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

Trinity Term 2010

CS1011 Introduction to Programming I & II

Wednesday, 28 April RDS – Main 14:00 – 17:00

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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. The mathematician Augustus De Morgan was aged 43 in the year 1849AD. This is interesting because 43 squared is 1849, ie, in 1849 his age was the square root of the year.

Given that no person has ever lived longer than 123 years (and assuming that no one ever will!), write a Java application that will determine if it is possible that anyone who is alive today is, has ever been, or will ever be alive in a year that is the square of their age.

If it is possible, your program should print out the years in which it happens and the ages that the people concerned will have in those years.

Q2. The first primes are

$$2, 3, 5, 7, 11, 13, 17, 19, 23, 29, 31, 37, 41, 43, 47, 53, \ldots$$

One method for finding all the prime numbers in the range from 1 through to N is known as the 'sieve of Eratosthenes'. Consider the list of numbers from 2 through to N:

$$2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, \ldots, N$$

The first number 2 is a prime number, but the higher multiples of 2 $(4, 6, 8, \ldots)$ are not, and so they are crossed out in the list:

$$2, 3, \not{4}, 5, \not{6}, 7, \not{8}, 9, \not{10}, 11, \not{12}, 13, \not{14}, 15, \ldots, N$$

The first number after 2 that was not crossed out is 3, the next prime. We then cross out all higher multiples of 3 $(6, 9, 12, \ldots)$:

$$2, 3, \not{4}, 5, \not{6}, 7, \not{8}, \not{9}, \not{10}, 11, \not{12}, 13, \not{14}, \not{15}, \ldots, N$$

The next number not crossed out is 5, the next prime, and so we cross out all higher multiples of 5 $(10, 15, 20, \ldots)$. We repeat this procedure until we reach the first number in the list that has not been crossed out and whose square is greater than N. All the numbers that are not crossed out in the list will be the primes from 2 through to N.

Write a Java class `Sieve` whose instances represent a sieve of Eratoshenes. Your class should provide the following methods:

(i) a constructor that takes the maximum number N in the sieve,

(ii) a method to mark off the higher multiples of a given number in the sieve,

(iii) a method to find all the prime numbers in the sieve,

(iv) a method which returns the state of the sieve as a `String` object.

Write a Java application, using the `Sieve` class, which offers and implements the following 'menu loop'. Your application should handle inappropriate input from the user.

```
Menu:
(1) List prime numbers from 1 through to N.
(2) Quit.
```

Q3. For transmission between computers a digital photograph can be represented as a two-dimensional array of values representing the relative brightness of the corresponding points in the photograph. Higher values represent darker points and lower values brighter points. During transmission some of the values may be corrupted due to transmission errors. A value may be assumed to have been corrupted if it differs by more than 1.0 from any of the surrounding values. Such a corrupted value may be corrected by replacing it with the average of the surrounding values.

Write a Java application that reads in a description of a photograph and corrects any corrupted points before printing out the revised description.

If it helps, you may assume that no two adjacent points will ever be corrupted.

Q4. Word-Links was a game developed by Lewis Caroll. A series of words of the same length, where any two consecutive ones differ in one letter only, for example,

tears sears stars stare stale stile smile

is called a 'chain'. The objective of the Word-Links game is to find a chain between two given related words. The above example is a chain between words 'tears' and 'smile'.

Write a Java class `WordList` whose instances represent a list of words which may or may not be a 'chain' of words. Your class should provide the following methods:

(i) a constructor that takes the words which are to be in the word list,

(ii) a method which determines if two words are of the length and differ by exactly one letter,

(iii) a method which determines if the word list is a Lewis Caroll chain,

(iv) a method which returns the word list as a `String` object.

Write a Java application, using the `WordList` class, which offers and implements the following 'menu loop'. Your application should handle inappropriate input from the user.

```
Menu:
(1) Enter a list of words.
(2) Determine if the word list is a Lewis Carroll chain.
(3) Quit.
```

Q5. The Winter Olympic Games is a major international sporting tournament that is held every four years. The Games include a Bobsleigh competition, which involves driving a bobsleigh down an icy track as fast a possible. There are three bobsleigh events for national teams of two and four men, or of two women respectively. Teams are named based on their ranking within their country (e.g. Canada1 and Canada2). In each event, each team makes four runs down the track, proceeding

one team at a time. The winner is the team that completes their four runs in the lowest cumulative time. Some teams may crash their bobsleigh and are then disqualified from competing further.

The state of each event is recorded in a league table, ordered by lowest cumulative time taken, which records for each team, the number of runs completed and their cumulative time (or the fact that they have been disqualified) and details of each of their runs.

Write a Java class to represent a Bobsleigh event league table that provides the following methods:

(i) An appropriate constructor;

(ii) A method to record the result of a single run;

(iii) A method to report the winner of the event (if finished);

(iv) A method to retrieve the statistics for a named team;

(v) A method to retrieve the name of the team in a specified position in the event;

Your class **must** make use of additional classes to represent teams, runs and times.

Q6. A polynomial $P(x)$ in one variable x of degree n has the following general form:

$$P(x) = \sum_{i=0}^{n} a_i x^i = a_n x^n + a_{n-1} x^{n-1} + \ldots + a_2 x^2 + a_1 x + a_0$$

where $a_n \neq 0, a_{n-1}, \ldots, a_2, a_1$ and a_0 are constants, the coefficients of the polynomial. Polynomials may be added or multiplied.

The addition of a polynomial $P(x)$, of degree n, to a polynomial $Q(x)$, of degree m, is a polynomial $P(x) + Q(x)$, of degree $max(n, m)$, defined by the following formula:

$$P(x) + Q(x) = \left(\sum_{i=0}^{n} a_i x^i\right) + \left(\sum_{j=0}^{m} b_j x^j\right) = \begin{cases} (\sum_{i=0}^{n}(a_i + b_i)x^i) + (\sum_{i=n+1}^{m} b_i x^i) & \text{if } n \leq m, \\ (\sum_{i=0}^{m}(a_i + b_i)x^i) + (\sum_{i=m+1}^{n} a_i x^i) & \text{otherwise.} \end{cases}$$

The product of a polynomial $P(x)$, of degree n, by a polynomial $Q(x)$, of degree m, is a polynomial $P(x) \times Q(x)$, of degree $n + m$, defined by the following formula:

$$P(x) \times Q(x) = \left(\sum_{i=0}^{n} a_i x^i\right) \times \left(\sum_{j=0}^{m} b_j x^j\right) = \sum_{k=0}^{n+m} \left(\sum_{i+j=k} a_i \times b_j\right) x^k$$

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

(i) a constructor that takes the coefficients of the polynomial,

(ii) a method to sum the current polynomial with another polynomial to produce a new polynomial,

(iii) a method to multiply the current polynomial with another polynomial to produce a new polynomial,

(iv) a method which returns the polynomial as a `String` object formatted as it would be mathematically expressed from highest to lowest power of x, for example, the following polynomial $-x^3 + 2x^2 - x + 2$ should be formatted as the `String` object `"-x^3 + 2x^2 - x + 2"`.

Write a Java application, using the `Polynomial` class, which offers and implements the following 'menu loop'. Your application should handle inappropriate input from the user.

```
Menu:
(0) Enter coefficients of polynomial P(x).
(1) Enter coefficients of polynomial Q(x).
(2) Sum polynomials P(x) and Q(x).
(3) Multiply polynomials P(x) and Q(x).
(4) Quit.
```