BME 790: Engineering Programming and Signal Processing
Fall 2013

Homework Assignment #3
Assigned Monday, October 14, 2013
Due: Wednesday, October 23, 2013

Read sections 3.1–3.5 of Hayden, 2nd edition, and then complete the following problem.

1. Problem 3.50 part (a), (b) and (d). Please note that this is the sort of problem you might have on your exam for Fourier Series.

2. Problem 3.51 (a), (b), and (e).

3. Let's try an application of Fourier Series, using a biomedically relevant signal, the EKG.

   (a) Use your modified code, FourierS.m, that you completed for Worksheet 6 in class and download EKGdata.mat from the Sakai site.

   (b) Store EKGdata.mat in a directory that MATLAB has access to.

   (c) Test your program on a square wave of arbitrary width (your choice - like we did in class). Remember you'll need to discretize the signal

   (d) Plot your original square wave on the same plot as 'Series', the output of your Fourier Series (using hold on or plot commands) to verify your program is working correctly. Make sure to check the scale of your output.

   (e) Plot your $|X[k]|$ and $\angle X[k]$ as a function of frequency in Hz for your square wave, making whatever assumptions you need to about the periodic input.

   (f) Make a new square wave, keeping the width the same as you had before but shift the function in time. How does this change your $|X[k]|$ and $\angle X[k]$ coefficients? Plot the previous values of X[k] on top of the new values using 'hold on' and '*' or another plot command for easy viewing. How does shifting the square wave while keeping the width constant affect the magnitude and phase of X[k]?

   (g) Load EKGdata.mat into MATLAB using the 'load' command and plot your EKGdata as a function of the variable Time. EKGdata.mat will have two variables, Time and EKGdata, which should be self explanatory.

   (h) Cut EKGdata down to one R-R interval only such that your new array contains only 1 complete heartbeat. Explain the method you chose to do this, and justify it. Plot your new EKGdata as a function of a new time vector (starting at t=0 instead of some arbitrary time) and determine the fundamental period of the EKG. Based on the period, can you speculate on the species this EKG dataset is from? Note: This EKG dataset comes from another Master's student working in a lab who was interested in filtering this data!

(i) Apply the MATLAB program FourierS (or a modification thereof) to find the first 20 terms of a Fourier Series fitting your one RR interval of the EKG data

(j) Plot the Fourier Series estimate of the EKG signal on top of the original raw EKG data.

(k) Is 20 terms enough for a good fit of your EKG?

(l) Plot your $|X[k]|$ and $\angle X[k]$ terms as a function of frequency in Hertz as we've done in class.

(m) Noise is a constant problem in real biomedical signals, from patient movement, to electronic noise, it can be a major headache for biomedical engineers. 60 Hz noise is a common problem in any system that uses AC to DC conversion. Does your EKGdata have 60 Hz noise? How can you tell? Are there any ways you can use the Fourier Series to reduce this noise? Supply any plots needed to justify your answer.

(n) Extra Credit! Try zeroing the 60 Hz noise component (only). Explain how you did this and what the result is. Did this do a good job of removing noise? Why or why not?