

### Final Exam

**Instructions: Do all problems. Show all work. Problems are weighted as shown. Note that there are 9 problems.**

**(10) 1.** What transform is used in both JPEG and MPEG encoding and why? For each (JPEG and MPEG), describe briefly but with some level of detail, how this method is used.

**(10) 2.** Digital transforms are used in two ways in MP3 encoding. Describe these two ways and why they are used.

**(14) 3.** “The Boss” wants to see the frequency content of a particular time-domain signal: a recording of the vibrations of some structure being struck repeatedly with a hammer--an impulse response. More importantly, she just wants a pretty picture to show investors.

**(a)** “The Boss” says, “Just take the FFT of the entire signal.” Explain why that might not be the best idea. What do you propose instead?

**(b)** “The Boss” says, “Just give me some picture that shows the frequencies at which the structure is resonating. Something that says ‘You need to buy our super strength earthquake foam.’” Write a MATLAB script that will load the wav file “bang.wav” and plot the normalized dB magnitude DFT of a 2,048-sample segment starting at time 1 second—the time of the first impulse response—windowed by a Hann window. Remember to show only the frequencies  $[0, F_s/2]$  so you do not have to explain the existence of negative frequencies. Limit the y-scale to  $[-60, 0]$  dB. (Hint: remember wavread returns the data and the associated sampling rate.)

**(10) 4.** Problem 14.7.

**(10) 5.** Do the following:

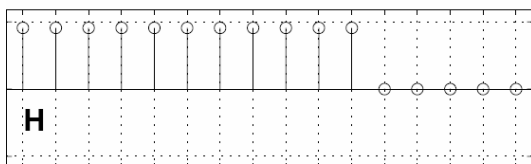
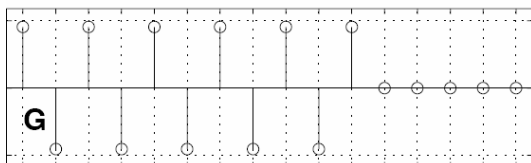
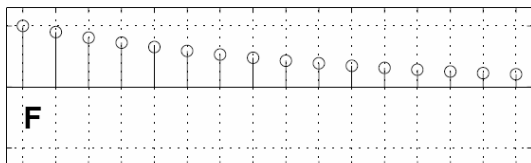
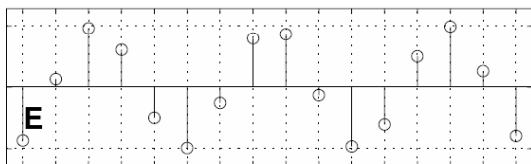
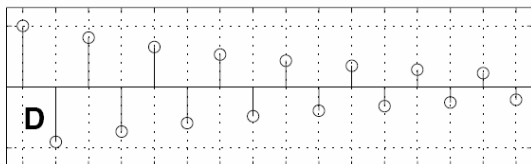
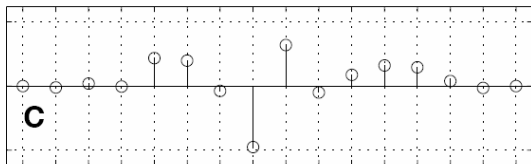
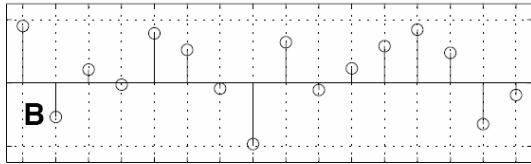
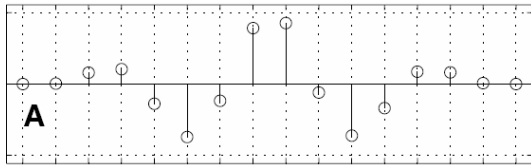
**(a)** Simplify  $W_M^{klM-kr}$  where  $k, l,$  and  $r$  take on values from 0 to  $M - 1$ .

**(b)** Show that  $W_{M/2}^k = W_M^{2k}$  where  $0 \leq k \leq \frac{M}{2} - 1$ .

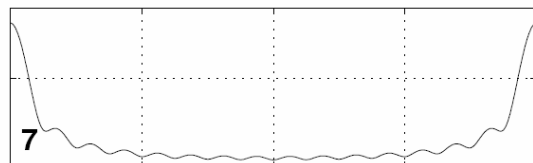
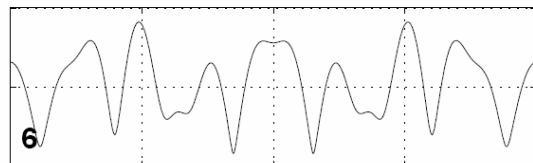
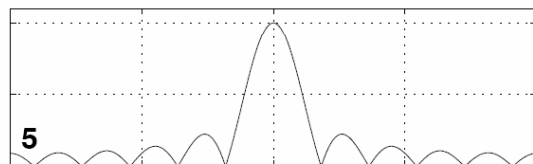
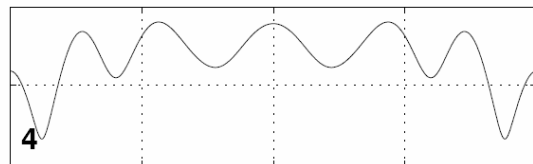
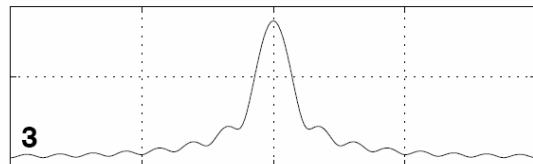
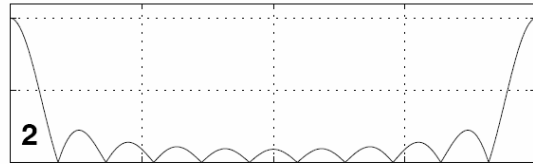
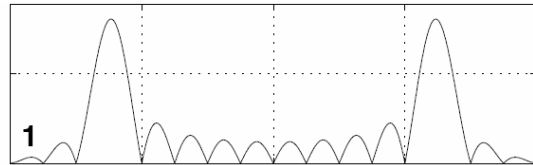
**(10) 6.** Figure 11.21 in the text shows the decimation-in-time FFT algorithm for  $N=8$ . Show that each stage of the algorithm in Fig. 11.21 consists of multiple uses of the basic module in Fig. 11.22. Then, prove that Fig. 11.22 simplifies to the “butterfly” in Fig. 11.23, and state why this is useful.

**(10) 7.** Problem 8.11(a).

**(16) 8.** In the figures below, match each time-domain signal on the left to its corresponding DTFT on the right by specifying the letter A through H that corresponds to the numbers 1 through 8.



0 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15  
n



0  $\pi$   $2\pi$   
 $\omega$

**(10) 9.** The linear prediction model is used for coding speech in digital cellular voice communications.

**(a)** Write the difference equation for an  $N$ th order linear prediction model.

**(b)** If  $N=3$  and the autocorrelation terms are

$R(0) = 1.0, R(1) = 0.866, R(2) = 0.554, \text{ and } R(3) = 0.225$ , write the matrix form of the linear simultaneous equations to be solved for the prediction coefficients.