CSCI 301
Computer Science 2
Fall, 2003
Programming Assignment 2*

17th September 2003

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TITLE

IMPLEMENTING AND USING A QUADRATIC FUNCTION CLASS

INTRODUCTION

A quadratic function is a function of one variable, x, of the form $f(x) = ax^2 + bx + c$. The function's coefficients a, b, and c are fixed real numbers. A root of a function is a value of its variable for which the function is zero. A quadratic function whose first coefficient is non-zero may have up to two real roots; the familiar quadratic formula identifies them:

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

In this project, inspired by programming projects 8 and 9 on pages 87 and 88 of the text, you will write, document and test a class that provides a quadratic function type and a simple program that exercises the class.

DESCRIPTION

You are to design and implement a C++ class that provides a quadratic function type and then write a simple program that exercises the class. In particular, the class's operations should be the following:

- A constructor that initializes a newly declared quadratic function object to represent $0x^2 + 0x + 0$.

*based on http://condor.stcloudstate.edu/~julstrom/cs301/projects/p2s03.html

- A function that assigns three **double** values that represent the function $f(x) = ax^2 + bx + c$ to a class object.
- Three functions that return the first, second, and third coefficients, respectively, of a quadratic function object.
- A function that returns the number of distinct real roots the represented function has. Note the discussion in the text's Project 9, and use the returned value 3 to represent an infinite number of roots.
- A function that returns the smaller of a quadratic function's two real roots according to the quadratic formula.
  - *Note*: this function makes sense only if the quadratic's first coefficient is non-zero.
- A function that returns the larger of a quadratic function's two real roots according to the quadratic formula.
  - *Note*: this function makes sense only if the quadratic's first coefficient is non-zero.
- A function whose one explicit parameter is a **double** value x.
  - The function returns the value $f(x)$ of f at x.
- A function that writes a quadratic function to the terminal.

The program that uses this class should read in three coefficients, report the number and values of the corresponding function's roots (if there are one or two of them), and evaluate the function for one x value entered by the user.

INPUT

The program will read three coefficients of a quadratic function and one x value, all **double**s.

OUTPUT

The program will prompt for its several inputs and report the information listed above.

ERRORS

The program may assume that all input is as described; it need not detect any errors.

EXAMPLE

Two runs of the program might look like this:

```
Enter the coefficients of a quadratic function a*x^2 + b*x
   + c:
a -> 1.0
b -> 0.0
c -> -1.0
The function f(x) = x^2 - 1 has two real roots.
Their values are -1 and 1.
Enter a value at which to evaluate f(x):  2.0
f(2) = 3.
```

and

```
Enter the coefficients of a quadratic function a*x^2 + b*x
   + c:
a -> 12.5
b -> -7.9
c -> -5.2
The function f(x) = 12.5*x^2 - 7.9*x - 5.2
has two real roots.  Their values are -0.402231 and 1.03423.

Enter a value at which to evaluate f(x):  1.5
f(1.5) = 11.075.
```

OTHER REQUIREMENTS

Implement the quadratic function class in two separate files: a header file whose suffix is ".h" and an implementation file whose suffix is ".cxx". Compile the class and the main program separately and link their object files.

Make the class's data members private so that the client program has no access to them.

COMPUTATIONAL DETAILS

The discriminant, D, is the expression $b^2 - 4ac$. When D is positive, there are two real roots. When D is negative, there are two complex roots. (if b is 0 in this case, then the roots are purely imaginary).

When there is a pair of real roots, lets label the root with the largest magnitude, R_1, and the smaller, R_2. If $|R_1| \gg |R_2|$, then the accuracy of the smaller root, R_2, suffers from catastrophic cancellation. To prevent this, use the following formulae instead of the standard when $b \neq 0$ and $D > 0$:

$R_1 = \frac{t}{a}$, $R_2 = \frac{c}{t}$, where $t = -\frac{b + sgn(b)\sqrt{D}}{2}$.

Note: $sgn()$ represents the sign function which returns $+1$ if its argument is positive, and -1 if its argument is negative.

HAND IN

See `http://condor.stcloudstate.edu/~julstrom/cs301/handin.html` for a description of what to hand in: design document, user document, code, tests, and summary.