**B1.1 Tutorials**

Q1 Evaluate the following :



**Q2:** The continuous cosine signal x(t)=16cos(300πt +π/7) is sampled using the following sampling frequencies (i) 350 Hz (ii) 450 Hz (iii) 750 Hz to form 3 discrete signals x1[n], x2[n] and x3[n].

For each sampling frequency

(i) Write down an analytic for the sampled signals and compute Ω (Digital Frequency) and N (Fundamental Period)

(ii) By hand and using Matlab draw exactly one period of each sampled signal

(iii) Draw the one sided Magnitude and Phase Spectrum of the Sampled Signals . For the frequency axis use both the f (Hz) and the Ω labels.

(iv) Draw the 2- sided Magnitude and Phase Spectrum of the Sampled Signals. For the frequency axis use both the f (Hz) and the Ω labels.

(v) Compute the power of the sampled signals analytically and from the Magnitude spectrum of part (iv) above.

(vi) The discrete signal x1[n] is converted into a Digital signal xQ1 [n] using a uniform quantiser and 4 bits where the value of zero is associated with one of the levels (mid-thread). Draw one fundamental period of both signals on the same plot. Compute the Signal to Quantisation Noise ratio (SQNR) in dBs. Repeat the above process using 8 bits and comment on your observations.

**Q3**: It is required to form a discrete model of a LTI continuous system that is described by the following 1st order differential equation that has an impulse response h(t)=exp(-0.5t)u(t) :

Using a sampling frequency of fs = 4Hz or T = ¼ sec and the approximation to the differential

dy(t)/dt = [y(nT)-y(nT-T)]/T = { y[n] – y[n-1] }/ T

where T is the sampling interval determine a linear difference equation that describes the discrete model.

Tabulate the first 10 samples of the impulse response and step response of the discrete model.

What is the characteristic equation of this discrete model ?

Explain the similarities and differences between the impulse response of the discrete model and that of the continuous system.

**Q4:** The unit impulse response of a LTI discrete system is measured as

h[n]= 3δ[n-3]+ 0.5δ[n-4]+ 0.2δ(n-5)+ 0.7δ[n-6]-0.8δ[n-7]

What is the output of this system due to an input x[n]=u[n-1]-u[n-3] ?

Sketch all discrete signals.

**Q5:** If x[n]=anu[n] and h[n] = bnu[n] find y[n]=x[n]\*h[n] for (ii) a ≠ b and (ii) a = b. Sketch your responses.

**Q6**: Linear Convolution and Correlation:

Compute the convolution y[n]=x[n]\*h[n] where:

(a) x[n]={0,0,**1**,2,4,0,0} and h[n]={0,0,**1**,1,1,1,0,0}

(b) x[n]={0,0,**1**,2,4,0,0} and h[n]=x[n]

Confirm the commutative property for Q8(a) above.

(c)(from lecture slides)

Use pen and paper to filter the following 5x5 image (I) using a 3x3=Sobel Edge detector to produce an output Iout. You may assume that the elements outside the borders of I equals 0. In your answer the dimension of the processed image Iout should remain of size 5x5

8 12 56 12 10

8 10 60 14 8

I = [ 9 12 59 10 8 ]

10 10 61 10 6

11 10 62 10 5

(d)Linear Correlation

1. Compute the Energy, and the Normalised Autocorrelation

Lags for the following 2 Discrete signals.

1. x1[n]=[-**4** -4 -1 3 5 1 0 -3]
2. x2[n**]=[5** 0 -2 2 3 2 5 -2]
3. Plot the Normalised Autocorrelation coefficients as a functionof lags and from these plots deduce with reasons which signal has a periodic component and which signal is of a random nature.

**Q7**: The impulse response of a LTI discrete system is h[n]=(1/3)nu[n]. Find the response of this system to the input x[n]= exp(jnπ/4). \*hint: do not use the convolution sum directly .

**Q8:** An interconnected system is shown below:

h1[n]

x[n]

y[n]

+

h2[n]

h3[n]

Given h1[n]=[ **1** 2 1 ], h2[n]= [ 3 **4** 2 1 1 ] and h3[n]=δ[n-2] find the impulse response of the overall system.

**Q9: Block Convolution**

Using M=3 and L=6 use (i) Overlap Save and (ii) Overlap Add block convolution methods to compute the linear convolution between x[n] and h[n] where

x[n] = [ 1 2 3 4 5 6 5 4 3 2 1 2 3 4 5 ]

h[n]= [ 1 2 1 ]

You must use Cyclic Convolution in this problem because, as you will see later in the course, the FFT based fast convolution algorithm will be used which forms the cyclic convolution. Therefore as indicated in the lectures you will need to discard invalid (aliased) output samples in the overlap save method and you will need to append zeros onto blocks in the Overlap Add method.