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**Software Testing**

**Assignment 2**

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# **Case Study**

## **Introduction**

An **Equation** in one unknown quantity (let it be x) in the form ax2 + bx + c = 0 is known as a **Quadratic equation**, where a, b, c are constants and a ≠ 0 while b and c can be zero. Here “a” is called the coefficient of x2, “b” is the coefficient of x and “c” is a constant term. The word “Quadratic” comes from “**Quadratum**”, the Latin word for square. Hence, a quadratic equation is an equation where the variable is of the second degree. Therefore, a Quadratic equation is also called an “Equation of Degree 2”. Many real-world problems can be studied and solved using Quadratic Equations. **Quadratic equations** are used in everyday life too, as when calculating areas, determining a product's profit or formulating the speed of an object, projectile motion etc.

## **Brief Description**

In a programming competition the students are required to design a program that takes three numbers (a, b, c) as inputs and determine whether the equation is Quadratic or not. The standard form of Quadratic Equation is ax2+bx+c=0, where a, b, c are constants and “a” cannot be zero. The program should have a method that calculates the nature of the roots of the Quadratic equation weather the roots of the equation are Real, Equal or Imaginary using the discriminant b2-4ac. Following are the conditions that should be meet:

* If b2-4ac>0 the roots are Real and Unequal
* If b2-4ac=0 the roots are Real and Equal
* If b2-4ac<0 the roots are Imaginary

The program should also have a method to calculate the roots of the equation using the formula . Each function should first test whether the inputs will form the Quadratic equation, and then perform the desired functionality; otherwise, the program should display a message “**Not a Quadratic Equation**”. The problem with the Quadratic Formula is that when using Floating point Arithmetic, it may be subjected to loss of significance in calculating rules of the equation, more similar the two numbers are the precision decreases, so the constants a, b, c should be integer rather than Floating-point numbers or Decimal numbers. The inputs for the constants a, b, c should be within the range from [0,200]. The program should display the following menu

1. Check Equation is Quadratic.
2. Check the nature of the roots.
3. Calculate the roots of Quadratic equation.

The users can select the above-mentioned options by pressing the number. The program should throw an exception if the user tries to select the invalid option. The program should also handle all the necessary exceptions.

# **Identified Functions**

## **Function 1 (isQuadratic (a, b, c))**

The function isQuadratic (a, b, c) take three numbers as input and checks weather the numbers form the Quadratic Equation or not, if the coefficient a ≠ 0 the program returns “Quadratic Equation” otherwise the program returns “Not a Quadratic Equation”.

## **Function 2 ( checkRoots (a, b, c))**

The checkRoots (a, b, c) takes the three input and using the discriminant formula b2 -4ac checks weather the roots of the Quadratic Equation are “Real”, “Equal” or “Imaginary” and returns the nature of roots.

## **Function 3 (calculateRoots (a, b, c))**

The calculateRoots (a, b, c) takes the three input and using the formula calculates the roots of the Quadratic Equation.

# **Black Box Testing**

## **Worst Case BVA**

### **Function 1 (isQuadratic (a, b, c))**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Cases** | **a** | **b** | **c** | **Expected output** |
| 1 | 0 | 0 | 0 | Not a Quadratic Equation |
| 2 | 0 | 0 | 1 | Not a Quadratic Equation |
| 3 | 0 | 0 | 100 | Not a Quadratic Equation |
| 4 | 0 | 0 | 199 | Not a Quadratic Equation |
| 5 | 0 | 0 | 200 | Not a Quadratic Equation |
| 6 | 0 | 1 | 0 | Not a Quadratic Equation |
| 7 | 0 | 1 | 1 | Not a Quadratic Equation |
| 8 | 0 | 1 | 100 | Not a Quadratic Equation |
| 9 | 0 | 1 | 199 | Not a Quadratic Equation |
| 10 | 0 | 1 | 200 | Not a Quadratic Equation |
| 11 | 0 | 100 | 0 | Not a Quadratic Equation |
| 12 | 0 | 100 | 1 | Not a Quadratic Equation |
| 13 | 0 | 100 | 100 | Not a Quadratic Equation |
| 14 | 0 | 100 | 199 | Not a Quadratic Equation |
| 15 | 0 | 100 | 200 | Not a Quadratic Equation |
| 16 | 0 | 199 | 0 | Not a Quadratic Equation |
| 17 | 0 | 199 | 1 | Not a Quadratic Equation |
| 18 | 0 | 199 | 100 | Not a Quadratic Equation |
| 19 | 0 | 199 | 199 | Not a Quadratic Equation |
| 20 | 0 | 199 | 200 | Not a Quadratic Equation |
| 21 | 0 | 200 | 0 | Not a Quadratic Equation |
| 22 | 0 | 200 | 1 | Not a Quadratic Equation |
| 23 | 0 | 200 | 100 | Not a Quadratic Equation |
| 24 | 0 | 200 | 199 | Not a Quadratic Equation |
| 25 | 0 | 200 | 200 | Not a Quadratic Equation |
| 26 | 1 | 0 | 0 | Quadratic Equation |
| 27 | 1 | 0 | 1 | Quadratic Equation |
| 28 | 1 | 0 | 100 | Quadratic Equation |
| 29 | 1 | 0 | 199 | Quadratic Equation |
| 30 | 1 | 0 | 200 | Quadratic Equation |
| 31 | 1 | 1 | 0 | Quadratic Equation |
| 32 | 1 | 1 | 1 | Quadratic Equation |
| 33 | 1 | 1 | 100 | Quadratic Equation |
| 34 | 1 | 1 | 199 | Quadratic Equation |
| 35 | 1 | 1 | 200 | Quadratic Equation |
| 36 | 1 | 100 | 0 | Quadratic Equation |
| 37 | 1 | 100 | 1 | Quadratic Equation |
| 38 | 1 | 100 | 100 | Quadratic Equation |
| 39 | 1 | 100 | 199 | Quadratic Equation |
| 40 | 1 | 100 | 200 | Quadratic Equation |
| 41 | 1 | 199 | 0 | Quadratic Equation |
| 42 | 1 | 199 | 1 | Quadratic Equation |
| 43 | 1 | 199 | 100 | Quadratic Equation |
| 44 | 1 | 199 | 199 | Quadratic Equation |
| 45 | 1 | 199 | 200 | Quadratic Equation |
| 46 | 1 | 200 | 0 | Quadratic Equation |
| 47 | 1 | 200 | 1 | Quadratic Equation |
| 48 | 1 | 200 | 100 | Quadratic Equation |
| 49 | 1 | 200 | 199 | Quadratic Equation |
| 50 | 1 | 200 | 200 | Quadratic Equation |
| 51 | 100 | 0 | 0 | Quadratic Equation |
| 52 | 100 | 0 | 1 | Quadratic Equation |
| 53 | 100 | 0 | 100 | Quadratic Equation |
| 54 | 100 | 0 | 199 | Quadratic Equation |
| 55 | 100 | 0 | 200 | Quadratic Equation |
| 56 | 100 | 1 | 0 | Quadratic Equation |
| 57 | 100 | 1 | 1 | Quadratic Equation |
| 58 | 100 | 1 | 100 | Quadratic Equation |
| 59 | 100 | 1 | 199 | Quadratic Equation |
| 60 | 100 | 1 | 200 | Quadratic Equation |
| 61 | 100 | 100 | 0 | Quadratic Equation |
| 62 | 100 | 100 | 1 | Quadratic Equation |
| 63 | 100 | 100 | 100 | Quadratic Equation |
| 64 | 100 | 100 | 199 | Quadratic Equation |
| 65 | 100 | 100 | 200 | Quadratic Equation |

### **Function 2 (checkRoots (a, b, c))**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Cases** | **a** | **b** | **c** | **Expected output** |
| 1 | 0 | 0 | 0 | Not a Quadratic Equation |
| 2 | 0 | 0 | 1 | Not a Quadratic Equation |
| 3 | 0 | 0 | 100 | Not a Quadratic Equation |
| 4 | 0 | 0 | 199 | Not a Quadratic Equation |
| 5 | 0 | 0 | 200 | Not a Quadratic Equation |
| 6 | 0 | 1 | 0 | Not a Quadratic Equation |
| 7 | 0 | 1 | 1 | Not a Quadratic Equation |
| 8 | 0 | 1 | 100 | Not a Quadratic Equation |
| 9 | 0 | 1 | 199 | Not a Quadratic Equation |
| 10 | 0 | 1 | 200 | Not a Quadratic Equation |
| 11 | 0 | 100 | 0 | Not a Quadratic Equation |
| 12 | 0 | 100 | 1 | Not a Quadratic Equation |
| 13 | 0 | 100 | 100 | Not a Quadratic Equation |
| 14 | 0 | 100 | 199 | Not a Quadratic Equation |
| 15 | 0 | 100 | 200 | Not a Quadratic Equation |
| 16 | 0 | 199 | 0 | Not a Quadratic Equation |
| 17 | 0 | 199 | 1 | Not a Quadratic Equation |
| 18 | 0 | 199 | 100 | Not a Quadratic Equation |
| 19 | 0 | 199 | 199 | Not a Quadratic Equation |
| 20 | 0 | 199 | 200 | Not a Quadratic Equation |
| 21 | 0 | 200 | 0 | Not a Quadratic Equation |
| 22 | 0 | 200 | 1 | Not a Quadratic Equation |
| 23 | 0 | 200 | 100 | Not a Quadratic Equation |
| 24 | 0 | 200 | 199 | Not a Quadratic Equation |
| 25 | 0 | 200 | 200 | Not a Quadratic Equation |
| 26 | 1 | 0 | 0 | Equal Roots |
| 27 | 1 | 0 | 1 | Imaginary Roots |
| 28 | 1 | 0 | 100 | Imaginary Roots |
| 29 | 1 | 0 | 199 | Imaginary Roots |
| 30 | 1 | 0 | 200 | Imaginary Roots |
| 31 | 1 | 1 | 0 | Real Roots |
| 32 | 1 | 1 | 1 | Imaginary Roots |
| 33 | 1 | 1 | 100 | Imaginary Roots |
| 34 | 1 | 1 | 199 | Imaginary Roots |
| 35 | 1 | 1 | 200 | Imaginary Roots |
| 36 | 1 | 100 | 0 | Real Roots |
| 37 | 1 | 100 | 1 | Real Root |
| 38 | 1 | 100 | 100 | Real roots |
| 39 | 1 | 100 | 199 | Real Roots |
| 40 | 1 | 100 | 200 | Real Roots |
| 41 | 1 | 199 | 0 | Real Roots |
| 42 | 1 | 199 | 1 | Real Roots |
| 43 | 1 | 199 | 100 | Real Roots |
| 44 | 1 | 199 | 199 | Real Roots |
| 45 | 1 | 199 | 200 | Real Roots |
| 46 | 1 | 200 | 0 | Real Roots |
| 47 | 1 | 200 | 1 | Real Roots |
| 48 | 1 | 200 | 100 | Real Roots |
| 49 | 1 | 200 | 199 | Real Roots |
| 50 | 1 | 200 | 200 | Real Roots |
| 51 | 100 | 0 | 0 | Equal Roots |
| 52 | 100 | 0 | 1 | Imaginary Roots |
| 53 | 100 | 0 | 100 | Imaginary Roots |
| 54 | 100 | 0 | 199 | Imaginary Roots |
| 55 | 100 | 0 | 200 | Imaginary Roots |
| 56 | 100 | 1 | 0 | Real Roots |
| 57 | 100 | 1 | 1 | Imaginary Roots |
| 58 | 100 | 1 | 100 | Imaginary Roots |
| 59 | 100 | 1 | 199 | Imaginary Roots |
| 60 | 100 | 1 | 200 | Imaginary Roots |
| 61 | 100 | 100 | 0 | Real Roots |
| 62 | 100 | 100 | 1 | Real Roots |
| 63 | 100 | 100 | 100 | Imaginary Roots |
| 64 | 100 | 100 | 199 | Imaginary Roots |
| 65 | 100 | 100 | 200 | Imaginary Roots |

### **Function 3 (calculateRoots (a, b, c))**

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Cases** | **a** | **b** | **c** | **Expected output** |
| 1 | 0 | 0 | 0 | Not a Quadratic Equation |
| 2 | 0 | 0 | 1 | Not a Quadratic Equation |
| 3 | 0 | 0 | 100 | Not a Quadratic Equation |
| 4 | 0 | 0 | 199 | Not a Quadratic Equation |
| 5 | 0 | 0 | 200 | Not a Quadratic Equation |
| 6 | 0 | 1 | 0 | Not a Quadratic Equation |
| 7 | 0 | 1 | 1 | Not a Quadratic Equation |
| 8 | 0 | 1 | 100 | Not a Quadratic Equation |
| 9 | 0 | 1 | 199 | Not a Quadratic Equation |
| 10 | 0 | 1 | 200 | Not a Quadratic Equation |
| 11 | 0 | 100 | 0 | Not a Quadratic Equation |
| 12 | 0 | 100 | 1 | Not a Quadratic Equation |
| 13 | 0 | 100 | 100 | Not a Quadratic Equation |
| 14 | 0 | 100 | 199 | Not a Quadratic Equation |
| 15 | 0 | 100 | 200 | Not a Quadratic Equation |
| 16 | 0 | 199 | 0 | Not a Quadratic Equation |
| 17 | 0 | 199 | 1 | Not a Quadratic Equation |
| 18 | 0 | 199 | 100 | Not a Quadratic Equation |
| 19 | 0 | 199 | 199 | Not a Quadratic Equation |
| 20 | 0 | 199 | 200 | Not a Quadratic Equation |
| 21 | 0 | 200 | 0 | Not a Quadratic Equation |
| 22 | 0 | 200 | 1 | Not a Quadratic Equation |
| 23 | 0 | 200 | 100 | Not a Quadratic Equation |
| 24 | 0 | 200 | 199 | Not a Quadratic Equation |
| 25 | 0 | 200 | 200 | Not a Quadratic Equation |
| 26 | 1 | 0 | 0 | X=0 |
| 27 | 1 | 0 | 1 | X1=+1*i*, X2=-1*i* |
| 28 | 1 | 0 | 100 | X1=+10*i*, X2=-10*i* |
| 29 | 1 | 0 | 199 | X1=+14.106*i*, X2=-14.106*i* |
| 30 | 1 | 0 | 200 | X1=+14.142*i*, X2=-14.142*i* |
| 31 | 1 | 1 | 0 | X1=0, X2=-1 |
| 32 | 1 | 1 | 1 | X1=-0.5+0.866*i*, X2=-0.5-0.866*i* |
| 33 | 1 | 1 | 100 | X1=-0.5+0.9.987*i*, X2=-0.5-9.987*i* |
| 34 | 1 | 1 | 199 | X1=-0.5+14.097*i*, X2=-0.5-14.097*i* |
| 35 | 1 | 1 | 200 | X1=-0.5+14.133*i*, X2=-0.5-14.133*i* |
| 36 | 1 | 100 | 0 | X1=0, X2=-100 |
| 37 | 1 | 100 | 1 | X1=-0.0100, X2=-99.99 |
| 38 | 1 | 100 | 100 | X1=-1.01, X2=-98.98 |
| 39 | 1 | 100 | 199 | X1=-2.03, X2=-97.96 |
| 40 | 1 | 100 | 200 | X1=-2.04, X2=-97.95 |
| 41 | 1 | 199 | 0 | X1=0, X2=-199 |
| 42 | 1 | 199 | 1 | X1=-0.005, X2=-198.99 |
| 43 | 1 | 199 | 100 | X1=-0.50, X2=-198.49 |
| 44 | 1 | 199 | 199 | X1=-1.005, X2=-197.99 |
| 45 | 1 | 199 | 200 | X1=-1.01, X2=-197.99 |
| 46 | 1 | 200 | 0 | X1=0, X2=-200 |
| 47 | 1 | 200 | 1 | X1=-0.005, X2=-199.995 |
| 48 | 1 | 200 | 100 | X1=-0.501, X2=-199.49 |
| 49 | 1 | 200 | 199 | X1=-1, X2=-199 |
| 50 | 1 | 200 | 200 | X1=-1.005, X2=-198.99 |
| 51 | 100 | 0 | 0 | X=0 |
| 52 | 100 | 0 | 1 | X1=+0.1*i*, X2=-0.1*i* |
| 53 | 100 | 0 | 100 | X1=+1*i*, X2=-1*i* |
| 54 | 100 | 0 | 199 | X1=+1.410*i*, X2=-1.410*i* |
| 55 | 100 | 0 | 200 | X1=+1.4142*i*, X2=-1.4142*i* |
| 56 | 100 | 1 | 0 | X1=0, X2=-0.01 |
| 57 | 100 | 1 | 1 | X1=-0.005+0.099*i*, X2=-0.005-0.099*i* |
| 58 | 100 | 1 | 100 | X1=-0.005+0.099*i*, X2=-0.005-0.099*i* |
| 59 | 100 | 1 | 199 | X1=-0.005+1.41*i*, X2=-0.005-1.41*i* |
| 60 | 100 | 1 | 200 | X1=-0.005+1.414*i*, X2=-0.005-1.414*i* |
| 61 | 100 | 100 | 0 | X1=0,X2=-1 |
| 62 | 100 | 100 | 1 | X1=-0.010,X2=-0.9898 |
| 63 | 100 | 100 | 100 | X1=-0.5+0.866*i*, X2=-0.5-0.8686*i* |
| 64 | 100 | 100 | 199 | X1=-0.5+1.31*i*, X2=-0.5-1.31*i* |
| 65 | 100 | 100 | 200 | X1=-0.5+1.322*i*, X2=-0.5-1.322*i* |

## **Strong robust equivalence class Testing:**

### **Function 1 (isQuadratic (a, b, c))**

**Total test cases:** 16 test cases

**Test Data:** Enter the 3 Integer Value (a, b, c)

**Pre-condition:** 0 ≤ a ≤ 200, 0 ≤ b ≤ 200 and 0 ≤ c ≤ 200

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Cases** | **a** | **b** | **c** | **Expected Output** |
| 1 | o | 100 | 100 | Not a Quadratic Equation |
| 2 | 100 | 100 | 100 | Quadratic Equation |
| 3 | -1 | 100 | 100 | value of “a” out of Range |
| 4 | 100 | -1 | 100 | value of “b” out of Range |
| 5 | 100 | 100 | -1 | value of “c” out of Range |
| 6 | -1 | -1 | 100 | value of “a” & “b” out of Range |
| 7 | 100 | -1 | -1 | value of “b” & “c” out of Range |
| 8 | -1 | 100 | -1 | value of “a” & “c” out of Range |
| 9 | -1 | -1 | -1 | value of “a”, “b” & “c” out of Range |
| 10 | 201 | 100 | 100 | value of “a” out of Range |
| 11 | 100 | 201 | 100 | value of “b” out of Range |
| 12 | 100 | 100 | 201 | value of “c” out of Range |
| 13 | 201 | 201 | 100 | value of “a” & “b” out of Range |
| 14 | 100 | 201 | 201 | value of “b” & “c” out of Range |
| 15 | 201 | 100 | 201 | value of “a” & “c” out of Range |
| 16 | 201 | 201 | 201 | value of “a”, “b” & “c” out of Range |

### **Function 2 (checkRoots (a, b, c))**

**Total test cases:** 18 test cases

**Test Data:** Enter the 3 Integer Value (a, b, c)

**Pre-condition:** 0 ≤ a ≤ 200, 0 ≤ b ≤ 200 and 0 ≤ c ≤ 200

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Cases** | **a** | **b** | **c** | **Expected Output** |
| 1 | 0 | 1 | 1 | Not a Quadratic Equation |
| 2 | 1 | 1 | 0 | Real Roots |
| 3 | 1 | 0 | 0 | Equal Roots |
| 4 | 1 | 0 | 1 | Imaginary Roots |
| 5 | -1 | 1 | 1 | value of “a” out of Range |
| 6 | 1 | -1 | 1 | value of “b” out of Range |
| 7 | 1 | 1 | -1 | value of “c” out of Range |
| 8 | -1 | -1 | 1 | value of “a” & “b” out of Range |
| 9 | 1 | -1 | -1 | value of “b” & “c” out of Range |
| 10 | -1 | 1 | -1 | value of “a” & “c” out of Range |
| 11 | -1 | -1 | -1 | value of “a”, “b” & “c” out of Range |
| 12 | 201 | 1 | 1 | value of “a” out of Range |
| 13 | 1 | 201 | 1 | value of “b” out of Range |
| 14 | 1 | 1 | 201 | value of “c” out of Range |
| 15 | 201 | 201 | 1 | value of “a” & “b” out of Range |
| 16 | 1 | 201 | 201 | value of “b” & “c” out of Range |
| 17 | 201 | 1 | 201 | value of “a” & “c” out of Range |
| 18 | 201 | 201 | 201 | value of “a”, “b” & “c” out of Range |

### **Function 3 (calculateRoots (a, b, c))**

**Total test cases:** 18 test cases

**Test Data:** Enter the 3 Integer Value (a, b, c)

**Pre-condition:** 0 ≤ a ≤ 200, 0 ≤ b ≤ 200 and 0 ≤ c ≤ 200

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
| **Test Cases** | **a** | **b** | **c** | **Expected Output** |
| 1 | o | 1 | 1 | Not a Quadratic Equation |
| 2 | 1 | 1 | 0 | X1=0, X2=-1 |
| 3 | 1 | 0 | 0 | X=0 |
| 4 | 1 | 0 | 1 | X1=+1*i*, X2=-1*i* |
| 5 | -1 | 1 | 1 | value of “a” out of Range |
| 6 | 1 | -1 | 1 | value of “b” out of Range |
| 7 | 1 | 1 | -1 | value of “c” out of Range |
| 8 | -1 | -1 | 1 | value of “a” & “b” out of Range |
| 9 | 1 | -1 | -1 | value of “b” & “c” out of Range |
| 10 | -1 | 1 | -1 | value of “a” & “c” out of Range |
| 11 | -1 | -1 | -1 | value of “a”, “b” & “c” out of Range |
| 12 | 201 | 1 | 1 | value of “a” out of Range |
| 13 | 1 | 201 | 1 | value of “b” out of Range |
| 14 | 1 | 1 | 201 | value of “c” out of Range |
| 15 | 201 | 201 | 1 | value of “a” & “b” out of Range |
| 16 | 1 | 201 | 201 | value of “b” & “c” out of Range |
| 17 | 201 | 1 | 201 | value of “a” & “c” out of Range |
| 18 | 201 | 201 | 201 | value of “a”, “b” & “c” out of Range |

## **Comparing Strong Robust Equivalence vs Robust Worst BVA**

### **Function 1 (IsQuadratic (a, b, c))**

The number of test cases generated using **Strong Robust Equivalence class testing = 16** and the number of test cases generated using robust worst BVA = **49 test case.**

### **Function 2 (checkRoots (a, b, c))**

The number of test cases generated using **Strong Robust Equivalence class testing = 18** and the number of test cases generated using robust worst BVA = **343 test case**

### **Function 3 (calculateRoots (a, b, c))**

The number of test cases generated using **Strong Robust Equivalence class testing = 18** and the number of test cases generated using robust worst BVA = **343 test case**

The strong robust equivalence class testing method includes in the test suite a test case from each element of Cartesian product of all equivalence classes of valid and invalid values of all parameters. The number of test cases generated using **Strong Robust Equivalence class testing are less as compared to**  the robust worst-case boundary value testing method which tests boundary values, inner and outer OFF points, and nominal point and for all parameters Comparing the two methods clearly shows the number of reduced test case in **Strong Robust Equivalence class testing**