BENG-320 Fall-2017

Homework #1 Due: Sep 13, 2017

Instructions:

Please submit the homework including MATLAB scripts and plots as **A SINGLE DOCUMENT (PDF)** on Blackboard. You are allowed to scan in handwritten work, as long as it is legible, but please be sure to combine everything, including MATLAB scripts and plots, into a single document. All your plots should be properly annotated with both the axes labeled. Also include a separate zip file as required for Ques. **4**.

Points: [20+15+15+15+15] = 80

Question 1: [20 points]

Plot the following signals in MATLAB. Put your code and the resulting plots in your PDF.

a) [5 points]

$$y(t) = \begin{cases} 2t, & 0 < t < 1 \\ \frac{1}{2}(t^2 - 4t + 3), & 1 < t < 3 \\ 0, & \text{otherwise} \end{cases}$$

b) $z(t) = 3\cos 4t + 2\sin(2t - \pi/4)$ over the interval $-2 \le t \le 4$ s

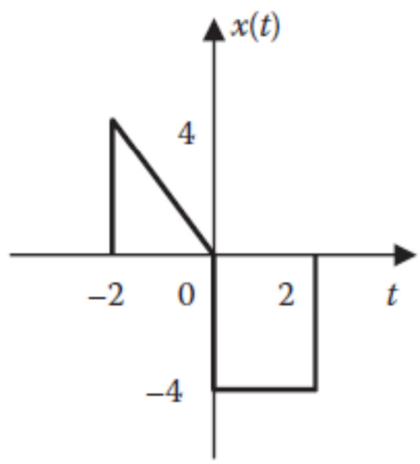
You can use a sampling frequency of *1000*Hz for a very smooth plot to define the variable '*t*' in MATLAB. Is the signal periodic (consider the amplitudes to 2 decimal places only for ease)? If it's periodic what is the corresponding period. **[5 points]**

c) Plot the signal $x_c(t) = 2\sin(200\pi t)$ over the interval $0 \le t \le 2$ s. You can still use a sampling frequency of 1000Hz to define your time variable 't' in MATLAB.

On the same graph, plot the signals, $x_{cd}(t) = e^{-2t} x_c(t)$ and $x_{ci}(t) = e^{+2t} x_c(t)$. Comment on the nature of the three signals you just plotted and the influence of multiplying the factors e^{-2t} and e^{+2t} on the signal $x_c(t)$. **[10 points]**

Question 2: [15 points]

a) Consider the signal $x(t)$ shown below. Sketch and label the transformed signals below: **[12 points]**

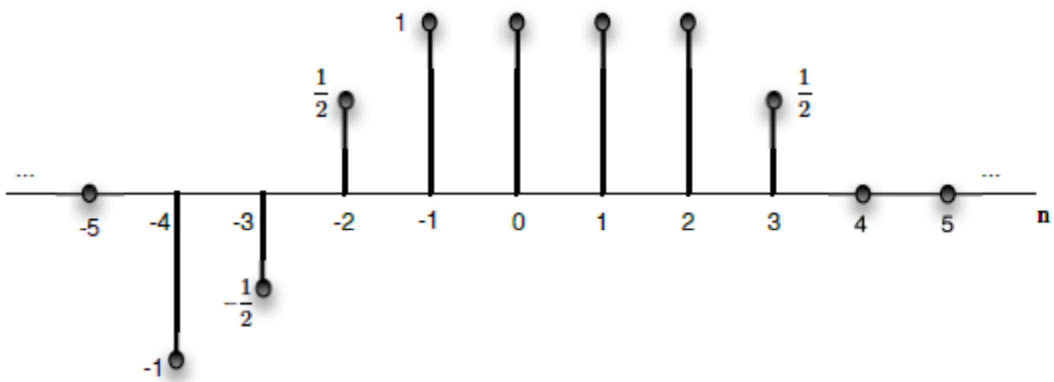


i) $z(t) = -x(-t) + 1$

ii) $y(t) = x\left(\frac{t}{2}\right)$

iii) $c(t) = x\left(-\frac{2}{3}t + \frac{1}{2}\right)$

b) Express the following signal as a function of shifted and amplitude scaled impulses, where δ[n] is the impulse function defined as: $\delta[n] = \begin{cases} 1 & \text{for } n = 0 \\ 0 & \text{otherwise} \end{cases}$. **[3 points]**

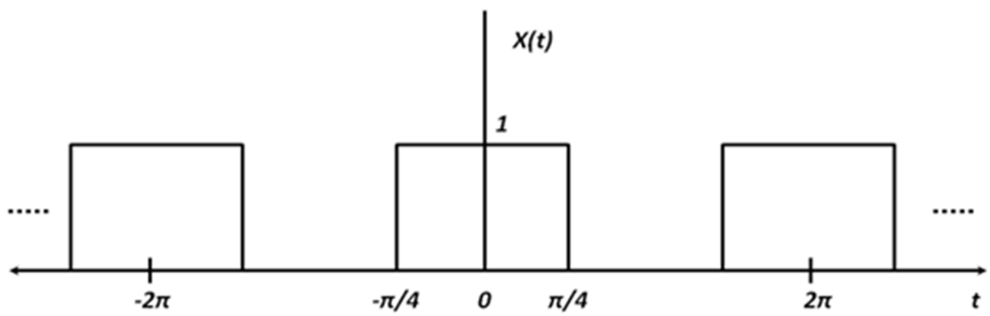


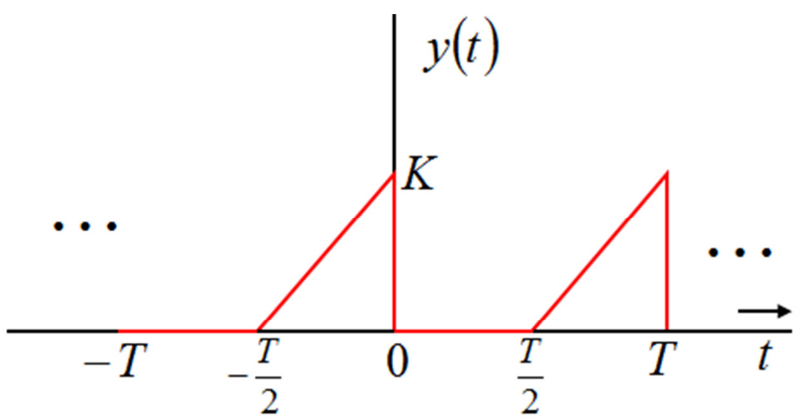
Question 3: [15 points]

Consider the periodic signals $x(t)$ and y(t) shown in the figure below. Compute for each of these signals:

a) the average (mean) value **[3 +3 points]**

b) the root mean square (rms) value **[4 +5 points]**





Question 4: [15 points]

Recording, plotting and listening to the speech signals at different sampling rates. Use your computer's microphone to record the following speech signals, save them as audio files (one for each of the alphabets below):

Vowels: /A/, /I/, /U/, /E/, /O/,

Fricatives: /S/, /F/

Plosives: /T/, /P/

a) Plot the waveforms for these three types of speech signals above as a function of time. **[9 points]**

b) ***Comment on what relative differences/similarities (if any) you could observe in your these signals***. **[2 points]**

c) Use soundsc() function of MATLAB to play the voice back at i) original sampling frequency (ii) 4 times the sampling frequency and (iii) 1/4th of the sampling frequency. **[2 points]**

Zip the files and upload them with your PDF, note it should be your own recording. Put all of your work starting from loading your sound files, defining your time-axes, displaying the signals using plots and playback commands soundsc() with different sampling frequencies as required above in a single MATLAB script to be included in your PDF document. **[2 points]**

Question 5: [15 points]

The amount of force exerted during a particular muscle movement task is measured as a function of time along with a single-channel Electromyography (EMG) sensor recording of muscle activity. The file Time_Force_EMG.txt contains 3 columns, the first one being time, the second one the force and the third one the EMG recorded electrical activity in millivolts (mV).

Write a MATLAB script to accomplish the following tasks:

a) Load the file "Time_Force_EMG.txt" in MATLAB *(use the MATLAB load command)* and store time (1st column), force (2nd column) and EMG (3rd column) as three variables "*t*", "*force*" and "*emg*", respectively. **[2 points]**

b) What was the sampling frequency, f_s, used in this acquisition? **[2 points]**

c) The force was measured indirectly in arbitrary units and we are not interested in the absolute values. We desire to map the force to Percentage Maximum Volumetric Contraction (% MVC). This can be done in a 2-step normalization process: Step 1: Subtract the minimum value of the force variable from the force to get a new minimum of zero. Step 2: Divide the result in Step 1 by the range of the force variable. Store the final normalized force (in %MVC) in the variable *force_norm*. **[4 points]**

d) Using a subplot (see *help subplot*), plot the normalized force ***force_norm*** as a function of time in the first subplot and ***emg*** as a function of time in the second subplot. **[4 points]**

e) What relationship can you observe between ***force_norm*** and ***emg***? What do you think happens to this relationship toward the end of this sequence? **[3 points]**