ME565 - Winter 2020 **Due: 5:00:00pm Monday March 13^{th}, 2020**
Homework 5

Exercise 5-1: Now, we will use the FFT to simultaneously compress and re-master an audio file. Please download the file `r2112.mat` and load this file (`load r2112.mat;`) at the beginning of your code for this problem to load the audio data into the matrix `rush` and the sample rate `FS`.

(a) Listen to the audio signal (`>>sound(rush,FS);`). Compute the FFT of this audio signal.

(b) Compute the power spectral density vector. Plot this to see what the output looks like. Also plot the spectrogram using the same parameters as in lecture 17.

(c) Now, download `r2112noisy.mat` and load this file to initialize the variable `rushnoisy`. This signal is corrupted with high-frequency artifacts. Manually zero the last 3/4 of the Fourier components of this noisy signal (if `n=length(rushnoisy)`, then zero out all Fourier coefficients from `n/4:n`). Use this filtered frequency spectrum to reconstruct the clean audio signal. When reconstructing, be sure to take the real part of the inverse Fourier transform: `cleansignal=real(ifft(filteredcoefs));`.

Because we are only keeping the first 1/4 of the frequency data, you must multiply the reconstructed signal by 2 so that it has the correct normalized power. Be sure to use the `sound` command to listen to the pre- and post-filtered versions. Plot the power spectral density and spectrograms of the pre- and post-filtered signals.

Exercise 5-2: Use the Laplace transform to solve the following ODEs:

(a) $\ddot{x} + 5\dot{x} + 6x = u(t)$

(b) $\ddot{x} - 2\dot{x} + 2x = u(t)$

Solve each of these for the following initial conditions and forcing functions (hint: use the Laplace transforms from above so simplify the expression in the frequency domain. I would not recommend using convolution, if you can avoid it):

(i) Step response: A step input (i.e., $u(t)$ is a Heaviside function) with zero initial conditions

(ii) Impulse response: An impulsive input (i.e., $u(t)$ is a Delta function) with zero initial conditions

For each case, plot your solution and also plot Matlab's solution using the `step` and `impulse` commands.

(iii) Initial condition response: $u(t) = 0$ with initial conditions $x(0) = 1$ and $\dot{x}(0) = 0$.

(iv) Initial condition response: $u(t) = 0$ with initial conditions $x(0) = 0$ and $\dot{x}(0) = 1$.

Summary: Solve both equations (a) and (b) using the forcing and initial conditions from (i)-(iv).
