such an array might be:

1	4	3	2
2	1	4	3
3	2	1	4
4	3	2	1

Write a Java application that reads a value for n from its user and prints out a filled array.

Q4. The Towers of Hanoi, also called the Towers of Brahma, is a mathematical game or puzzle. It consists of three towers, and a number of rings of different sizes which can slide onto any tower. The puzzle starts with the rings in a neat stack in ascending order of size on a tower labelled 'A', the smallest at the top, thus making a conical shape. For example the Towers of Hanoi puzzle with 4 rings starts as follows:



The objective of the puzzle is to move the entire stack of rings to the tower labelled 'B', obeying the following rules:

- Only one ring may be moved at a time.
- Each move consists of taking the upper ring from one of the towers and sliding it onto another tower, on top of the other rings that may already be present on that tower.
- No ring may be placed on top of a smaller ring.

Write a Java class `TowersOfHanoi` whose instances model the Towers of Hanoi puzzles. Your class should provide the following methods:

(i) a constructor method `TowersOfHanoi` which takes the number of rings that are to be in the constructed Tower of Hanoi puzzle. The method initialises the puzzle by ensuring that the given number of rings are on tower labelled 'A' in decreasing order of size from the bottom of the tower upwards;

(ii) a method `hasTowerRings` which determines if a given tower has any rings on it;

(iii) a method `findDepthOfDroppedRing` which finds the depth a ring will fall when placed on to a given tower; where the depth will be the number of ring heights a ring will fall when placed on a tower. For example, in the above illustration of a Towers of Hanoi puzzle, a ring place on tower 'A' will fall a depth of 2 and a ring place on tower 'B' or 'C' will fall a depth of 6.

(iv) a method `isMoveAllowed` which determines whether a player is allowed to move the top ring from a given tower onto another given tower. The method ensures that rules of the puzzle are upheld, i.e., a larger ring can not be placed onto a smaller ring;

(v) a method `moveRing` which moves the top ring from a given non-empty tower onto another given tower if possible.

Q5. The "Cricket World Cup" is a major international cricket tournament that is held every four years. Participating countries are entitled to bring a squad of fifteen players to the tournament. For each match that it plays, each country must select a team of eleven players from their squad. A player may be a "wicket keeper", a "batsman", a "bowler", or an "all-rounder" (i.e., both a batsman and a bowler). Some squad members may be unavailable for selection due to injury. Batsmen are described by their current batting average, a number between 0 and 200, with better batsmen have higher averages.

Write a Java method that given a description of some country's squad, selects the best six available batsmen from the squad for inclusion in a team. You may assume that there are at least six batsmen/all-rounders available.

Your solution should include a definition of a class whose instances represent players.

Q6. Consider the following poem penned by Lewis Carroll:

> I often wondered when I cursed,
> Often feared where I would be—
> Wondered where she'd yield her love,
> When I yield, so will she.
> I would her will be pitied!
> Cursed be love! She pitied me...

The poem when read vertically — the first words of each line, then the second words, then the third, and so on — yields exactly the same poem as when read horizontally. A poem with this property is know as a *square poem*.

Write a Java class `Poem` whose instances represent poems. Your class should provide the following methods:

(i) a constructor method `Poem` which takes the text of the multiline poem and which separates the poem text into lines and then into words; [Hint: use the `split` method of the `String` class and store the poem as an array of arrays of `String` objects.]

(ii) a method `removeSurroundingPunctuation` which takes an English word surrounded by punctuation and which returns the English word with the surrounding punctuation removed. However the method should not remove apostrophes within words. For example, the method will return the word `"love"` when given the text `"love!"` and the method will return the word `"she'd"` when given the word `"she'd"`;

(iii) a method `isSquareMatrix` which will determine if current poem has the same number of words in each of its lines and that this number is the same as the number of lines in the current poem;

(iv) a method `isSquarePoem` which will determine if the current poem is a square poem.