Signal & Data Analysis in Neuroscience
Bar Ilan, Spring 2020 Due: June 25 10:00 AM.

Frequency domain

1) Fourier transform (analytic +Matlab)

a) Calculate analytically the Fourier Transform of: $x(t) = \cos(2\pi at) \cdot \cos(2\pi bt)\ ,\ a,b > 0$

You can use the following hint: cos(a)*cos(b) = 1/2*[cos(a-b)+ cos(a+b)]

Consider the signal for a=10 and b=110: x(t) = $\cos(2\pi \cdot 10 \cdot t) \cdot \cos(2\pi \cdot 110 \cdot t)$

b) Plot the signal over a time period of 2 seconds. **(MATLAB)**
c) What is the minimal sampling rate required for calculating DFT of this signal without aliasing?
d) Sample the signal at a sampling rate of 160 Hz for 2 seconds. Calculate the DFT of the sampled signal and plot its amplitude. Explain the results. **(MATLAB)**
e) Sample the signal at a sampling rate of 250 Hz for 40 seconds. Calculate the DFT of the sampled signal and plot its amplitude. Explain the results. **(MATLAB)**

2) Fourier transform (Matlab)

MATLAB has a built-in sound file that you can load into memory by simply typing
>> load handel. Executing this command will load several objects into the memory:
y is the sound file, a N x 1 vector storing the waveform values at regularly-spaced samples, and ***Fs*** is the sampling rate, which is set to the default of 8192 frames/sec. This means that 8192 data points in the vector are equal to 1 second of music.
You can hear the sound by typing >> sound(y, Fs) if you have a sound card.
a) Find the Fourier Transform of this signal and plot it as function of frequency in Hz.
b) You'll notice that some frequencies are more prevalent than others. What are the 2 highest power frequencies in the song? What is their power?

3) Sampling theorem

A 200Hz sinusoidal signal is sampled at a rate of 240 samples/second. Spectral analysis of the sampled signal will reveal a peak at the following frequency:

a. 40Hz
b. 80Hz
c. 120Hz
d. 160Hz
e. 200Hz

Explain your answer.