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Solving Linear Differential Equations Using the Quadratic ODE Method

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I. Introduction

Differential equations are known to be types of mathematical equations that describe the relationships between variables and their derivatives. These equations play a crucial role in various fields of science and engineering since it enables us to model and analyze complex systems that evolve over time. The concept of differential equations can be classified into several types based on the order and the nature of the derivatives involved. The simplest type first of all is the first-order differential equation, which involves only the first derivative of the dependent variable with respect to the independent variable. Next up would be the second-order differential equation, which involves the second derivative of the dependent variable, is more complex in a sense. Higher-order differential equations, which involve derivatives of higher orders, are used to model more complex systems with multiple variables and interactions.

The use of solving differential equations is to determine whether the roots obtained from the equation were real or imaginary. The objective of the project is to be able to solve the roots given constants from the function '$ax^2 + bx + c$'. The results obtained would determine the classification of the roots. Overall, differential equations are a powerful tool for modeling and analyzing complex systems in various fields of science and engineering, and their importance is likely to increase as we continue to face more complex challenges in these areas.

II. Objectives

The objectives of the project are as follows:

1. To come up with a code that can solve quadratic equations
2. To determine the roots of the said quadratic equation
3. To classify correctly the roots obtained from the quadratic equation

III. Related Work

The existence of the quadratic equation gives readers a broad view of the different methods to solve these equations. As mentioned earlier, the ordinary different equation is one of those methods. Although this project only aims to determine the roots of the equation and classify whether it is real, equal, or imaginary, some other similar works would include Symbolab, Photomath, and the like. Both of these calculators mentioned both have the ability to solve the quadratic equation. Although, specifically speaking, the project only caters to the roots and its classification. The classification of the roots tells readers its nature. The nature of the roots of the equation, in other words.

IV. Methodology

```cpp
#include <iostream>
#include <cmath>

// this is the function being called in order to find the roots of the quadratic equation
void findRoots(double a, double b, double c) {
    // this part of the code calculates the discriminant
    double discriminant = b * b - 4 * a * c;

    if (discriminant > 0) {
        // if the discriminant is greater than 0, therefore roots are real and different
        double root1 = (-b + sqrt(discriminant)) / (2 * a);
        double root2 = (-b - sqrt(discriminant)) / (2 * a);
        std::cout << "The roots obtained are real and different." << std::endl;
        std::cout << "Root 1 = " << root1 << std::endl;
        std::cout << "Root 2 = " << root2 << std::endl;
    } else if (discriminant == 0) {
        // if the discriminant is equal to 0, then the roots are real and the same
        double root1 = -b / (2 * a);
        std::cout << "The roots obtained are real and the same." << std::endl;
        std::cout << "Root 1 = Root 2 = " << root1 << std::endl;
    } else {
        // if the discriminant is less than zero, then the roots are complex
        double realNumber = -b / (2 * a);
        double imaginaryNumber = sqrt(-discriminant) / (2 * a);
        std::cout << "The roots obtained are complex and different." << std::endl;
        std::cout << "Root 1 = " << realNumber << " + " << imaginaryNumber << "i" << std::endl;
        std::cout << "Root 2 = " << realNumber << " - " << imaginaryNumber << "i" << std::endl;
    }
}

int main() {
    double a, b, c;
    std::cout << "Enter the coefficients a, b, and c: ";
    std::cin >> a >> b >> c;

    findRoots(a, b, c);

    return 0;
}
```

Input Collection Phase

1. Entering the coefficients
    - There are three coefficients, by standard, present in a quadratic equation
    - Each constant corresponds to a variable ‘a’, ‘b’, and ‘c’

Data Processing and Output Phase

- Determining the Discriminant
    - To solve for the discriminant, the formula is given by ‘$b^2 – 4ac$’ wherein the variables mentioned correspond to the constants present in the equation
- Classifying the Roots according to the Discriminant
    - Real and Different – If the discriminant is greater than 0
    - Real and the Same – If the discriminant is equal to 0
    - Complex and Different – If the discriminant is less than 0

V. Results and Discussion

Now, as the project is a simple but may be a tedious process for those who are not familiar with Mathematics at all, written below is a sample process of the actual code with given variables.

```
Enter the coefficients a, b, and c: 1 0 16
The roots obtained are complex and different.
Root 1 = -0 + 4i
Root 2 = -0 - 4i
```

As seen above, the coefficients listed down were separated by spaces. Any number can be inputted as a, b, or c. The coefficients listed down were 1, 0, and 16. Now, solving for the discriminant gives us a value of -64 which is less than 0. Therefore, the roots obtained are classified

as complex and different. This works with any value of a, b, and c. The conditions for real, equal, and imaginary roots correspond respectively with the value of the discriminant.

VI. Conclusion and Future Work

In summary, as this is only one of the methods to solve the quadratic equation, the scope of the project is limited as seen in the methodology. Certain methods can still be implemented when solving for quadratic equations. Only difference is there are other factors that need to be considered when solving. As there are other solving interfaces that cater to this field of Mathematics, some inputs that could be embedded within the project would be other complex methods in solving. Although it would seem impossible and tedious, it can be doable within a given timeframe.

VII. Contributions

Student Name	Tasks Assigned	Percentage of the Work Contribution
Diaz, John Patrick M.	○ Introduction ○ Conclusion	Had to shoulder all the other workloads 100%
Infante, Rey Allen C.	○ Methodology ○ Related Work	No reply 0%
Lugtu, Nathan Angelo D.	○ Objectives ○ Methodology	No reply 0%

VIII. References

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