CMPT 130 - FIC 202002 - Assignment 1

Due Date: Wednesday, June 3rd, 2020 at 11:55PM

Problem Statement

Write a C++ program that solves the **bi-quadratic equation**

$$ax^4 + bx^2 + c = 0$$

and prints out the **solutions** of the equation to the screen.

Input Format

Your program must take the three coefficients **a, b, c** as input. You can assume the user will always enter a non-zero coefficient **a**. Therefore, your program typically should start as follows

Enter the coefficient a: ____ ↵
Enter the coefficient b: ____ ↵
Enter the coefficient c: ____ ↵

Where the ____ means the user will enter input to your program.

Output Format

The output of your program is either

This bi-quadratic equation has no solutions. OR

This bi-quadratic equation has the following solutions: PRINT THE SOLUTIONS HERE

Remark:- You don't have to print how many distinct solutions the bi-quadratic equation has. Also, it is ok to print the same solution multiple times; for example the bi-quadratic equation $x^4=0$ has four equal solutions x=0.0. In this case, it is ok to print the output **This bi-quadratic equation has the following solutions: 0.0, 0.0, 0.0, 0.0**. If you would like to print the distinct solutions only, that is ok too and it would look like **This bi-quadratic equation has the following solutions: 0.0 Both are ok.**

Submission Format

You are required to submit your program online through Moodle. You will find a submission button for Assignment 1 on Moodle under Topic 4 and you are required to upload your C++ program source code (.cpp) file. **No assignment is received by email!!!**

Submission Deadline

The deadline to upload your program online is **Wednesday June 3rd, 2020 at 11:55PM**. Moodle will not allow you to upload after this date and time.

Marking

A nonworking program will automatically get zero. A program that works but doesn't give right output or gives partial right output will lose marks depending how severe its shortcoming is.

Mathematical Background

For those of you with no solid background in mathematics of polynomials, I will explain how bi-quadratic equations are solved.

As its name implies, a bi-quadratic equation is a quadratic equation of a special form; therefore the method of quadratic formula we saw for solving quadratic equations (see Lab Work for Week 3) is enough to solve these problems. Indeed, observe that a bi-quadratic equation is a quadratic equation in x^2 (not in x). Therefore the simplest way, to solve such problems is to substitute $\mathbf{x^2}$ by another variable, say **w** to get:

$$\boldsymbol{Let\ w = x^2 \quad so\ that \quad w^2 = x^4}$$

Then the given bi-quadratic equation can be written in **w** as follows

$$\boldsymbol{aw^2 + bw + c = 0}$$

which is a quadratic equation in **w**. Now, we can solve for w using the quadratic formula $\boldsymbol{w = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}}$

Once, we have solved for w, we can easily solve for x as follows $\boldsymbol{x = \pm\sqrt{w}}$

Depending on how many solutions we have for **w** and their signs, we can easily find how many solutions we have for **x**. (Remember the assignment is to find the solutions in terms of **x**). Therefore, the following algorithm will be good enough to compute the solutions.

- If the quadratic equation $\boldsymbol{aw^2 + bw + c = 0}$ has **no solutions** then automatically the **bi-quadratic equation has no solutions**.
- If the quadratic equation $\boldsymbol{aw^2 + bw + c = 0}$ has **one negative** solution, then the **bi-quadratic equation has no solutions**.
- If the quadratic equation $\boldsymbol{aw^2 + bw + c = 0}$ has **two negative solutions**, then the **bi-quadratic equation has no solutions**.
- If the quadratic equation $\boldsymbol{aw^2 + bw + c = 0}$ has **one non-negative** solution, then the **bi-quadratic equation has two solutions** given by the plus-or-minus square root of the non-negative solution.
- If the quadratic equation $\boldsymbol{aw^2 + bw + c = 0}$ has **one negative solution and one non-negative solution**, then the **bi-quadratic equation has two solutions** given by the plus-or-minus square root of the non-negative solution.
- If the quadratic equation $\boldsymbol{aw^2 + bw + c = 0}$ has **two non-negative solutions**, then the **bi-quadratic equation has four solutions** given by the plus-or-minus square roots of each of the non-negative solutions.

Examples

In order for you to test your program for all possible types of inputs, I have prepared a list of 9 bi-quadratic equations and solved them manually. Please use these examples to test your program and make sure it gives the right output.

	Equation	Solutions
1.	**$1.0\,x^4 + 2.0x^2 + 2.0 = 0$**	**no solutions**
2.	**$1.0\,x^4 + 6.0x^2 + 9.0 = 0$**	**no solutions**
3.	**$1.0\,x^4 + 5.0x^2 + 6.0 = 0$**	**no solutions**
4.	**$1.0\,x^4 + 5.0x^2 = 0$**	**0.0, 0.0**
5.	**$1.0\,x^4 = 0$**	**0.0, 0.0, 0.0, 0.0**
6.	**$1.0\,x^4 - 6.0x^2 + 9.0 = 0$**	**1.73205, -1.73205, 1.73205, -1.73205**
7.	**$1.0\,x^4 + 1.0x^2 - 6.0 = 0$**	**1.4142, -1.4142**
8.	**$1.0\,x^4 - 5.0x^2 = 0$**	**0.0, 0.0, 2.23607, -2.23607**
9.	**$1.0\,x^4 - 5.0x^2 + 6.0 = 0$**	**1.41421, -1.41421, 1.73205, -1.73205**

Please also note that your output may have -0.0 instead of 0.0 which is ok. Also, the number of decimal places in your output may be different from the sample example outputs shown above. That is ok too.