3.7 Problems

1. Using the "`dtft`" function developed in this chapter, compute the DTFT $X\left(e^{j\omega}\right)$ of the following finite-duration sequences over $0 \leq \omega \leq \pi$ with a frequency spacing of π/M radians (i.e. $M = 1000$). For each DTFT, use the `subplot` command to plot the magnitude $|X\left(e^{j\omega}\right)|$ in one subplot and the phase $\angle X\left(e^{j\omega}\right)$ in another subplot.

   (a) $x[n] = \left\{\underset{\uparrow}{4}, 3, 2, 1, -1, -2, -3, -4\right\}$.

   (b) $x[n] = (0.6)^{|n|}\left(u[n+10] - u[n-11]\right)$.

   (c) $x[n] = n(0.9)^n\left(u[n] - u[n-21]\right)$.

   (d) $x[n] = \cos[0.5\pi n]\left(u[n] - u[n-51]\right)$.

   Include your Matlab code for generating the plots (no need to turn in the dtft function).

2. For the following two sequences,

$$\begin{aligned} x[n] &= \left\{-4, 5, 1, \underset{\uparrow}{-2}, -3, 0, 2\right\} \\ h[n] &= \left\{6, \underset{\uparrow}{-3}, -1, 0, 8, 7, -2\right\} \end{aligned}$$

   Determine $y[n] = x[n] * h[n]$ using a frequency-domain approach. More specifically, first determine $X(e^{j\omega})$ and $H(e^{j\omega})$ by taking the DTFT of $x[n]$ and $h[n]$. Next find $Y(e^{j\omega}) = X(e^{j\omega})H(e^{j\omega})$. Finally, take the inverse DTFT of $Y(e^{j\omega})$ to obtain $y[n]$. Compare your result against that obtained with time domain convolution (you may refer to the solution to problem 3(a) from chapter 2). Do this both analytically and in Matlab. The Matlab version will require you to write a function for computing the inverse DTFT. Turn in the following:

   (a) Your analytical solution showing expressions for $X(e^{j\omega})$, $H(e^{j\omega})$, $Y(e^{j\omega})$, and $y[n]$ plus your observation regarding how your $y[n]$ compares to the $y[n]$ from problem 3(a) in chapter 2.

   (b) Your Matlab function for computing the inverse DTFT.

   (c) Plots of the magnitude and phase of $X(e^{j\omega})$, $H(e^{j\omega})$, $Y(e^{j\omega})$ and the Matlab code used to produce the plots.

   (d) A stem plot that compares $y[n]$ computed using the frequency-domain approach and $y[n]$ computed using the time-domain approach (the solution to problem 3(a) from chapter 2).

3. An FIR filter filter of length 3 is defined by a symmetric impulse response; that is, $h[0] = h[2]$. Let the input to this filter be a sum of two cosine sequences of angular frequencies 0.3 rad/samples and 0.6 rad/samples, respectively. Determine the impulse response coefficients so that the filter passes only the high-frequency component of the input.