16.36 Communication Systems Engineering

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MASSACHUSETTS INSTITUTE OF TECHNOLOGY
Department of Aeronautics and Astronautics

16.36: Comm. Sys. Engineering
Problem Set No. 1

Problem 1: Text problem 2.12, choose any four of the six

Problem 2: Text problem 2.13

Problem 3:

a) Derive the Fourier transform for $\text{Cos}(2\pi f_o t)$; (see Table 2.1 for the answer, but provide the derivation!)
b) Suppose $f_o = 10$, and that the signal is sampled at sampling rate of 30 samples per second. Sketch the frequency response of the sampled signal and show how a low-pass filter can recover the original signal.
c) Now suppose that the signal is sampled at a rate of 15 samples per second; sketch the frequency response of the sampled signal.

Note: In your sketches, you can limit yourselves to a bandwidth of 40Hz.

Problem 4: Text problem 2.40 (part 1 only). Instead of x(.005), solve for x(.01).

Problem 5: Matlab Exercise

a) Generate a sinusoidal waveform with two frequency components, 5 Hz and 10 Hz. Since Matlab only uses discrete (sampled, not continuous) signals, a sampling rate must be chosen to properly produce the waveform without aliasing. Any rate above 20 Hz will suffice, so use 30 Hz. Produce a one second plot of the waveform.
b) We next will find the frequency spectrum of the signal from part a. To do so, first use the Fast Fourier Transform function (`fft`) to bring the signal into the frequency domain. Use the `fftshift` function to produce a plot that will zero center the signal.
c) Now, create a lowpass filter to recover the 5 Hz component of the signal. Produce a plot of the filter and the filtered signal in the frequency domain.
d) With the filtered signal, take the Inverse Fast Fourier Transform (`ifft`) to bring the signal back into the time domain. Produce a plot with one second of the signal to show that the 5 Hz signal was recovered. Hint: `ifft` needs the signal to be in the same form as the output of the `fft`, so if you were working with the shifted signal, you will need to shift it again before inputting it to the `ifft`.

Be sure to turn in commented code and clearly labeled plots.

Usage information with examples on the Fast Fourier Transform (`fft`) is located at http://www.mathworks.com/access/helpdesk/help/techdoc/math/brentm1-1.html (same as located in the Matlab documentation).
For information on the Inverse Fast Fourier Transform function (`ifft`), see Matlab documentation for usage details.