**Deliverable 3**

CRC Model

Calculator is main class with functions for:

* Choose Function (User chooses initial function to use)
* Parse Additional Function (After choosing first and entering values, can choose to parse additional function or get answer)
* Display History (Displays calculator history of the current user since they started using calculator)
* Addition (Simple addition function)
* Subtraction (Simple subtraction function)
* Multiplication (Simple multiplication function)
* Division (Simple division function)
* History (History is an array of Functions, which are separate classes for special ones and strings for simple arithmetic)

Exponential Function is a class

* Calculate Answer (calculates value of exponential function after user enter values for a, b, and x – currently x can only be an integer)
* Get Superscript (takes in string and outputs it as an exponent)
* Set Multiplier Number
* Set Base Number
* Set Exponent
* Multiplier Number (the value of a for the function)
* Base Number (the value of b for the function)
* Exponent (the value of x for the function)
* Answer (the final answer of the function after values entered)

Pseudo Code for Exponential Function

‘\*\*’ Denotes the exponential arithmetic in the Python language.

function calculate\_answer(mult\_num, base\_num, exp\_num, answer)

answer = (mult\_num) \* (base\_num \*\* exp\_num)

return answer

function set\_mult\_num(String mNum)

if ‘/’ in mNum

try

num = contents of mNum before ‘/’

den = contents of mNum after ‘/’

mult\_num = float(num)/float(den)

return mult\_num

catch Division By Zero Exception

return None

else

mult\_num = float(mNum)

Task

Compute the sum of the square root of 2, the cube root of 3 and the fourth root of 4 using the Exponential Function (√2 + 3√3 + 4√4). Hint: use fractions in the exponent.

Persona

Marco is a 2nd year Concordia Student in the Pure and Applied Math Undergraduate program. As a student, he uses a calculator almost every day, mostly for trigonometric functions or simple arithmetic. He prefers the practical aspect of math, specifically algebra and statistics, and enjoys solving problems. While not experienced with computers, he has used an online scientific calculator before and has some experience with command line. A hard worker who values simplicity and ease of use, he hopes to become a TA for an algebra class in the future.

Use Case

This use case is a simple use of our Eternity System. The user is a student, and the purpose of their use is to retrieve an answer to a problem. The Choose Function use case is a generalized use case, which branches into Choose Special Functions or Choose Simple Arithmetic. The initial use case also has the preconditions that the student has analyzed the problem and identified the desired function and needed values. The user makes a choice, and is then asked to Enter Values, for their chosen functions. Once values have been entered, the system gives the student the chance to Parse Secondary Function. If they want to, then Parse Secondary Function becomes an extension of Choose Function as the student must now choose a second function to parse. Once the secondary function is parsed, or if none was chosen, then student moves on to Perform Calculation, which is a generalization of the Receive Final Answer use case and displays the answer to their function. The student can then view the calculator history, as at least one function must be performed for the history to not be empty.

Micro Architecture Design

The micro architecture design for the Eternity System is broken down into classes. One Calculator class, which acts as the main class and how the user interacts with the Calculator, and the Function classes, a class for each of the special functions that includes any subordinate functions or variables they may need. This way, each function can be modified on its own without changing the Calculator class. The Calculator class includes the functions for simple arithmetic and allows the user to parse functions as well. This was done since both of those are functions of the calculator system, and not special functions designed by others. Each function class also has a \_\_str\_\_ function which is used to store the function information in history, which can be viewed later. The Calculator has only 1 data member which is the History, represented as an array, which stores the information of all calculations done from the latest start up of the system. The History can also be displayed through the Calculator class.

The Exponential Function class has several functions, such as the set methods to set the values for the function: multiplier, base, and exponent. The set functions are also used to handle any division by zero errors, since the user can enter fractions as input. An example of which is given in the pseudocode for the set\_mult\_num function. If the user enters a fraction with 0 as the denominator, the set functions return None, so the function is never evaluated. The get super function is just used to display the exponent as a subscript to the screen, instead of using the ^ sign. The calculate\_answer function implements the pseudocode algorithm for exponential function. Since any division by zero errors were caught in the set functions, the algorithm only calculates the answer using the values inputted. And finally, the \_\_str\_\_ method allows the information from the function to be displayed as a string.

Algorithm

The algorithm made use of the exponential arithmetic operator for python. The \*\* does not work as efficiently as the math library power function but returns the result with a very small percent difference. The arithmetic operator was chosen over designing a new exponential function both for simplicity, as the code is easier to understand and smaller. It was also chosen for decimal and fractional exponents, as when using decimal exponents, the Exponential Function becomes more complex, leaving more room for uncertainty and difference in the final answer. Originally, the root function was going to be used to change the base value and exponent values for decimal and fractional exponents, since #1/a = a√#, however, using the built-in arithmetic operator was determined to be simpler and more efficient. Minimizing the number of functions used, as well as decreasing the running time of the function.

Previous algorithm

The algorithm chosen was used to deal with decimal or fractional exponents. When the exponent is an integer, calculating the answer becomes trivial, the base is multiplied by itself the exponent number of times, and then multiplied by the multiplier to get a final answer. When the exponent is a fraction or decimal, it was decided the easiest way to deal with it, was changing the base so that the exponent becomes an integer. The algorithm works by first turning the decimal into a fraction if it is not already a fraction. This is done by multiplying the exponent by integer values starting from 2 and increasing by 1 each time, until the exponent becomes an integer. Increasing by 1 was decided since it is unclear how many digits the decimal will have and to avoid missing smaller integer values to multiply by. For instance, if the fraction is 4/100, while multiplying by 100 seems like the easiest choice, we can multiply by 25 and get 1 instead, making it even simpler.

To turn the decimal into a fraction, we multiply it by the integer value found over itself (essentially, multiplying it by 1). With a fraction, the denominator can be used to change the base, since #1/a is equivalent to a√#. The get\_root and Root functions are used to determine the specified root, since the denominator can be any value, for passed argument. This generates a new base, and then the numerator is used as the new exponent value for the new base. Since the exponent is an integer again, the new base is multiplied by itself, the passed number of times. The calculate\_answer function deals with all 3 of the mentioned cases, when the exponent is already a fraction, when it is an integer, or when it is a decimal, and calls the get\_root function if need be.

The root function was used since it still allows the original algorithm for calculating the exponential function to be used. It is also easier to deal with the exponents when they are integers, while for the base, it does not matter since it is just being used for simple multiplication. The get\_root function works by first taking an integer i and assigning it the value of 1. It is then multiplied the desired number of times for the root (twice for square, thrice for cube, etc.), to determine if it is the root value. The starting position was chosen to be 1, since we do not know what root we are looking for util the function is called, meaning an educated guess cannot be made for the value, like with simple square root. If the value of i is the root value, the function returns i, else it increments i by 1 until it is the root, or until the multiplication of i to itself the root number of times is greater than the value, we are trying to find the root for. Meaning that the root of the passed value is between i and i – 1. When that is the case, the root is not an integer, so Root is called. It is initially called with a range of i and i – 1, and calculates the middle value between the two, mid, to see if it is the root, or a reasonable approximation. If it is, it returns the middle value, if it is greater than the root, it calls Root again, with a range from i – 1 to mid, and if it is less, it calls Root with a range from mid to i. This cycle repeats, as the function calls itself, changing the interval of search each time, until it finds the root, or the root within a reasonable difference of the value |value - midn| < 0.000000001. 0.000000001 was chosen to offer a little more precision than ordinary calculator, and to ensure no infinite loops.

Test Result

Calculate the cube root of 3 using the Exponential Function.

A screenshot of a computer

Description automatically generatedText

Description automatically generatedUsing percent difference, we will see the error percentage from the cube root value calculated using the Eternity System. For simplicity, we will use up to 11 decimal points each, for both values. In this instance V1 is the exact answer for cube root of 3, while V2 is the answer from Eternity.

Percent Difference = [|V1 – V2|/([V1+V2]/2)] x 100

V1 = 1.44224957031

V2 = 1.44224957031

Percent Difference = 0.0 %

This margin of error is 0% when dealing with up to 11 decimal points.