SEMESTER S6

DIGITAL SIGNALS AND PROCESSING

Course Code	**PBEVT604**	**CIE Marks**	60
Teaching Hours/Week (L: T:P: R)	3:0:0:1	**ESE Marks**	40
Credits	4	**Exam Hours**	2 Hrs. 30 Min.
Prerequisites (if any)	Mathematics for Electrical and Physical Sciences (GYMAT101, GYMAT201)	**Course Type**	Theory

Course Objectives:

1. Understand the definitions and classifications of continuous and discrete-time signals, and perform basic operations on these signals, including analysing their frequency characteristics.
2. Comprehend the fundamental properties of continuous-time and discrete-time systems, with a focus on linear time-invariant (LTI) systems, their impulse responses, and various types of convolutions.
3. Gain proficiency in the Fourier transform for both continuous and discrete-time signals, understand the sampling theorem, and learn about frequency aliasing and the properties of the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT).
4. Develop the ability to design and analyse digital FIR and IIR filters, understand their transfer functions and structures, and apply various methods for digital filter design.

SYLLABUS

Module No.	**Syllabus Description**	**Contact Hours**
1	**Introduction to Continuous andDiscrete Time Signals:** Definition of signal, Basic continuous-time signals, Frequency and angular frequency, Basic operation on signals, Basic discrete-time signals - Frequency and angular frequency of discrete-time signals, Classification of continuous-time & discrete- time signals: Periodic and Non-periodic signals, Even and Odd signals, Energy and power signals.	**9**

2	**Systems:** System definition, Continuous-time and discrete-time systems, Properties – Linearity, Time invariance, Causality, Invertibility, Stability, Representation of systems using impulse response. Linear time invariant systems: LTI system definition, Response of a discrete-time LTI system and the convolutional sum, Circular convolution, Linear convolution through circular convolution, Correlation of discrete-time signals.	9
3	**Frequency analysis of signals:** Fourier transform of continuous-time and discrete-time signals, Parseval's theorem, Interpretation of Spectra,Sampling theorem (Proof not needed), Frequency aliasing due to sampling, Need for anti-aliasing filters, Discrete Time Fourier Transforms – properties, Discrete Fourier Transform – Properties -DFT as a linear transformation, IDFT, FFT-Radix-2 DIT and DIF algorithms, FFT Algorithms for IDFT.	9
4	**Digital Filters:** Digital FIR Filter, Transfer function - Difference equation, Linear phase FIR filter, Concept of windowing, Direct form and cascade realization. Digital IIR Filters – Transfer function, Difference equation, Direct and parallel Structures, Design of analog Butterworth filters, Analog frequency transformations, Impulse invariance method, Bilinear transformation, Analog prototype to digital transformations.	9

Suggestion on Project Topics

1. Collect various real-world signals (audio, temperature, ECG, etc.) and classify them into continuous-time and discrete-time signals. Perform basic operations such as scaling, shifting, and time-reversal on these signals and analyse their properties.

2. Generate discrete-time signals and compute their frequency components using the Discrete Fourier Transform (DFT). Analyse the frequency spectrum and compare it with the theoretical frequency components.

3. Capture audio signals using a microphone, classify them as continuous-time signals, and convert them into discrete-time signals. Perform operations like filtering, amplification, and noise reduction.

4. Obtain ECG signals, classify them, and perform basic operations to analyse heart rate variability, detect anomalies, and filter out noise.

5. Design a discrete-time linear time-invariant (LTI) system and determine its impulse response, then compute the output of the system for various input signals using convolution.

6. Analyse the properties (linearity, time-invariance, causality, and stability) of a given discrete-time system and provide theoretical justifications and practical demonstrations for each property.

7. Design and implement a digital equalizer for audio systems, utilizing the properties of linear time-invariant (LTI) systems. Analyse its performance in adjusting different frequency bands.

8. Develop a real-time noise cancellation system using digital filters, leveraging convolution and system properties. Test the system in various noisy environments.

9. Compute the Fourier transform of continuous-time and discrete-time signals and analyse their spectra. Use tools like MATLAB, Octave or Python for computation and visualization.

10. Investigate the effects of sampling on signal representation and design an anti-aliasing filter. Demonstrate the sampling theorem and implement the filter to prevent aliasing.

11. Design a spectrum analyser to monitor and analyse the frequency spectrum of wireless communication signals. Use Fourier transforms to visualize and interpret the spectral components.

12. Design and implement an anti-aliasing filter for digital image processing, ensuring high-quality image acquisition without aliasing effects.

13. Design a Finite Impulse Response (FIR) filter using the windowing method. Implement the filter in MATLAB, Octave or Python and analyse its frequency response.

14. Design an Infinite Impulse Response (IIR) filter using the bilinear transformation method. Compare its performance with an analog prototype and analyse stability and frequency response.

15. Design and implement a Finite Impulse Response (FIR) filter to improve audio signal quality in a music player. Analyse the filter's performance in real-time audio enhancement.

16. Design an Infinite Impulse Response (IIR) filter to optimize signal transmission in communication systems. Evaluate its performance in reducing noise and improving signal clarity.

Course Assessment Method
(CIE: 60 marks, ESE: 40 marks)

Continuous Internal Evaluation Marks (CIE):

Attendance	Project	Internal Ex-1	Internal Ex-2	Total
5	30	12.5	12.5	60

End Semester Examination Marks (ESE)

In Part A, all questions need to be answered and in Part B, each student can choose any one full question out of two questions

Part A	Part B	Total
• 2 Questions from each module. • Total of 8 Questions, each carrying 2 marks **(8x2 =16 marks)**	• 2 questions will be given from each module, out of which 1 question should be answered. Each question can have a maximum of 2 sub divisions. Each question carries 6 marks. **(4x6 = 24 marks)**	**40**

Course Outcomes (COs)

At the end of the course students should be able to:

	Course Outcome	Bloom's Knowledge Level (KL)
CO1	Identify and classify continuous and discrete-time signals, analyse their frequency components, and perform basic operations on these signals.	**K2**
CO2	Demonstrate an understanding of the properties and representations of continuous-time and discrete-time systems, particularly focusing on linear time-invariant (LTI) systems and their impulse responses.	**K2**
CO3	Proficiency in applying Fourier transforms to continuous and discrete-time signals, interpreting spectra, understand the implications of the sampling theorem, and utilizing the properties of the Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT).	**K3**
CO4	Design and analyse digital FIR and IIR filters, understand their structures and transfer functions, and apply techniques such as impulse invariance and bilinear transformation for digital filter design.	**K3**

Note*: K1- Remember, K2- Understand, K3- Apply, K4- Analyse, K5- Evaluate, K6- Create*

CO-PO Mapping Table:

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	1	1	1	1	1				1	1	-	
CO2	2	1	1	1	1				1	1	-	
CO3	2	2	1	1	2				1	1	1	1
CO4	2	2	1	2	2				1	1	1	1

Text Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Digital Signal Processing: Principles, Algorithms& Applications	John G. Proakis, Dimitris G. Manolakis	Pearson,	4e, 2007
2	Signals and Systems	Simon Haykin , Barry Van Veen	Wiley	2e, 2007
3	Digital Signal Processing: A computer – based approach	Sanjit K. Mitra	McGraw Hill Education	4e, 2013
4	Signals and Systems,	A Anand Kumar	Prentice Hall India Learning Private Limited	3e, 2013

Reference Books				
Sl. No	Title of the Book	Name of the Author/s	Name of the Publisher	Edition and Year
1	Digital Signal Processing	Monson Hayes	McGraw Hill Education	2e, 2009
2	Schaum's Outline of Signals and Systems	Hwei P. Hsu	McGraw Hill	4e, 2019
3	Signals And Systems	Sanjay Sharma	S K Kataria and Sons	2013

Video Links (NPTEL, SWAYAM…)	
Module No.	**Link ID**
1	https://archive.nptel.ac.in/courses/117/101/117101055/
2	https://archive.nptel.ac.in/noc/courses/noc20/SEM1/noc20-ee31/
3	https://onlinecourses.nptel.ac.in/noc20_ee15/preview
4	https://nptel.ac.in/courses/108106151

PBL Course Elements

L: Lecture (3 Hrs.)	R: Project (1 Hr.), 2 Faculty Members		
	Tutorial	**Practical**	**Presentation**
Lecture delivery	Project identification	Simulation/ Laboratory Work/ Workshops	Presentation (Progress and Final Presentations)
Group discussion	Project Analysis	Data Collection	Evaluation
Question answer Sessions/ Brainstorming Sessions	Analytical thinking and self-learning	Testing	Project Milestone Reviews, Feedback, Project reformation (If required)
Guest Speakers (Industry Experts)	Case Study/ Field Survey Report	Prototyping	Poster Presentation/ Video Presentation: Students present their results in a 2 to 5 minutes video

Assessment and Evaluation for Project Activity

Sl. No	Evaluation for	Allotted Marks
1	Project Planning and Proposal	5
2	Contribution in Progress Presentations and Question Answer Sessions	4
3	Involvement in the project work and Team Work	3
4	Execution and Implementation	10
5	Final Presentations	5
6	Project Quality, Innovation and Creativity	3
Total		**30**

1. **Project Planning and Proposal (5 Marks)**
   - Clarity and feasibility of the project plan
   - Research and background understanding
   - Defined objectives and methodology

2. **Contribution in Progress Presentation and Question Answer Sessions (4 Marks)**
   - Individual contribution to the presentation
   - Effectiveness in answering questions and handling feedback

3. **Involvement in the Project Work and Team Work (3 Marks)**
   - Active participation and individual contribution
   - Teamwork and collaboration

4. **Execution and Implementation (10 Marks)**
   - Adherence to the project timeline and milestones
   - Application of theoretical knowledge and problem-solving
   - Final Result

5. **Final Presentation (5 Marks)**
   - Quality and clarity of the overall presentation

- Individual contribution to the presentation
- Effectiveness in answering questions

6. **Project Quality, Innovation, and Creativity (3 Marks)**

    - Overall quality and technical excellence of the project
    - Innovation and originality in the project

Creativity in solutions and approaches