Complex Numbers

A *complex number* is a number that can be expressed in the form $a + bi$, where *a* and *b* are real numbers and *i* is the imaginary unit, which satisfies the equation $i^2 = -1$. Just like real numbers, various arithmetic operations are defined for complex numbers. [Wikipedia]

Addition

$$(a + bi) + (c + di) = (a + c) + (b + d)i$$

Subtraction

$$(a + bi) - (c + di) = (a - c) + (b - d)i$$

Multiplication

$$(a + bi) * (c + di) = (ac - bd) + (ad + bc)i$$

Division

$$(a + bi)/(c + di) = \left(\frac{ac + bd}{c^2 + d^2}\right) + \left(\frac{bc - ad}{c^2 + d^2}\right) i$$

Note that you must check for a denominator of (0 + 0i). If this is the case your code should provide a resultant value of (0 + 0i).

Conjugate

$$conj(a + bi) = a - bi$$

Square Root

There are two cases to be considered and two roots for each case

First case: $b \neq 0$

$$\sqrt{(a + bi)} = \left(\sqrt{\frac{a + \sqrt{a^2 + b^2}}{2}} \pm \sqrt{\frac{-a + \sqrt{a^2 + b^2}}{2}}\, i\right)$$

Second case: $b = 0$

If $a \geq 0$

$$\sqrt{(a+bi)} = \left(\pm\sqrt{a} + 0i\right)$$

If $a < 0$

$$\sqrt{(a+bi)} = \left(0 \pm \sqrt{-a}i\right)$$

Magnitude (Absolute Value)

$$|(a+bi)| = \sqrt{a^2 + b^2}$$

Equality

Two complex numbers are equal if their complex and real parts are equal

$$(a+bi) = (c+di) \rightarrow (a = c)and(b = d)$$

The Problem

Create a class to implement complex numbers in both C++ and Java. A complex number will be represented in your code by two floating pointing numbers (float or double), the real part and the imaginary part, *a* and *b* in the above expressions. The method prototypes you will use for C++ are the following, all public:

```
ComplexNumber()
ComplexNumber(double r, double i)
ComplexNumber(const ComplexNumber &cn)
~ComplexNumber()
void setR(double r)
void setI(double i)
double getR()
double getI()
void print()
ComplexNumber add(const ComplexNumber &rhs)
ComplexNumber sub(const ComplexNumber &rhs)
ComplexNumber mult(const ComplexNumber &rhs)
ComplexNumber div(const ComplexNumber &rhs)
ComplexNumber conj()
ComplexNumber sqrt()
double mag()
bool equals(const ComplexNumber &rhs)
```

The method prototypes you will use for Java are the following:

```
public ComplexNumber()
public ComplexNumber(double _r, double _i)
public ComplexNumber(ComplexNumber rhs)
public void finalize()
public void setR(double r)
public void setI(double i)
public double getR()
public double getI()
public String toString()
ComplexNumber add(ComplexNumber rhs)
ComplexNumber sub(ComplexNumber rhs)
ComplexNumber mult(ComplexNumber rhs)
ComplexNumber div(ComplexNumber rhs)
double mag ()
ComplexNumber conj ()
ComplexNumber sqrt ()
boolean equals (ComplexNumber rhs)
```

Deliverables

- Source code attached to assignment in Blackboard
- Results from running the given main function with the command lines provided
- A reflective essay on your successes, difficulties, and how you tested your code to ensure correctness

Notes

- For C++ use **`#include <cmath>`** and **`std::sqrt(x)`** to access the square root [of a floating point number] function
- For the complex number sqrt function you may return only the positive result (you may ignore the negative result)