Engr 123 **Assigned: April 4, 2018**
Assignment 08 **Due: April 23, 2018**
Plot and the Charting tool **Not accepted late**

The Fourier series provides a method of rewriting almost any periodic function as an infinite sum of sines and cosines. In trigonometric form the Fourier series is written as:

$$f(t) = \frac{a_0}{2} + \sum_{k=1}^{\infty} a_k \cdot Cos(\omega_0 kt) + \sum_{k=1}^{\infty} b_k \cdot Sin(\omega_0 kt)$$

where

$$a_k = \frac{2}{T} \cdot \int_T f(t) \cdot Cos(\omega_0 kt) dt \quad \text{and} \quad b_k = \frac{2}{T} \cdot \int_T f(t) \cdot Sin(\omega_0 kt) dt$$

For example, find the Fourier series for the square wave shown below.

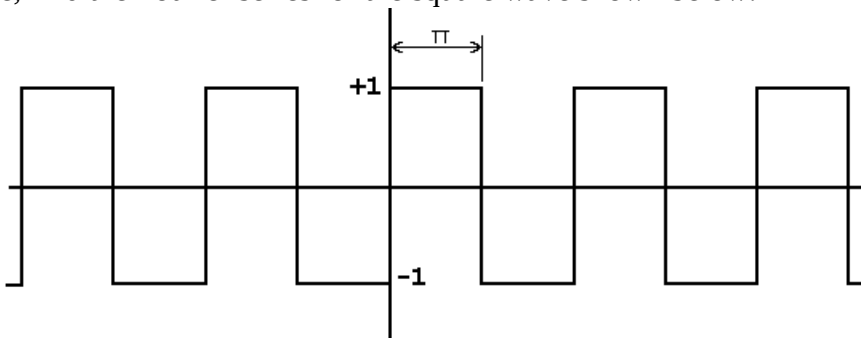

Figure 1
A square wave with a period of 2π.

Solution:

To find the coefficients a_k and b_k, we need to integrate over one period. For this problem we will take the period from 0 to 2π. The equation for f(t) is:

$$f(t) = \begin{cases} +1 & 0 \le t \le \pi \\ -1 & \pi \le t \le 2\pi \end{cases}$$

The equations for a_k and b_k can be evaluated as:

$$a_k = \frac{1}{\pi} \int_0^{\pi} (+1) Cos(2\pi kt) dt + \frac{1}{\pi} \int_{\pi}^{2\pi} (-1) Cos(2\pi kt) dt = 0$$

$$b_k = \frac{1}{\pi} \int_0^{\pi} (+1) Sin(2\pi kt) dt + \frac{1}{\pi} \int_{\pi}^{2\pi} (-1) Sin(2\pi kt) dt = \begin{cases} 0 k even \\ \frac{4}{k\pi} k odd \end{cases}$$

We can then write f(t) as a Fourier series.

$$f(t) = \sum_{\substack{k=1 \\ k odd}}^{\infty} \frac{4}{k\pi} Sin(2\pi kt)$$

Thus we see that a square wave, or any periodic function, can be rewritten as an infinite sum of sines and cosines. The frequency of these sines and cosines is referred to as the "frequency content" of the wave.

For this problem we will use the C# Charting tool to plot the Fourier series sum of the square wave above using a finite number of terms specified by the user. In the equation for the Fourier series for the square wave we replace the sum which goes from k = 1 to ∞ with a sum which goes from 1 to N where N is a variable input by the user.

$$f(t) = \frac{4}{\pi} \sum_{\substack{k=1 \\ k=odd}}^{\infty} (1/k) \sin(2\pi kt)$$

Write a program in C# which will evaluate the equation for f(t) above for values of t ranging from 0 to 2π in steps of 1/100 for the first N terms of the series
(k = 1, 3, 5, … N). Use the C# Charting tool to plot the sum on a graph which ranges from x = -2π to x = +2π and y = -1.5 to y = +1.5. The figure below shows what the Fourier series looks like for 5 terms. (This plot was done using Matlab and plots the square wave as well as the Fourier series approximation.

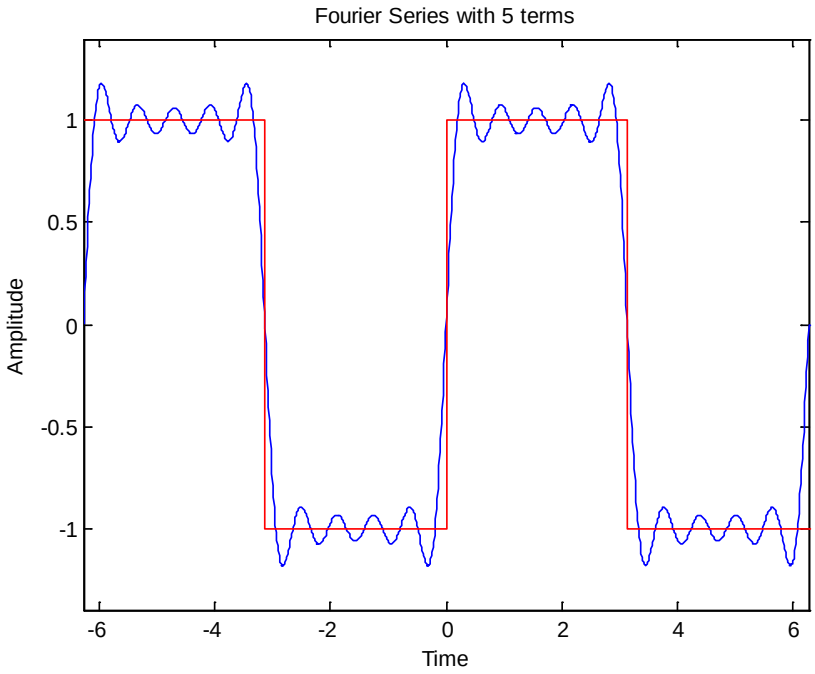

Figure 2
A MATLAB plot of a square wave using the first five terms of the Fourier series.

For your program you must have a GUI interface with a way for the user to enter the value of N and a button to do the plot.

Your project should also have a menu item called About. When the user click on About you should display a second window which gives some information about the program. A sample About box is shown in Figure 3.

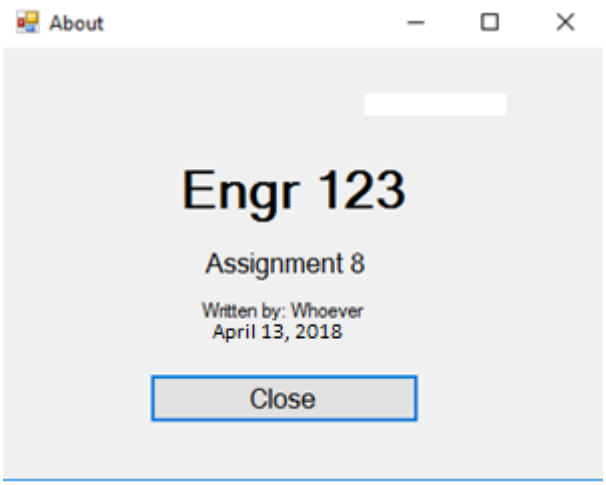

Figure 3
Typical About box

After you get your program running correctly, place a copy of the design into the project folder as a doc or docx file. Right click on the *project folder* and choose Send To → Compressed zip file. Rename the compressed zip file as Asn08XXX.zip where XXX are you three initials. Upload the renamed file to \\cecsfp01\users\everyone\engr123.