Wherever relevant, use $\alpha = 1 + \mod(x, 3)$, where $x$ is the last three digits of your registration number. Wherever relevant, plot signals with normalised axes, with an appropriate resolution for time and with appropriate labels and legends.

**Problem 1.** (Window Functions)

1. Explore the following windows: (a) Rectangular (b) Hamming (c) Hanning.

2. Plot the spectrum of the window (if $\alpha = 1$ use Hanning window, if $\alpha = 2$ use Blackman window, if $\alpha = 3$ use Hamming window) signal for different lengths. Use a 1024 point DFT and normalise the magnitude by the actual lengths (Say $N = 100, 200, 300$).

**Problem 2.** (FIR filter design)
Design digital low pass FIR filter using rectangular and (if $\alpha = 1$ use Hanning window, if $\alpha = 2$ use Blackman window, if $\alpha = 3$ use Hamming window) functions for a cut-off frequency of $\omega_c = \frac{\pi}{\alpha+1}$ rad/sample. Select the window length for all the window functions to be 21.

1. Plot the impulse response of the two filters.

2. Perform a bode analysis on the two filters and comment on them.

**Problem 3.** (Filtering using FIR filters)
Plot the spectrogram of the $instru\alpha.wav$ (same as Exp. 5 & 6). Use any window of your choice and sample duration for the window. Design a digital FIR filter (using windowing) to only extract the fundamental (the first major peak excluding $\omega = 0$) and remove the rest including $\omega = 0$. Write it into a .wav file and listen. Also plot the spectrogram to ensure that you only have the fundamental. You may use the same specs that you have used in Exp. 6.

**Problem 4.** Differentiate between the time-domain windowing and the window-based FIR filter design. Can you give a descriptive comparison of the same?

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