ECES-352
Winter 2019
Homework #2

Reading: In Signal Processing First, Appendix A on Complex Numbers; and Ch. 2 on Sinusoids.

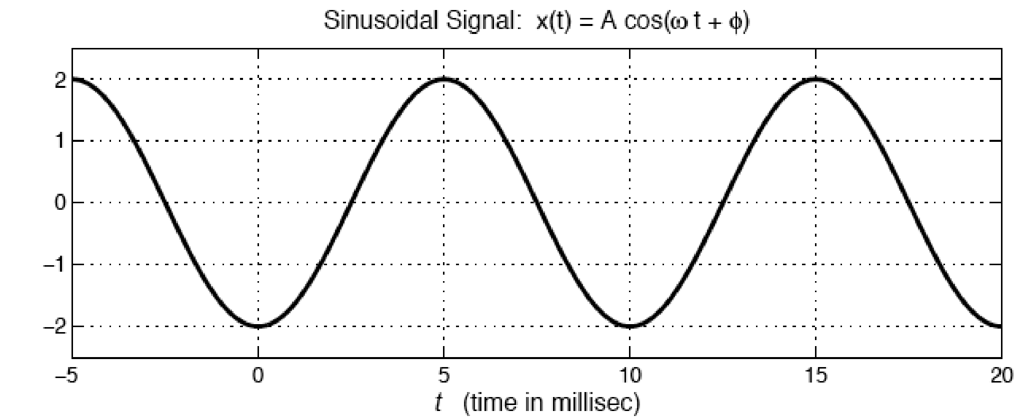
Your homework is due at the beginning of class each Tuesday. See syllabus for late policy.

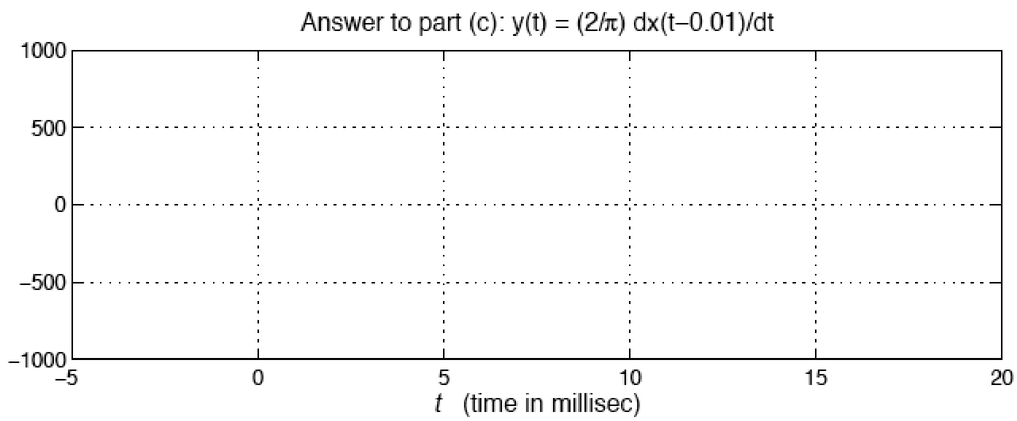
Problem 1

Suppose that MATLAB is used to plot a sinusoidal signal. The following MATLAB code generates the signal and makes the plot. Draw a sketch of the plot that will be done by MATLAB. Determine the amplitude (A), phase (ϕ), and period of the sinusoid and label the period on your plot.

```
Fo = 12;
Z = -1 + i;
dt = 1/(50*Fo);
tt = -0.05 : dt : 0.15;
xx = real( Z*exp( 2j*pi*Fo*tt ) );
%
plot( tt, xx ),   grid title( 'SECTION of a SINUSOID' ),
xlabel('TIME   (sec)')
```

Problem 2





(a) The above figure shows a plot of a sinusoidal wave $x(t)$. From the plot, determine the values of A, ω_0, and $-\pi < \phi \leq \pi$ in the representation

$$x(t) = A\cos(\omega_0 t + \phi)$$

Where appropriate, be sure to indicate the units of the sinusoidal signal parameters.

(b) The signal $x(t)$ in part (a) can be written as the real part of a complex exponential. Determine Z for the complex signal $z(t) = Ze^{j\omega_0 t}$ such that $x(t) = \Re e\{z(t)\}$.

(c) Sketch the signal $y(t) = \frac{2}{\pi}\frac{d}{dt}[x(t - 0.01)]$, where $x(t)$ is the signal from part (a). Use the axes provided above or make your own axes covering the same time interval.

Problem 3

Each of the following signals may be simplified, and expressed as a single sinusoid of the form: $A\cos(\omega t + \phi)$. For each signal, draw a vector diagram of the complex amplitudes (phasors), and use vector addition to estimate the amplitude A and phase ϕ of the sinusoid. Then use the phasor addition theorem to find the exact values for A and ϕ.

(a) $x_a(t) = 2\cos(27\pi t - 2\pi/3) - \cos(27\pi t + 3\pi/4)$

(b) $x_b(t) = \sqrt{3}\cos(18.776\pi t + 15.5\pi) + 3\cos(18.776\pi t - 12.5\pi) + \sqrt{3}\cos(18.776\pi t + 18\pi)$

(c) $x_c(t) = \cos(120\pi t + 3\pi/4) + \cos(120\pi t + 5\pi/4) + 2\sin(120\pi t - \pi/4) + 2\sin(120\pi t + \pi/4)$
Hint: Note that the last two terms in $x_c(t)$ are sines rather than cosines.

Problem 4

Define $x(t)$ as

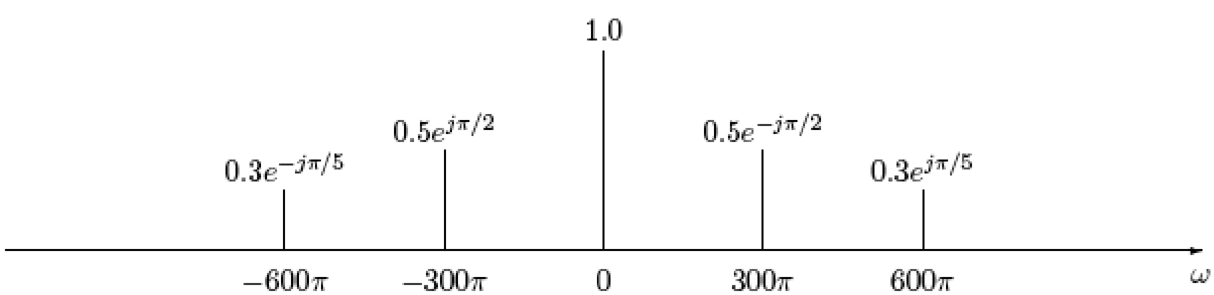
$$x(t) = \sqrt{3}\cos(\omega_0 t + \pi/3) + \sin(\omega_0 t + \pi/2)$$

(a) Find a complex-valued signal $z(t)$ such that $x(t) = \Re e\{z(t)\}$. Simplify $z(t)$ as much as possible, so that you can identify its complex amplitude. Hint: Be careful to note that the second term in $x(t)$ is a sine rather than a cosine.

(b) Assume that $\omega_0 = 0.1\pi$ rad/sec. Make a plot of $\Re e\{(1 - j)e^{j\omega_0 t}\}$ over the range $-10 \le t \le 10$ secs. How many periods are included in the plot?

Problem 5

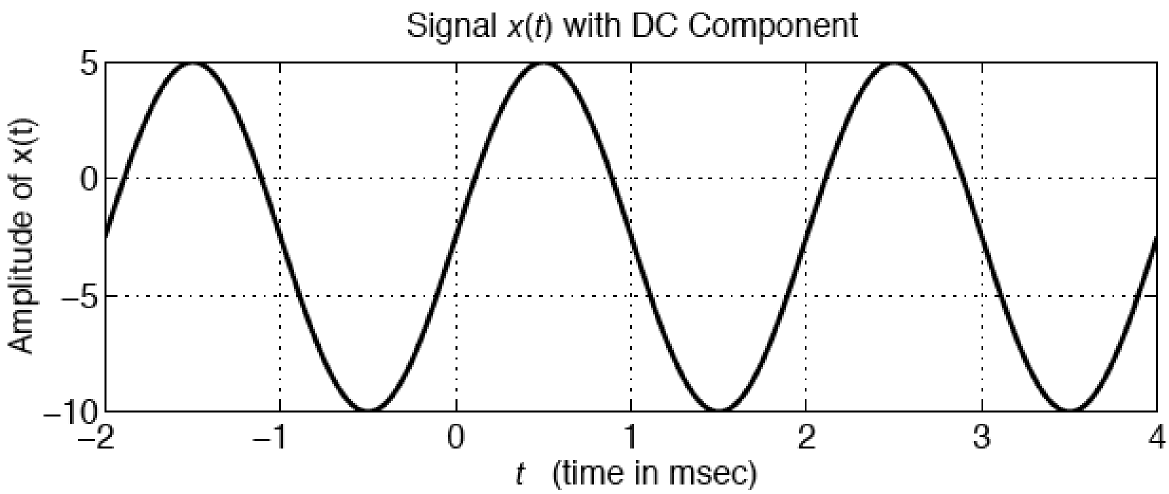
A real signal $x(t)$ has the following two-sided spectrum:



(a) Write an equation for $x(t)$ as a sum of cosines.

(b) Plot the spectrum of the signal $y(t) = 2x(t) + 10\cos(250\pi(t - 0.002))$.

Problem 6



The above signal $x(t)$ consists of a DC component plus a cosine signal. The terminology *DC component* means a component that is constant versus time.

(a) What is the frequency of the DC component? What is the frequency of the cosine component?

(b) Write an equation for the signal $x(t)$. You should be able to determine numerical values for all the amplitudes, frequencies, and phases in your equation by inspection of the above graph.

(c) Expand the equation obtained in the previous part into a sum of positive and negative frequency complex exponential signals.

(d) Plot the two-sided spectrum of the signal $x(t)$. Show the complex amplitudes for each positive and negative frequency contained in $x(t)$.