Quiz & Portions Due Thursday February 1, 2018

Make note of the following:
• Please write on only one side of the paper

Problems:
1. Z&T text 2.22. Fourier series
2. Z&T text 2.29a. Fourier transform
3. Z&T text 2.31 b & e. Fourier transform properties
4. Full-Response Pulse Shapes. To be turned in. Generate all requested plots using Python (preferably in a Jupyter notebook). Setting up Pandoc and MikTeX to get printable PDF output is preferred, but second best is to take screenshots of notebook content and paste into a Word document (Open Office, etc.). It is also possible to just set up Pandoc so you can export the notebook to a printable HTML document with graphics, text, and equations. Solutions will not be provided for this problem until after the quiz.

In digital communications pulse shapes are used to control the bandwidth occupied by the corresponding signal spectrum. A binary bit stream can be sent using a bipolar sequence of pulses, i.e.,

\[ x(t) = \sum_{n = -\infty}^{\infty} d_n p(t - nT_b) \]

where \( d_n = \pm 1 \) are the data bits mapped from (0,1) to (-1,1) and \( p(t) \) is a pulse shape nonzero only on the interval \( 0 \leq t \leq T_b \). Note the bit rate is \( R_b = 1/T_b \). The Fourier transform of \( p(t) \), denoted \( P(f) \), is the spectrum of the pulse shape and is of interest in this problem. Three pulse shapes considered are:

- \( p_{REC}(t) = A_{REC} \Pi\left(\frac{t - T_b/2}{T_b}\right) \), rectangular shape
- \( p_{HS}(t) = A_{HS} \sin\left(\frac{\pi}{T_b} t\right) \Pi\left(\frac{t - T_b/2}{T_b}\right) \), halfsine shape
- \( p_{RC}(t) = A_{RC} \left[1 - \cos\left(\frac{2\pi t}{T_b}\right)\right] \Pi\left(\frac{t - T_b/2}{T_b}\right) \), raised cosine shape

a.) With \( A_{REC} = A_{HS} = A_{RC} = 1 \), \( T_b = 1 \), and a sampling interval of 0.01s or sampling rate of \( f_s = 100 \) Hz, plot all three pulse shapes on the same plot for \(-0.25 \leq t \leq 1.25\). Label the axes of the plot and include a legend that denotes the shape type as REC, HS, RC.
b.) Find values for the pulse amplitude constants such that the energy in each
pulse is 1j. A numerical solution is OK, and actually preferred.

c.) Plot the Fourier transform of each pulse shape, including the amplitude scaling of part (b), on a single plot. I want the plot in dB versus frequency over [-10,10] Hz. Use the function FT_approx() found in the Chapter 2 Jupyter notebook to numerically evaluate the Fourier transform. If say you have the pulse shape as an ndarray in variable xREC from part (a) and the scaling factor A_REC from part (b), the spectrum plot can be obtained as follows:

```python
f, XREC = FT_approx(A_REC*xREC, t, 4096)
plot(f, 20*log10(abs(XREC)))
... ylim([-80, 0])
xlim([-10, 10])
grid();
```

Comment on the relative spectral compactness of each spectrum. Which pulse shape do you think is the most spectrally efficient?

5. Z&T text 2.35 b and c. Convolution