E2.5 Signals & Linear Systems

Tutorial Sheet 1 – Introduction to Signals & Systems

(Lectures 1 & 2)

1.* Sketch each of the following continuous-time signals. For each case, specify if the signal is causal/non-causal, periodic/non-periodic, odd/even. If the signal is periodic specify its period.

(i) $x(t) = 2\sin(2\pi t)$

(ii) $x(t) = \begin{cases} 3e^{-2t}, & t \geq 0 \\ 0, & t < 0 \end{cases}$

(iii) $x(t) = 1/|t|$

2.* Sketch the signal

$$x(t) = \begin{cases} 1-t, & 0 \leq t \leq 1 \\ 0, & \text{otherwise} \end{cases}$$

Now sketch each of the following and describe briefly in words how each of the signals can be derived from the original signal $x(t)$.

(i) $x(t+3)$

(ii) $x(t/3)$

(iii) $x(t/3+1)$

(iv) $x(-t+2)$

(v) $x(-2t+1)$

3.** Sketch each of the following signals. For each case, specify if the signal is causal/non-causal, periodic/non-periodic, odd/even. If the signal is periodic specify its period.

(i) $x[n] = \cos(n\pi)$

(ii) $x[n] = \begin{cases} 0.5^{-n}, & n \leq 0 \\ 0, & n > 0 \end{cases}$

4.*** Consider the rectangular function

$$\Pi(t) = \begin{cases} 1, & |t| < 1/2 \\ 1/2, & |t| = 1/2 \\ 0, & \text{otherwise} \end{cases}$$

(i) Sketch $x(t) = \sum_{k=0}^{1} \Pi(t-k)$

(ii) Sketch $x(t) = \sum_{k=-\infty}^{+\infty} \Pi(t-k)$. (Hint: there is a simple way to express this signal.)

5.** Consider a discrete-time signal $x[n]$, fed as input into a system. The system produces the discrete-time output $y[n]$ such that

$$y[n] = \begin{cases} x[n], & n \text{ even} \\ 0, & n \text{ odd} \end{cases}$$

(i) Is the system described above memoryless? Explain.
(ii) Is the system described above causal? Explain.
(iii) Are causal systems in general memoryless? Explain.
(iv) Is the system described above linear and time-invariant? Explain.

6.** State with a brief explanation if the following systems are linear/non-linear, causal/non-causal, time-invariant/time-varying.

(i) $y[n] = x[n] - x[n-1]$
(ii) $y[n] = \text{sgn}(x[n])$
(iii) $y[n] = n^2 x[n+2]$

7.** State with a brief explanation if the following systems are linear/non-linear, causal/non-causal, time-invariant/time-varying.

(i) $y(t) = x(t)\cos(2\pi f_o t + \phi)$
(ii) $y(t) = A\cos(2\pi f_o t + x(t))$
(iii) $y(t) = \int_{-\infty}^{t} x(\delta)d\delta$
(iv) $y(t) = x(2t)$
(v) $y(t) = x(-t)$

8. Matlab Exercise:

Exercise 1: Trying it Out

Go through the examples in the notes for tutorial 1 & 2. Make sure that you understand them.

Exercise 2: Noisy Sinewave

- Generate a vector signal with 4 cycles of 1kHz sinewave at a sampling frequency of 44.1kHz and an amplitude of 1V.
- Plot the signal on the screen and label the X and Y axes with the correct labels.
- Convert your matlab code into a function in an M-file.

- Use ‘help’ to lookup the description of the built-in function randn().
- Generate a normally distributed random noise signal, also at 44.1KHz with the same number of samples as your sincwave. The rms value of the noise should be 0.1V.
- Add the noise to your original signal and plot it.
- Plot all three signals as a combined plot.