ELEC 3004/7312: Signals Systems & Controls
Week 2: Tutorial 1: Periodic Signals

This tutorial reviews periodic sinusoidal signals and some basic operations on them in MATLAB. The objective is to familiarize yourself with some tools that will be of assistance later in the course.

Part 1. Periodic Signals

A periodic continuous time signal has the property that there is a positive value of ***T*** for which $x(t) = x(t+T)$.

Using MATLAB (or equivalent), please generate and plot (with axes labeled):

a) A sine wave with a 10Hz frequency
b) A cosine wave of 10Hz frequency (try to do this directly from the wave in (a))
c) A sine wave of 20Hz (again, try do this directly from the wave in (a))

d) A square wave and saw-tooth wave of 10Hz frequency
e) Compare your results in (d) to that from the `square` and `sawtooth` functions

Try plotting these with points only (the '.' option), lines (default), and as discrete steps (using the `stairs` plotting function).

Part 2. Even and Odd Signals

Even and odd signals refer to their symmetry under time reversal.
An even signal is defined such that it is identical to its time-reverse counterpart,
i.e., $x(-t) = x(t)$

Using this definition as a basis, write a matlab routine to test if a sample sequence represents an even signal. An "isevensequence" function as it were.

Use this to test the following cases:

a) The sine wave function from above.
b) The sinc function (`tt = linspace(-7,7); yy = sinc(tt);`).
   Is this even or odd or neither?
c) A 10Hz Gaussian pulse with 60% bandwidth, truncated where the envelope falls 40 dB below the peak. See `doc gauspuls` for details.

Part 3. Euler's Relation and Sinusoidal Signals

Recall that $Ae^{i\theta} = A\left(\cos\left(\theta\right) + i\sin\left(\theta\right)\right)$. **Why?**

As a hint, consider the Taylor series expansions (about 0) for e^x, sin(x), and cos(x):

$$e^x = 1 + x + \frac{x^2}{2!} + \frac{x^3}{3!} + \frac{x^4}{4!} + \ldots,\ \sin\left(x\right) = x - \frac{x^3}{3!} + \frac{x^5}{5!} - \frac{x^7}{7!} + \ldots,\ \cos\left(x\right) = 1 - \frac{x^2}{2!} + \frac{x^4}{4!} - \frac{x^6}{6!} + \ldots$$

If we substitute $\theta \to \omega t$ .This leads to the notion of a phasor, $A\angle\omega t$ or $x\left(t\right) = e^{i\omega t}$, where $\omega = 2\pi f$ because every cycle must incur 2π radians. Similarly, this can be written in terms of a sinusoidal function as: $A\cos\left(\omega t + \phi\right) = {}^{A}\!/_{2}\, e^{i\phi} e^{i\omega t} + {}^{A}\!/_{2}\, e^{-i\phi} e^{-i\omega t}$. **Verify that this is true.**

Part 4. Plotting Discrete-Time Sampling and Such

Technically MATLAB is discretizing the signals from above, but it tries to be a little careful. Sometimes it is better to plot the discrete values directly, such as via `stem` and the point and line option ('.-') of the `plot` command.

a) Plot the discrete values of the sinc function in Part 2 (b) using `stem`
b) For a 10 ms sample period (100 Hz sampling, e.g., `tt=0:0.01:1;`), plot (using `subplot`) sine waves of increasing frequency. Try (for example) a set such as 5 Hz, 15 Hz, 25 Hz, etc., to 45 Hz, 49 Hz, and 50 Hz. Are the results as expected? Why? Be sure to show the **line and the discrete points** the make up the graph.
c) For the case of 45 Hz and 49 Hz, and 50 Hz above, describe what happens if the time vector is changed to a 1 ms sample period?