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ECE
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National Institute of Technology Hamirpur (HP)
Electronics & Communication Engineering Department
End Semester Examination, November 2023
B.Tech./Dual Degree (ECE) – 3rd Semester
Communication Theory (EC-213)

Time: 3 Hrs. **Max. Marks: 50**

Note: The symbols and variables used have their usual meaning. All questions carry equal marks.

Q1. Attempt ***any two*** parts:

(a) Sketch the following signals and compute their normalized energy.
(i) $x_1(t) = t\,u(t)$, (ii) $x_2(t) = 2\,[u(t+1) - u(t-1)]$.

(b) Determine whether the system described by $y(t) = t\,x(t)$ (with input signal $x(t)$ and output signal $y(t)$) is time-invariant and stable.

(c) Establish the mathematical relation between unit step, unit impulse and unit ramp functions.

Q2. Discuss sampling theorem. What is aliasing and how it can be removed? A continuous time signal is given as: $x(t) = 8\cos 200\pi t$, determine

(i) Minimum sampling rate i.e., Nyquist rate required to avoid aliasing.
(ii) If sampling frequency f_s = 400 Hz. What is the discrete-time signal x(n) or $x(nT_s)$ obtained after sampling?
(iii) If sampling frequency f_s = 150 Hz. What is the discrete-time signal x(n) or $x(nT_s)$ obtained after sampling?
(iv) What is the frequency $0 < f \leq f_s/2$ of sinusoidal that yields samples identical to those obtained in part (iii)?

OR

Find the Fourier transform of the following signals: (i) $x_1(t) = e^{-|t|}$ (ii) $x_2(t) = \frac{1}{1+t^2}$. Also, determine the Nyquist rate (minimum sampling rate) for each of the following signals:

(i) $x(t) = \cos(200\pi t) + \sin(400\pi t)$
(ii) $y(t) = \frac{d}{dt}(x_1(t))$, where $x_1(t)$ is band limited to 20 KHz.

Q3. (a) List the properties of CDF. Find the constant k for the density function $f_X(x) = kx^2$, for $0 < x < 2$ and zero elsewhere. Also compute $P(1 < x < 2)$.

(b) What do you mean by mean value and variance of a random variable? Find the expected values $E(X)$ and $E(X^2)$ of a random variable X whose probability density function is given by

$$f_X(x) = \begin{cases} 2e^{-2x}, & x > 0; \\ 0, & \text{otherwise.} \end{cases}$$

Q4. (a) Discuss the following types of noise in communication systems

(i) Shot noise (ii) Thermal noise

(b) An amplifier operating over the frequency range from 16 MHz to 20 MHz has a 5 KΩ input resistor. Calculate the rms noise voltage at the input to this amplifier if the ambient temperature is 27°C.

Q5. (a) Consider a binary memoryless source X with two symbols x_1 and x_2. Show that the entropy $H(X)$ is maximum when both x_1 and x_2 are equiprobable.

(b) Find the mutual information of the channel shown in the channel diagram below. Given that $P(x_1) = 0.6$ and $P(x_2) = 0.4$.