



**UNIVERSITY  
of  
LIMERICK**  
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COLLEGE of INFORMATICS and ELECTRONICS

Department of Computer Science  
and Information Systems

**Final Assessment Paper**

Academic Year:	2005/2006	Semester:	Autumn
Module Title:	Intro. to Applied Digital Signal Processing	Module Code:	CS4156
Duration of Exam:	2½ hours	Percent of Semester Marks:	60
Lecturer:	P. Healy	Paper marked out of:	100

**Instructions to Candidates:**

- Answer all questions
- Each question counts for 20 marks.

1. A signal composed of sinusoids is given by

$$x(t) = 7 \cos(800\pi t + \frac{\pi}{4}) - 3 \cos(1600\pi t - \frac{\pi}{3}) + 3 \cos(3200\pi t)$$

- (a) Sketch the spectrum of this signal, indicating the complex size of each frequency component. (8 marks)
- (b) Is  $x(t)$  periodic? If so, what is its period? (6 marks)
- (c) Consider the signal defined as

$$x'(t) = x(t) + 5 \cos(1000\pi t + \frac{\pi}{2})$$

Is  $x'(t)$  periodic? If so, what is the period? (6 marks)

2. Suppose that an LTI system has a system function

$$H(z) = 1 + 5z^{-1} - 3z^{-2} + 2.5z^{-3} + 4z^{-5}$$

- (a) Determine the difference (or, system) equation that relates the output  $y[n]$  to the input  $x[n]$ ; (6 marks)
- (b) What is the order of the system? (4 marks)
- (c) Determine the output sequence  $y[n]$  when the input is  $x[n] = \delta[n]$ ; (6 marks)
- (d) Plot the output sequence  $y[n]$  you determined in the previous part. (4 marks)

3. One form of the *deconvolution* process starts with the output signal and the filter's impulse response, from which it should be possible to find the input signal. Determine the input signal,  $x[n]$ , in each of the following three cases, if

- (a) the output of an FIR filter with  $h[n] = \delta[n - 2]$  is (6 marks)

$$y[n] = u[n - 3] - u[n - 6]$$

- (b) the output of a first-difference FIR filter is (6 marks)

$$y[n] = \delta[n] - \delta[n - 4]$$

- (c) the output of a 4-point averager is (8 marks)

$$y[n] = -5\delta[n] - 5\delta[n - 2]$$

4. An LTI system is described by the difference equation

$$y[n] = -0.8y[n - 1] + 0.8x[n] + x[n - 1]$$

- (a) Determine the system function  $H(z)$  for this system. Express  $H(z)$  as a ratio of polynomials in  $z^{-1}$  (negative powers of  $z$ ) and also as a ratio of polynomials in positive powers of  $z$ ; (5 marks)
- (b) Plot the poles and zeros of  $H(z)$  in the  $z$ -plane; (5 marks)
- (c) From  $H(z)$  obtain an expression for  $H(e^{j\omega})$ , the frequency response of this system; (5 marks)
- (d) Show that  $|H(e^{j\omega})|^2 = 1$  for all  $\omega$ . (5 marks)

5. Write MATLAB statements for each of the following tasks

- (a) Create a vector, `oo`, of 11 1s; (5 marks)
- (b) Create a vector, `hh`, of 11  $\frac{1}{11}$ s; (5 marks)
- (c) Create a 51-point sample vector, `xx`, of  $\cos(0.07\pi t)$ ; that is, `xx[1]` sample should have value  $\cos(0.07\pi)$ ,  $0 \leq t \leq 50$ ; (5 marks)
- (d) Determine the output of an 11-point running average system when given input `xx` as above. (5 marks)