ECE 2305 – Introduction to C Programming

Programming Project 03

Calculating Pi

Program Features: Looping structure, variables, data input and output, mathematical operators, function calls.

The German mathematician Gottfried Wilhelm von Leibniz used the following infinite series of numbers in an early calculation of an approximate value for the transcendental number Pi:

$\pi = \sum(-1)k$ (4

$2k + 1$)

∞

k=0

Use a FOR loop to make a C++ program that uses Leibniz's series to calculate and display an approximate value for Pi by keeping a finite number of terms, N. This truncated series approximation for Pi has the formula

$\pi \cong \sum(-1)k$ (4

$2k + 1$)

N

k=0

Use double-precision floating-point numbers in performing the calculations.

Use a FOR loop to calculate an approximation of Pi for N = 0, N = 1 ... to N = 15. Find the % $error$ for each value of N, according to the formula

% $error = (approximate\ value\ of\ \pi - actual\ value\ of\ \pi) \times 100$

$actual\ value\ of\ \pi$

For the actual value of Pi, use the value found from

double const PI = 4*atan(1);

After each calculation display N, the approximated value of Pi, the actual value of Pi and the % $error$ on the screen. The first few lines in the output should look something like

the following illustration.

2

Student Name

ECE 2305

Programming Project 03

Leibniz Series Approximation of Pi

N Approximate Value Actual Value % Error

0 4.00000000000 3.14159265359 27.3239544735

1 2.66666666667 3.14159265359 - 15.1173636842

The first column is the value of N, the second column is the approximate value of Pi, the third column is the actual value of Pi and the fourth column is the % $error$.

Set the number of decimal points that are shown in the display with the following code. These line should be executed only once.

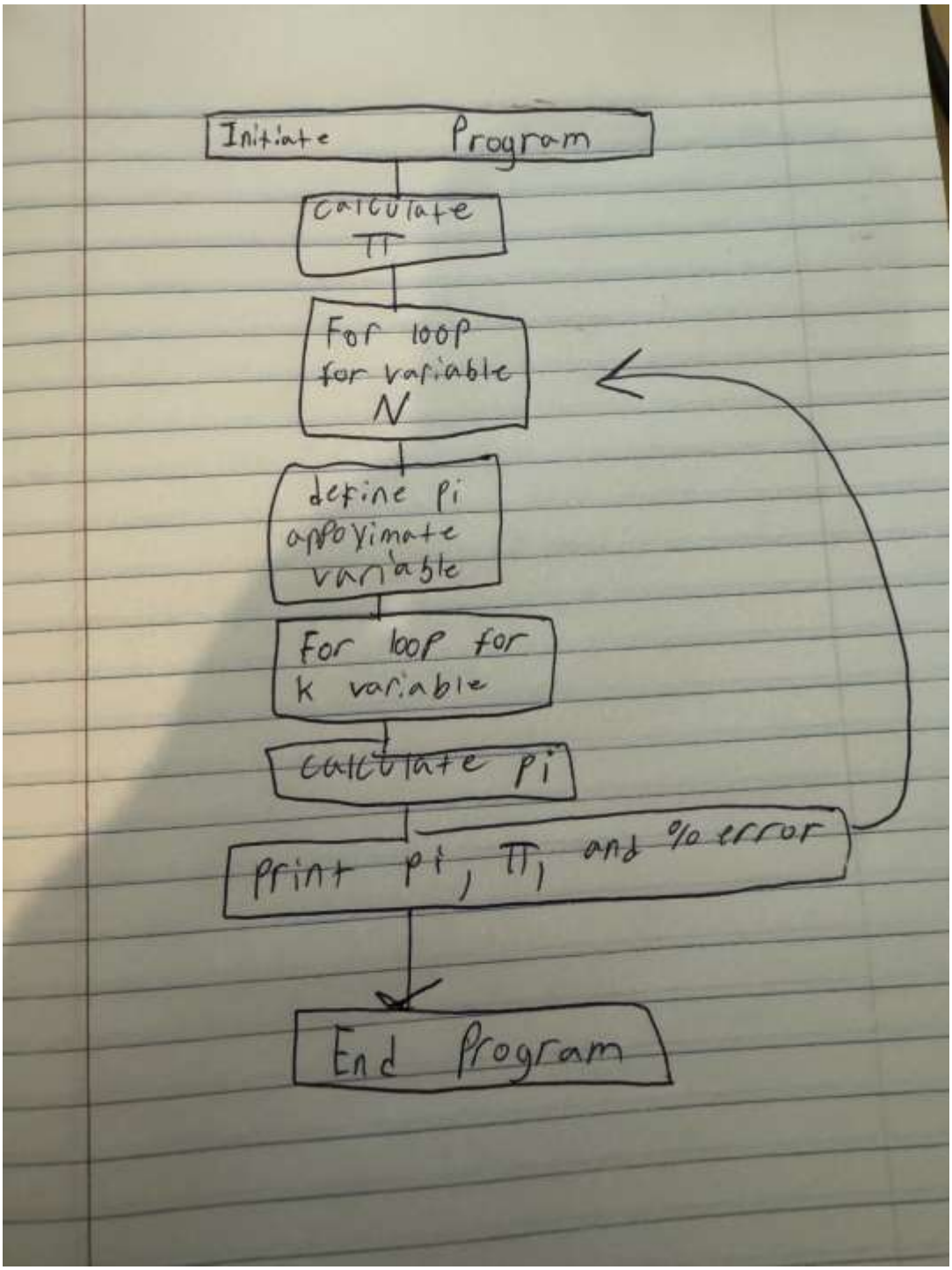
```
cout.setf(ios::fixed);
cout.setf(ios::showpoint);
cout.precision(15)
```

To document your work, create a Word document. Include the following material in the document.

A. A brief description of the purpose of the program and the structure of the program.

The purpose of this program is to find the value and percent error of Leibniz's formula for PI. It uses a nested for loop to complete this task.

B. A Flowchart to illustrate the structure of the program.

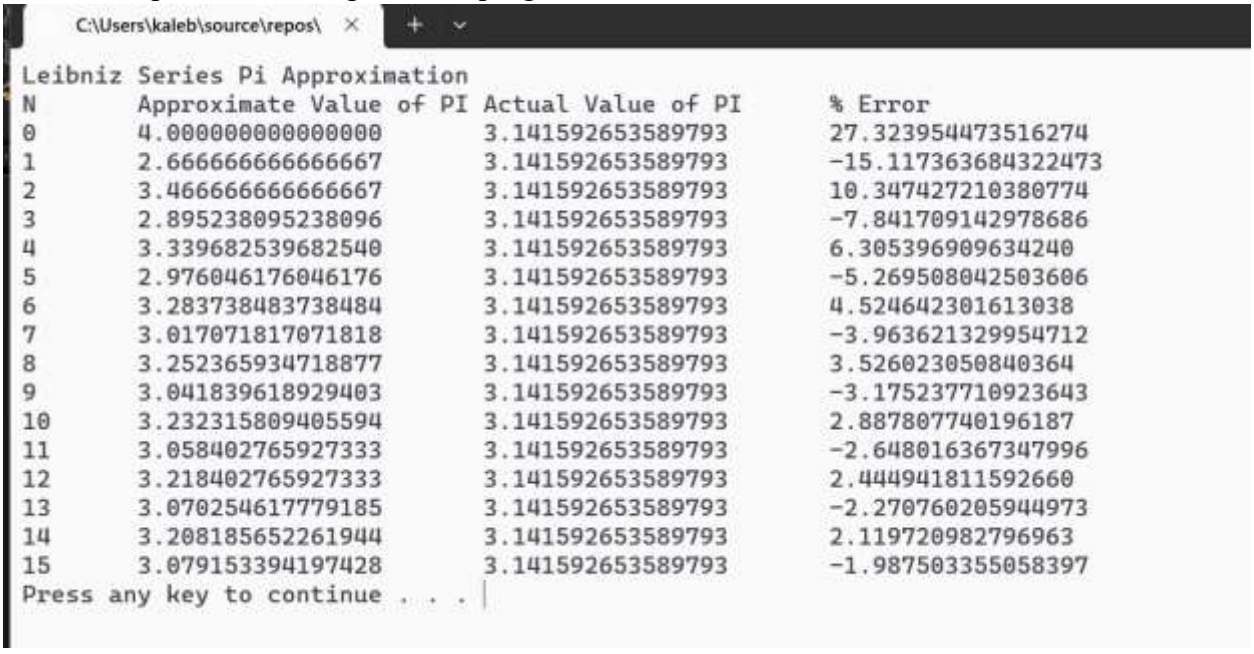


C. The code listing of the program.

Project5 (Global Scope)

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

using namespace std;

int main()
{
    cout.setf(ios::fixed);
    cout.setf(ios::showpoint);
    cout.precision(15);

    double const PI = 4 * atan(1);
    //double pi = 0;

    cout << "Leibniz Series Pi Approximation" << endl;

    cout << "N\t" << "Approximate Value of PI\t" << "Actual Value of PI\t" << "% Error" << endl;

    for (int N = 0; N <= 15; N++)
    {
        double  pi = 0;
        for (double k = 0; k <= N; k++)
        {
            pi = pi + (pow(-1, k) * (4 / (2 * k + 1)));

        }
        double percent_error = ((pi - PI) * 100) / PI;
        cout << N << "\t" << pi << "\t" << PI << "\t" << percent_error << endl;

    }
    system("pause");
    return 0;
}
```

D. A screen capture of the output of the program



Leibniz Series Pi Approximation

N	Approximate Value of PI	Actual Value of PI	% Error
0	4.000000000000000	3.141592653589793	27.323954473516274
1	2.666666666666667	3.141592653589793	-15.117363684322473

```
2     3.466666666666667     3.141592653589793     10.347427210380774
3     2.895238095238096     3.141592653589793     -7.841709142978686
4     3.339682539682540     3.141592653589793     6.305396909634240
5     2.976046176046176     3.141592653589793     -5.269508042503606
6     3.283738483738484     3.141592653589793     4.524642301613038
7     3.017071817071818     3.141592653589793     -3.963621329954712
8     3.252365934718877     3.141592653589793     3.526023050840364
9     3.041839618929403     3.141592653589793     -3.175237710923643
10    3.232315809405594     3.141592653589793     2.887807740196187
11    3.058402765927333     3.141592653589793     -2.648016367347996
12    3.218402765927333     3.141592653589793     2.444941811592660
13    3.070254617779185     3.141592653589793     -2.270760205944973
14    3.208185652261944     3.141592653589793     2.119720982796963
15    3.079153394197428     3.141592653589793     -1.987503355058397
Press any key to continue . . .
```

Save the Word document as a PDF file and submit the PDF document on Blackboard.