Homework #1

Matlab Part is due on Oct. 17, 2019

Optional Problems: #2.6(b), 2.16, 2.22, 2.33(a)(c), 2.53, 2.68

2.59
A system has the frequency response function

$$H(f) = \frac{4\pi + j2\pi f}{8\pi + j2\pi f}.$$

Determine and accurately plot the group delay and the phase delay.

2.62
The nonlinear system defined by

$$y(t) = x(t) + 0.1x^2(t)$$

has an input signal with the bandpass spectrum

$$X(f) = 4\Pi\left(\frac{f-20}{6}\right) + 4\Pi\left(\frac{f+20}{6}\right).$$

Find the spectrum of the output.

2.70
Determine the range of permissible cutoff frequencies for the ideal lowpass filter used to reconstruct the signal

$$x(t) = 10\cos(600\pi t)\cos^2(2400\pi t)$$

which is sampled at 6000 samples per second. Sketch $X(f)$ and $X_\delta(f)$. Find the minimum allowable sampling frequency.

Please email your Matlab assignment to the instructor. Both code and documentation, if any, need to be uploaded. No hardcopies are necessary.

Matlab Problems:

M1) **Convolution**
Assume we send the input signal $x[n] = [1\ 2\ 3\ 4\ 5\ 4\ 3\ 2\ 1]$ into an LTI system with impulse response

$$h[n] = \left[\begin{array}{ccccc} 0.0545 & 0.2442 & 0.4026 & 0.2442 & 0.0545 \end{array}\right].$$

Please write Matlab code to implement the following tasks
(a) Plot $x[n]$ and $h[n]$.

(b) Implement the convolution between $x[n]$ and $h[n]$ in two different ways:
(i) Simply use the command **conv**.

(ii) Write a Matlab code to decompose $x[n]$ into individual impulse functions. For each impulse function, plot its corresponding output. Finally, superimpose all individual outputs to form the overall output.

M2) **Fourier Transform and Spectrum**
(a) Use the command **fft** to implement the Fourier transform of $x[n]$ and $h[n]$ in *M1*. Plot $X[k]$ and $H[k]$.

(b) Calculate $Y[k] = H[k]X[k]$. Plot $Y[k]$.

(c) Use the command **ifft** to implement the inverse Fourier transform of $Y[k]$. Compare the *IFFT* result with the convolution result calculated in *M1*.

Remarks:

1. In *M2*, remember to pad extra zeros before you apply the *FFT* operation.