ASSIGNED: Feb. 19, 2015. **READ:** Sects. 4.4 & 5.1-5.2.
DUE DATE: Feb. 26, 2015. **TOPICS:** DTFT and DTFS.

Please $\boxed{\text{box}}$ your answers. Show your work. Turn in all Matlab plots and Matlab code.

[20] 1. We are given x[n]=$\{\ldots 18, 12, 6, 0, 6, 12, \underline{18}, 12, 6, 0, 6, 12, 18\ldots\}$ (a periodic signal).

[10] (a) Compute the Discrete-Time Fourier Series (DTFS) expansion of x[n].
Hint: x[n] has period=6, x[n] is real-valued, and x[n] is an even function.
[05] (b) Compute average power in the time domain. Your answer should agree with:
[05] (c) Compute average power in the frequency domain.

[20] 2. We are given DTFS coefficients x_k=cos($\pi k/4$)+sin($3\pi k/4$).
Note that x_k is entirely real-valued, but it is *not* an even function.

[5] (a) Explain why x[n] with these coefficients x_k has period=8.
[5] (b) Compute the *purely real* part of x[n] from the *even* part of x_k.
[5] (c) Compute the *imaginary* part of x[n] from the *odd* part of x_k.
[5] (d) Compute average powers in time and frequency domains. Confirm they agree.
Hint: One period of x[n] has only two real and two imaginary nonzero values.
Hint: Read off x[n] from $x_k=\sum_{n=0}^{N-1}\frac{x[n]}{N}e^{-j2\pi nk/N}$. Note $e^{-j2\pi nk/N}=e^{j2\pi(N-n)k/N}$.

[10] 3. Compute DTFTs of the following. Simplify to sums of sines and cosines.

[5] (a) $\{1, 1, \underline{1}, 1, 1\}$. [5] (b) $\{3, \underline{2}, 1\}$.

[10] 4. Use the inverse DTFT to evaluate the following integrals:

[5] (a) $\frac{1}{2\pi}\int_{-\pi}^{\pi}\frac{e^{j\omega}e^{j3\omega}}{e^{j\omega}-\frac{1}{2}}d\omega$. [5] (b) $\frac{1}{2\pi}\int_{-\pi}^{\pi}e^{j3\omega}2\cos(3\omega)d\omega$.
Hint: Replace $e^{j\omega}$ with z and compute $\mathcal{Z}^{-1}$ at a specific n.

[20] 5. x[n]=$\{1, 4, 3, 2, 5, 7, \underline{-45}, 7, 5, 2, 3, 4, 1\}$. Let $X(e^{j\omega})$=DTFT[x[n]]. Compute:

[5] (a) $X(e^{j\pi})$. [5] (b) arg[$X(e^{j\omega})$]. [5] (c) $\int_{-\pi}^{\pi}X(e^{j\omega})d\omega$. [5] (d) $\int_{-\pi}^{\pi}|X(e^{j\omega})|^2 d\omega$.
Hint: Do *not* actually compute $X(e^{j\omega})$! Use some properties of the DTFT.
Note: 45>1+4+3+2+5+7+7+5+2+3+4+1, so the phase is uniquely specified here.

[20] 6. Download `p5.mat`. In Matlab, type >>`load p5.mat` to get the sampled signal `X`.

[5] (a) Listen to `X` using `soundsc(X,24000)`. Describe it. (It's not the same as before.)
[5] (b) Plot the spectrum of `X` using the Matlab command from problem set #1.
Compare carefully to the spectrum plot from problem set #1. What did I do?
[5] (c) Use `fftshift` somehow and `Y=real(ifft(FY))` to unscramble `X`.
[5] (d) Use the modulation property of the DTFT to unscramble `X` more easily.
Hint: Shifting discrete-time frequency by π does what in the time domain?
Note: This is the digital version of *voice scramblers* used in World War II.
Turn in plots of the spectrum of `X` and of its unscrambled version.

"A chicken is just an egg's way of making another egg."