1. I sampled a signal at a rate of 1 kHz. I then produced two spectrograms of the signals using a Hamming window and a rectangular window, both of length \( L = 2^n \). The color scale is in dB.

![Spectrograms](image)

a) (2 pts) Which spectrogram was produced with a Hamming window? How can you tell?

The one on the left was produced with the Hamming window because it has a wider main lobe and lower magnitude side-lobes.

b) (2 pts) What is the length of the window used?

\[
\frac{3 \text{ sec} \times 1000 \text{ samples/sec}}{\approx 136} \quad \Rightarrow \quad \text{Length is } L = 128
\]

2. Suppose I have white noise with variance \( \sigma^2 \) as a random variable input \( X \) to an LTI system with impulse response resulting in ouput random variable \( Y \).

\[
h[n] = \begin{cases} 1, & n = 0 \\ 2, & n = 1 \\ 3, & n = 2 \\ 0, & \text{otherwise} \end{cases}
\]

a) (2 pts) What is the mean of \( Y \)?

\[
m_Y = m_X \sum_{k=-\infty}^{\infty} h[k] = 0.
\]

b) (2 pts) What is the cross correlation \( \phi_{yx} \)?

\[
\phi_{yx}[n] = h[n] \ast \phi_{xx}[n] = h[n] \ast \sigma^2 \delta[n] = \sigma^2 h[n]
\]

b) (2 pts) What is the autocorrelation \( \phi_{yy} \)?

\[
\phi_{yy}[n] = \phi_{xx}[n] \ast h[n] \ast \delta[-n]
\]

\[
= \begin{cases} 3 \sigma^2, & n = -2 \\ 3 \sigma^2, & n = -1 \\ 14 \sigma^2, & n = 0 \\ 8 \sigma^2, & n = 1 \\ 3 \sigma^2, & n = 2 \\ 0, & \text{otherwise} \end{cases}
\]