# Lab Assignment 6

## Description:

Write a program (lab6.c) that finds the roots of a second order equation. Assume that the second order equation of variable $x$ is expressed as: $f(x) = ax^2 + bx + c$. You are to write ONE function that takes as inputs the coefficients $\{a, b, c\}$ and computes and returns the roots $x_1, x_2$. In addition, your function will return a flag (an integer) to indicate the type of roots it found.

Since $f(x)$ is second order, in general it has two roots computed as

$$x_1 = \frac{-b + \sqrt{b^2 - 4ac}}{2a}, \; x_2 = \frac{-b - \sqrt{b^2 - 4ac}}{2a},$$

where the quantity $(b^2 - 4ac)$ is know as the discriminant.

In the calculation of the roots, there are a couple of points to consider:

- If $a = 0$, the quadratic equation cannot be used to find the roots, since this would involve dividing by zero. In this case, there is only one root, and that root is determined via $x_1 = -c/b$.

- The roots can be real or complex. Real roots occur when the discriminator is non-zero, i.e., $b^2 - 4ac \geq 0$. In this case, the roots are found directly from the quadratic equation as given above.

- Complex roots occur when the discriminator is negative, i.e., $b^2 - 4ac < 0$. For all second order equations with complex roots, these roots will be a complex conjugate pair. In the complex conjugate case, there are two parts to each root, the real part and the imaginary part. The real part of both complex roots $x_1, x_2$ is the same value, namely $-b/2a$. The imaginary part of both roots have the same magnitude but are of opposite sign, where the imaginary parts of $x_1, x_2$ evaluate to $\pm\sqrt{4ac - b^2}/2a$. With these two parts, the complex roots are expressed as

$$x_{1,2} = \frac{-b}{2a} \pm j\frac{\sqrt{4ac - b^2}}{2a}.$$

  Note that the roots have the format

$$x_{1,2} = x_{real} \pm jx_{imag},$$

  where, by convention, we have defined $j = \sqrt{-1}$.

- If the discriminator is zero, i.e., $b^2 - 4ac = 0$, then there are two roots, both of equal value. These repeated roots are $x_{1,2} = -b/2a$.

## Procedure lab6.c:

1. Ask the user for the coefficients $\{a, b, c\}$ in `main()`. Write your code such that it loops over all input sets, i.e., you run your program once to compute the roots for all of the test cases.
2. Create a function that calculates the value of both of the quadratic roots and returns the type of roots (single, complex, real). HINT: Arbitrarily choose some whole number to indicate real roots (1), complex roots (2), and a single root (3).
3. Your function **must** accept three inputs and passes back three outputs. HINT: use arrays to pass inputs and outputs.
4. Call this function from `main()` to compute the roots. In addition, your **function** must test the discriminant to determine the different cases that result in single, real or complex roots. In order to correctly display the result, your function must notify the calling function (in this case `main()`) of the type of the roots.
5. Display your result to `stdout` from `main()`. There are several types of results depending on the roots.
   - If the user enters "`1 0 -1`", the output should read (two real roots):
     `The roots of 1x^2 + 0x + -1 are x1 = 1, x2 = -1.`
   - If the user enters "`1 1 1`", the output should read (complex roots):
     `The roots of 1x^2 + 1x + 1 are x1 = 0.5 + 0.8660j, x2 = 0.5 + -0.8660j.`
   - If the user enters "`0 2 3`", the output should read (single root):
     `The root of 2x + 3 is x1 = -1.5.`
6. Below is the test data set that you are to use to verify your program. Note that there is no associated order to the solution; in other words, a set of roots of `0.0` and `2.0` is just as correct as `2.0` and `0.0`.

| a | b | c | $x_1$ | $x_2$ |
|---|---|---|---|---|
| 0 | 2 | 3 | -1.5 | N/A |
| 3 | 4 | 1 | -0.3333 | -1.0 |
| 1 | -2 | 2 | 1.0 + 1.0j | 1 + -1.0j |
| 4 | 0 | -1 | 0.5 | -0.5 |
| 4 | 0 | 1 | 0 + 0.5j | 0 + -0.5j |
| -5 | 10 | 0 | 2.0 | 0.0 |
| -2 | 4 | -2 | 1.0 | 1.0 |

## Deliverables (please staple and don't forget your name):

- Printout of lab6.c source code file.
- Printouts of the results.