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Question Paper Code: 1213188

B.E. / B.Tech. DEGREE EXAMINATIONS, NOV/ DEC 2024
Third Semester
Biomedical Engineering
U20BM303 – SIGNALS AND SYSTEMS
(Regulation 2020)

Time: Three Hours   Maximum: 100 Marks

Answer ALL questions

PART – A   (10 x 2 = 20 Marks)

1. Differentiate between energy and power signals with examples.

2. Justify the significance of linearity and time-invariance in system analysis.

3. How does the Fast Fourier Transform (FFT) improve the computation of the Discrete Fourier Transform (DFT)?

4. Recall the Parseval's theorem for a Fourier series.

5. Apply the sampling theorem to determine the minimum sampling rate for a signal with a bandwidth of 5 kHz.

6. Infer the effects of aliasing on a sampled signal in real-world applications, and propose strategies to mitigate these effects in digital signal processing systems.

7. Describe the transfer function of the electrical analog model of blood vessels.

8. Calculate the time constant of a simple RC model used to represent arterial compliance. Assume R = 1 kΩ and C = 2 μF.

9. Draw the electrical circuit model used for modeling blood pressure.

10. Draw the components of a block diagram representation of the cardiovascular system.

PART – B (5 x 16 = 80 Marks)

11. (a) (i) Examine the different types of standard signals with examples. Such as step, ramp, impulse, and sinusoidal signals. Discuss their characteristics and mathematical representations. (8)

(ii) Analyze the response of a continuous-time linear time-invariant (LTI) system to a given input signal $x(t)=e^{-2t}u(t)$ using convolution. Assume the system's impulse response is $h(t)=e^{-t}u(t)$. (8)

(OR)

(b) (i) A discrete-time LTI system has an impulse response $h[n]=(1/2)^n u[n]$. If the input to the system is $x[n]=2^n u[n]$, determine the system output using the convolution sum. (8)

(ii) Classify continuous-time (CT) and discrete-time (DT) signals. Provide examples and explain the criteria used for their classification, including periodicity, causality, and stability. (8)

12. (a) (i) Identify the properties of and Discrete-Time Fourier Series (DTFS) and compare their applications in signal processing. (8)

(ii) Given a continuous-time signal $x(t) = 3 \cos (2\pi t) + 2 \sin (4\pi t)$, use the Fourier Transform to find its frequency domain representation. (8)

(OR)

(b) (i) Derive the formula for the Discrete Fourier Transform (DFT) of a signal and solve for the DFT of a 4-point sequence $x[n]=\{1,2,3,4\}$. (8)

(ii) Discuss the advantages and limitations of Fast Fourier Transform (FFT) in ECG signal analysis. Provide a case study where FFT analysis is particularly useful. (8)

13. (a) (i) Explain the Sampling Theorem and discuss the consequences of violating the Nyquist criterion in signal reconstruction. (8)

(ii) Compute the Laplace Transform of $f(t) = e^{-3t} \sin (2t)$ and find the region of convergence (ROC). (8)

(OR)

(b) (i) Given a discrete-time signal $x[n] = 0.5^n u[n]$, where u[n] is the unit step function, calculate its Z-transform and discuss the region of convergence. (8)

(ii) A continuous-time signal $x(t) = \sin (2000\pi t)$ is sampled at a rate of 8000 samples per second. Determine if aliasing occurs, and justify your answer. (8)

14. (a) (i) Describe the physiological fluctuations observed in arterial pressure, heart rate, and respiration. Explain how these fluctuations impact physiological signal measurement and analysis. (8)

(ii) Design a basic signal conditioning circuit for an ECG signal with necessary components such as filters and amplifiers and explain their function in improving signal quality for analysis. (8)

(OR)

(b) (i) With the help of an electrical analog model, illustrate and explain the transfer function of blood vessels. How does this model help in understanding blood flow and pressure regulation? (8)

(ii) Discuss the unique characteristics of ECG, EEG, and EMG signals. How does the nature of each signal influence the design of signal conditioning equipment for accurate measurement? (8)

15. (a) Explain the block diagram representation of the immune response model to disease. Describe the interaction between various components within the immune system and how this model helps predict the body's response to an infection. (16)

(OR)

(b) Using an electrical analog model, show the respiratory system's response to increased airway resistance. If the resistance value is doubled while lung compliance remains constant, calculate the expected change in airflow and discuss the implications for respiratory function. (16)

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