National Exams December 2012

07-Elec-A3, Signals and Communications

3 hours duration

NOTES:

1. If doubt exists as to the interpretation of any question, the candidate is urged to submit with the answer paper, a clear statement of any assumptions made.
2. This is a Closed Book Exam but one aid sheet is allowed written on both sides. An approved calculator is permitted. Casio or Sharp approved models.
3. FIVE (5) questions constitute a complete paper. The first five questions as they appear in the answer book will be marked.
4. All questions are of equal value.
5. Clarity and organization of the answer are important.

1. **(Total 20 marks)** Figure 1, (a) and (b) shows the input $x(t)$ and the impulse response $h(t)$ for a linear time invariant (LTI) system, find and sketch the output signal $y(t)$.

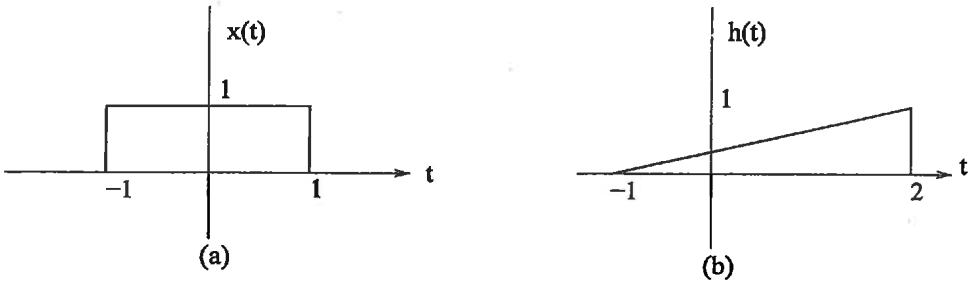

Figure 1:

2. **(Total 20 marks)** The following two questions are un-related to each other, solve each question independently.

   (a) **(10 marks)** A discrete-time LTI system is shown in Figure 2. Express the overal impulse response of the system, $h[n]$, in terms of $h_1[n], h_2[n], h_3[n], h_4[n]$, and $h_5[n]$.

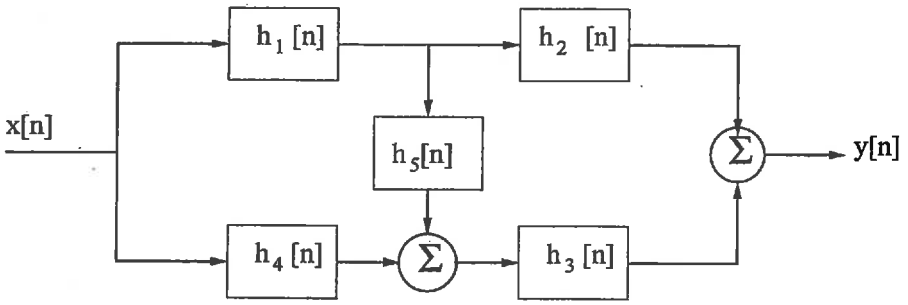

Figure 2:

   (b) **(10 marks)** Two LTI discrete systems in cascade have impulse response $h_1[n]$ and $h_2[n]$, respectively. Show that if $h_1[n] = (0.9)^n u[n] - 0.5(0.9)^{n-1}u[n-1]$ and $h_2[n] = (0.5)^n u[n] - 0.9(0.5)^{n-1}u[n-1]$, the cascade system is an identity system.

3. **(Total 20 marks)** For a system specified by the following difference equation

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

(a) **(10 marks)** Find frequency response of the system $H[e^{j\Omega}]$, plot magnitude and phase response of $H[e^{j\Omega}]$ as function of Ω, ($|H[e^{j\Omega}]|$, $\angle H[e^{j\Omega}]$).

(b) **(10 marks)** Find system response to the input $x[n]$, a sampled sinusoidal $\cos(1500t)$ with sampling interval $T = 0.001$.

4. **(Total 20 marks)**

   (a) **(10 marks)** Given the signal $x(t) = e^{-t}u(t)$, find and simplify the expression for the Fourier transform of the signal $y(t)$, where

$$y(t) = \int_{-\infty}^{t} [x(\lambda + 2) + x(\lambda - 1)]d\lambda.$$

   (b) **(10 marks)** Find and simplify the expression for the signal $g(t)$ whose Fourier transform is given as:

$$G(\omega) = j\pi \text{rect}(\frac{\omega}{4}) * [\delta(\omega + 10) - \delta(\omega - 10)]$$

   ("*" denotes convolution)

5. **(Total 20 marks)** Sketch the AM signal $[A + m(t)]\cos\omega_c t$ for periodic triangular signal $m(t)$ shown in the Figure 3. corresponding to the modulation index:

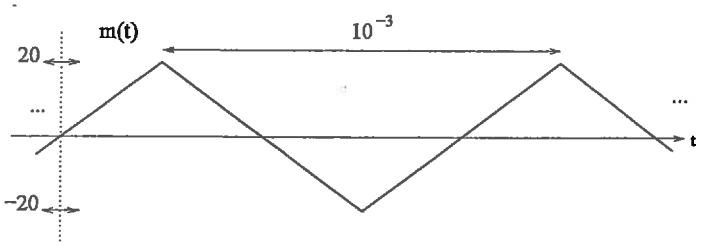

Figure 3:

(a) **(5 marks)** $\mu = 0.5$

(b) **(5 marks)** $\mu = 1$

(c) **(5 marks)** $\mu = 2$

(d) **(5 marks)** $\mu = \infty$

6. **(Total 20 marks)** In a certain telemetry system, there are eight analog measurements, each of bandwidth 4 kHz. Samples of these signals are time-division multiplexed, quantized, and binary coded. The error in sample amplitudes cannot be greater than 1% of the peak amplitude.

   (a) **(10 marks)** Determine L, the number of quantization levels.

   (b) **(10 marks)** Find the transmission bandwidth B_T if Nyquist criterion pulses with roll-off factor $r = 0.2$ are used. The sampling rate must be at least 25% above the Nyquist rate.