**Assignment 6 part 1**

I created a white noise signal by randomly generating numbers from a gaussian distribution with a mean of 2 and a standard deviation of 5. The white noise signal had a length of 100 000s. I created my own corel.m function and computed the biased auto-correlation coefficient function of white noise, with lags varying from -1000s to 1000s. The white noise as well as the biased auto-correlation-coefficient function can be seen in figure 1. As we can see, the correlation is approximately 1 when the lag is zero, and zero for all other lags. More precisely, the correlation at lag zero is 0.99999. Even though the signal is perfectly correlated with itself, it is not possible for it to reach a correlation of 1 since we used a biased auto-correlation-coefficient function.



Figure 1: White noise and its auto-correlation-coefficient function.

**Assignment 6 part 2**

**X1**

The auto-correlation-coefficient function of x1 can be seen in figure 2. Except at lag = 0, the correlation seems to be approximately zero. This suggests the signal was drawn from a probability density function with independent samples. To get an idea of what this probability density function is, the frequency distribution of x1 is shown in figure 1.



Figure 1: Sample auto-correlation coefficient function and frequency distribution of x1.

**X2**

The auto-correlation coefficient function of x2 can be seen in figure 3. The correlation reaches its peak at lag = 0, and progressively diminishes until a lag of approximately 0.01 where the correlation tends towards zero. However, the correlations seem to follow a certain pattern and to distinguish themselves from zero. This suggests there is a certain pattern to the signal, and most likely that it has noise.



Figure 3: Auto-correlation coefficient function of x3.

**X3**

The auto-correlation coefficient function of x3 can be seen in figure 4. Since the correlation reaches correlations of approximately 1 to -1 in a sinus wave pattern, this suggests the signal is mostly deterministic and itself follows a sinus wave pattern. From figure 4, we can also deduce the signal has a period of approximately 1 second.



Figure 4: Auto-correlation coefficient function of x4.

**X4**

The auto-correlation coefficient function of signal x4 is shown in figure 5. The correlations clearly follow a sinusoid pattern, but with relatively small values varying from approximately 0.08 to -0.08. This suggests the signal is composed of a single frequency component mostly buried in noise.



Figure 5: Auto-correlation coefficient function of signal x4.

**X5**

The auto-correlation coefficient function of signal x5 can be seen in figure 6. The ripples in the top panel of figure 6 resemble the one from module 6 slide 50. This suggested this signal has been passed through a low-pass filter, as is supported by the bottom panel of figure 6. The ripples might possibly also be caused by some periodicity in the signal.



Figure 6: Auto-correlation coefficient function of signal x5.

**Assignment 6 part 3**

**X6**

The auto-correlation coefficient function of the input and of the output of x6, as well as the cross-correlation between the input and output, can be seen in figure 7. According to module 6 slide 48, the input and output seem to follow a static relationship with noise. The input and output seem to be white noise, since the correlation is approximately zero when the lag is greater or lesser then zero.



Figure 7: Auto-correlation of the input and output of x7, with the cross-correlation between the two.

**X7**

Both the input and output of x7 are a combination of a linear slope over time with some stochastic component (see figure 8).



Figure 8: Input and output of x7.

The intercept and slope of the input are of -2 and 0.2, while the intercept and slope of the output are of 5 and 0.1. This suggests the system might have changed the intercept and slope of this linear relationship between energy and time. To test this hypothesis, we isolated the error component from the linear relationship of both the input and output noted above. We computed the cross-correlation between the errors of the input and output, as shown in figure 9. As we can see, the input and output errors do not seem to be cross-correlated, disproving the hypothesis stated above.



Figure 9: Auto-correlation of x7 input and output errors, with the cross-correlation between the input and output errors.

**X8**

The auto-correlation coefficient function of the input and of the output of x8, as well as the cross-correlation between the input and output, can be seen in figure 10. The relationship between the input and output seems to be static with some noise (module 6 slide 48). The correlation peak is not at zero but at -0.5s, suggesting the output is a delayed version of the input with some stochastic component added to it.



Figure 10: Auto-correlation of x8 input and output. with the cross-correlation between the input and output.

**X9**

The auto-correlation coefficient function of the input and of the output of x9, as well as the cross-correlation between the input and output, can be seen in figure 11. This pattern is similar to module 6 slide 51, suggesting the system might be a low-pass filter with some noise.



Figure 11: Auto-correlation of x9 input and output. with the cross-correlation between the input and output.

**X10**

The auto-correlation coefficient function of the input and of the output of x10, as well as the cross-correlation between the input and output, can be seen in figure 12.