# Problem Set 10

EECS123: Digital Signal Processing

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1. Problem 7.26 from Oppenheim, Schafer, and Buck.
2. Problem 7.27 from Oppenheim, Schafer, and Buck.
3. Problem 7.28 from Oppenheim, Schafer, and Buck.
4. Problem 7.31 from Oppenheim, Schafer, and Buck.
5. (a) Use the bilinear transformation method to design a second-order Butterworth digital LPF having cutoff frequency $\lambda_c = \pi/3$. Do this "by hand." DO NOT USE MATLAB!

   (b) Plot both the magnitude and phase of your frequency response. Do this by defining a vector `a` to be your numerator coefficients, a vector `b` to be your denominator coefficients, and using the MATLAB commands

   ```
   [h,w]=freqz(a,b,512);
   mag=abs(h);
   phase=angle(h);
   plot(w,mag)
   semilogy(w,mag)
   plot(w,phase)
   ```

   (c) From the above plots, determine whether the filter has the correct cutoff frequency. Comment on the shape of the phase response. Is it linear?

6. In this problem, we will compare the order of a Butterworth IIR filter and the length of a Parks-McClellan filter with identical specifications. You can use MATLAB for this question.

   (a) Design a Butterworth filter with order $N = 14$ and cutoff $\pi/2$. Use the following command:

   ```
   [b, a] = butter(14, 0.5);
   ```

   For minimax error values $\delta_p = \delta_s = 0.01$, and $W_p = W_s = 1$, find the transition band $(\omega_p, \omega_s)$.

   (b) With $\omega_p, \omega_s, \delta_p, \delta_s, W_p, W_s$ as in Part (a), find the minimum order of Parks-McClellan filter which meets these specifications. Compare the order of this filter with the Butterworth filter.