APS106 – LAB # 5
MONDAY, FEBRUARY 10, 2:00 - 4:00

OBJECTIVE:

At this stage in the course, you've been exposed to some important elements of programming, including selection (if, if/else, switch) and repetition (while, do while, for). The following lab is an opportunity to exercise your understanding of these elements. As you'll see, this lab will also have you check the validity of user input, and deal appropriately with input that you don't expect - this is an example of "error trapping" - an element of good programming practice.

PROBLEM:

The 19th century mathematical physicist Joseph Fourier claimed that arbitrary graphs can be represented by trigonometric series. It came as a shock to many mathematicians of his time that he turned out to be right! Fourier series decomposes a periodic function or periodic signal into a sum of sine and cosine functions. The Fourier series has many applications in electrical engineering, vibration analysis, acoustics, optics, signal processing, image processing, quantum mechanics and econometrics.

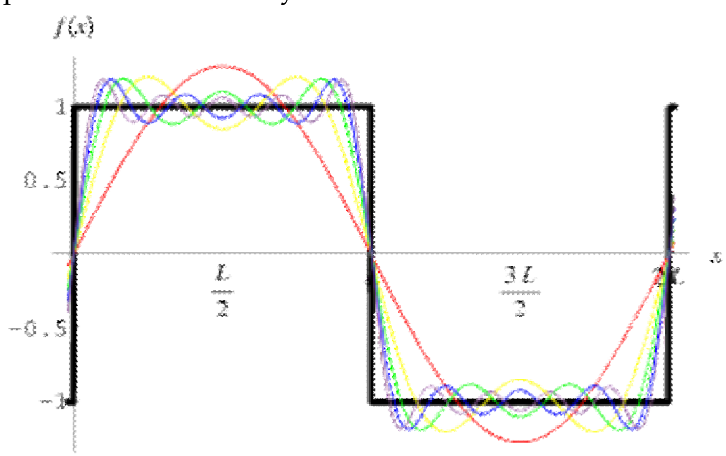
The Fourier series for a "square" waveform is given by

$$f(x) = \frac{4}{\pi}\left[\sin\left(\frac{\pi x}{L}\right) + \frac{1}{3}\sin\left(\frac{3\pi x}{L}\right) + \frac{1}{5}\sin\left(\frac{5\pi x}{L}\right) + \frac{1}{7}\sin\left(\frac{7\pi x}{L}\right) + \ldots\right]$$

Or, in a compact form,

$$f(x) = \frac{4}{\pi}\sum_{n=0}^{N}\frac{1}{(2n+1)}\sin\left(\frac{(2n+1)\pi x}{L}\right)$$

As shown in the figure below, the summation can be made to approach the value of the square waveform by taking increasingly more number of terms (the figure shows successive summation in different colours). However, very close to the points of discontinuity there is an overshoot called the Gibbs phenomenon.



Write a program that does the following:

1. asks the user for a positive integer value of N and a two positive floating point values of L and x such that $0.05L \le x \le 0.95L$, in order to avoid the "Gibbs phenomenon";
2. checks that the conditions given above are met; if they aren't, the program should repeatedly ask the user for the input values again;
3. calculates the value of $f(x)$ by evaluating the series;
4. and outputs the result; for example:

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Enter values for N, L and x: 1000  1.0  0.88
1000-term Fourier series evaluates to 0.9991 at x=0.88
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