

**Digital Signal Processing and Analysis****ENEX 304****Year/Part: III/I**

Teaching Schedule				Examination Scheme						Total
L	T	P	Total	Theory			Practical			
				Assessment Marks	Final		Assessment Marks	Final		
					Duration (Hrs)	Marks		Duration (Hrs)	Marks	
3	1	1.5	5.5	40	3	60	25	-	-	125

**Depth Codes**

E-Explanation	C-Circuit	D-Definition	DM-Demonstration
DV-Derivation	DW-Drawing	P-Proof	I-Illustration
NUM-Numerical	PRG-Programming	S-State	ACT-Activity-based Learning
MP- Mini Project	EXP-Experiment	REV-Review / Recap	PS- Problem Solving
QA- Question Answer	Q-Quiz	ST- Surprise Test	MT-Mid Term Test

Unit	Topic/ Sub topic	Depth Code	Description of Depth	Actual Plan		Plan for this semester		Week
				L	T	L	T	
<b>1</b>	<b>1. Discrete time signals and systems</b>			<b>6</b>				
	1.1. Basic elements of Digital Signal Processing	D, E	<ul style="list-style-type: none"> <li>Explain the basic elements of DSP</li> </ul>	0.25				
	1.2. Need of Digital Signal Processing over Analog Signal Processing	D, E	<ul style="list-style-type: none"> <li>Explain the advantage of digital signal over analog signal</li> </ul>	0.25				
	1.3. Sampling of continuous time signal, spectral properties of sampled signal.	D, E, N	<ul style="list-style-type: none"> <li>Definition, example of sampling of continuous time signal, Sampling Theorem, Ideal Sampling Derivation, Aliasing Effects</li> </ul>	0.5				
	1.4. Discrete time signal, basic signal types	D, E, N	<ul style="list-style-type: none"> <li>Signal definition, CT and DT signals, Basic signal (delta or impulse, unit step, ramp, Sinc, exponential, sinusoidal, Signum, Even and odd signal)</li> <li>Classification of signals (Even and Odd, Periodic and Non-Periodic, Causal and Non-causal, Deterministic and Random Signal)</li> </ul>	1	0.25			
	1.5. Transformation of independent variable	D, E, N	<ul style="list-style-type: none"> <li>Shifting, Folding, Scaling</li> </ul>	0.25				
	1.6. Energy signal, power signal	D, E, N	<ul style="list-style-type: none"> <li>Definition of Energy and Power Signal, their equations, Differentiate between energy and power signal</li> </ul>	1				

(Model Questions of Digital Signal Processing and Analysis)

	1.7. Periodicity of discrete time signal	D, E, N	<ul style="list-style-type: none"> <li>Definition of Periodic and Non-Periodic signals, Conditions of periodicity</li> </ul>	0.25	0.25			
	1.8. Discrete time Fourier transform and properties	D, E, N	<ul style="list-style-type: none"> <li>Definition of discrete time Fourier Transform and it's Properties (Demonstrate different properties)</li> </ul>	0.5				
	1.9. Discrete time system properties	D, E, N	<ul style="list-style-type: none"> <li>Memory and memoryless, Causal and Non-Causal, Linear and Non-Linear, Stable and Unstable, Time Variant and Time Invariant, Invertible Systems</li> </ul>	1	0.25			
	1.10. Linear time invariant (LTI) system convolution sum, properties of LTI system	D, E, N	<ul style="list-style-type: none"> <li>Derivation of Convolution, Properties of LTI System</li> </ul>	1	0.25			
<b>2</b>	<b>2. Z-transform</b>			<b>3</b>				
	2.1 Definition, convergence of Z-transform and region of convergence	D, E, N	<ul style="list-style-type: none"> <li>Definition of z-transform, convergence of z-transform, region of convergence, right-sided exponential sequence, left-sided exponential sequence, two-sided exponential sequence,</li> </ul>	1				
	2.2 Properties of Z-transform (linearity, time shift, multiplication by exponential sequence, differentiation, time reversal, convolution, multiplication)	D, E, N	<ul style="list-style-type: none"> <li>Properties of Z-transform</li> <li>linearity, time shift, multiplication by exponential sequence, differentiation, time reversal, convolution, multiplication</li> </ul>	1	0.5			
	2.3 Inverse z-transform by long division and partial fraction expansion.	D, E, N	<ul style="list-style-type: none"> <li>Inverse z-transform by long division and</li> <li>Partial fraction expansion.</li> </ul>	1	0.5			
<b>3</b>	<b>3. Analysis of LTI system in frequency domain</b>			<b>5</b>				
	3.1 Frequency response of LTI system, response to complex exponential	D, E, N	<ul style="list-style-type: none"> <li>Frequency response of LTI system, response to complex exponential</li> </ul>	1	0.25			
	3.2 Linear constant co-efficient difference equation and corresponding system function	D, E, N	<ul style="list-style-type: none"> <li>Linear constant co-efficient difference equation and corresponding system function</li> </ul>	2	0.25			
	3.3 Relationship of frequency response to pole-zero of system	D, E, N	<ul style="list-style-type: none"> <li>Relationship of frequency response to pole-zero of system</li> </ul>	1	0.25			
	3.4 Linear phase of LTI system and its relationship to causality.	D, E, N	<ul style="list-style-type: none"> <li>Linear phase of LTI system and its relationship to causality.</li> </ul>	1	0.25			
<b>4</b>	<b>4. Discrete filter structures</b>			<b>6</b>				
	4.1. FIR filter, Structures for FIR filter (direct form, cascade, frequency sampling, lattice)	D, E, N	<ul style="list-style-type: none"> <li>FIR filter and it's structures</li> <li>Direct form, Cascade, Frequency sampling, Lattice</li> </ul>	2	1			
	4.2. IIR filter, structures for IIR filter (direct form I, direct	D, E, N	<ul style="list-style-type: none"> <li>IIR filter and it's structures</li> </ul>	2	1			

	form II, cascade, lattice, lattice ladder)		<ul style="list-style-type: none"> <li>• Direct form I, Direct Form II, Cascade, Lattice, Lattice Ladder)</li> </ul>					
	4.3. Limit cycles and scaling	D, E, N	<ul style="list-style-type: none"> <li>• Limit Cycles and Scaling</li> </ul>	2				
<b>5</b>	<b>5. FIR filter design</b>			<b>9</b>				
	5.1. Filter design by window method, commonly used windows (rectangular window, Hanning window, Hamming window, Bartlett window, Blackman window)	D, E, N	<ul style="list-style-type: none"> <li>• Filter design by window method,</li> <li>• Rectangular window, Hanning window, Hamming window, Bartlett window, Blackman window</li> </ul>	4	1			
	5.2. Filter design by Kaiser window	D, E, N	<ul style="list-style-type: none"> <li>• Filter design by Kaiser window</li> </ul>	3	1			
	5.3. Filter design using optimum approximation, Remez exchange algorithm.	D, E	<ul style="list-style-type: none"> <li>• Filter design using optimum approximation</li> <li>• Remez exchange algorithm</li> </ul>	1				
	5.4. Types of FIR filters (Type-1, Type-2, Type-3 and Type-4)	D, E	<ul style="list-style-type: none"> <li>• Discuss Type-1, Type-2, Type-3 and Type-4 FIR filters</li> </ul>	1				
	<b>6. IIR filter design</b>			<b>9</b>				
	6.1. Filter design by impulse invariance method	D, E, N	<ul style="list-style-type: none"> <li>• Filter design by impulse invariance method</li> </ul>	2	0.5			
	6.2. Filter design using bilinear transformation	D, E, N	<ul style="list-style-type: none"> <li>• Filter design using bilinear transformation</li> </ul>	2	0.5			
	6.3. Design of digital low pass Butterworth filter	D, E, N	<ul style="list-style-type: none"> <li>• Design of digital low pass Butterworth filter.</li> </ul>	3	1			
	6.4. Frequency transformation of lowpass IIR filters (Transformation of lowpass digital filter prototype to highpass, bandpass and bandstop filters)	D, E, N	<ul style="list-style-type: none"> <li>• Show the transformation equation of lowpass digital filter prototype to highpass, bandpass and bandstop filters</li> <li>• Conversion from low pass to high pass, band pass and band stop filters</li> </ul>	2	1			
<b>7</b>	<b>7. Discrete Fourier transform</b>			<b>5</b>				
	7.1. Discrete Fourier transform (DFT) representation, properties of DFT (linearity, time shift, frequency shift, conjugation and conjugate symmetry, duality, convolution, multiplication), circular convolution	D, E, N	<ul style="list-style-type: none"> <li>• Representation of Discrete Fourier transform (DFT)</li> <li>• Properties of DFT: linearity, time shift, frequency shift, conjugation and conjugate symmetry, duality, convolution, multiplication</li> <li>• Circular convolution</li> </ul>	2	1			
	7.2. Fast Fourier Transform (FFT) algorithm (decimation in time algorithm, decimation in frequency algorithm)	D, E, N, Dr	<ul style="list-style-type: none"> <li>• Fast Fourier Transform (FFT) algorithm Decimation in time FFT algorithm and</li> <li>• Decimation in frequency FFT algorithm</li> </ul>	2	1			
	7.3. Computational complexity of FFT algorithm.	D, E, Dr	<ul style="list-style-type: none"> <li>• Computational time complexity of FFT algorithm</li> </ul>	1				
<b>8</b>	<b>8. Applications of Digital Signal Processing</b>			<b>2</b>				
	8.1. DSP application in Power System Monitoring and	D, E	<ul style="list-style-type: none"> <li>• Show how DSP is used in in Power System Monitoring and Diagnostics</li> </ul>	1				

*(Model Questions of Digital Signal Processing and Analysis)*

	Diagnostics (Fault Detection, Power Quality Analysis)		(Fault Detection, Power Quality Analysis)					
	8.2. DSP application in Protection and Control Systems (Smart Grid Management)	D, E	<ul style="list-style-type: none"><li>Show how DSP is used in Protection and Control Systems (Smart Grid Management)</li></ul>	0.5				
	8.3. DSP application in Reliability and Maintenance	D, E	<ul style="list-style-type: none"><li>Show how DSP is used Reliability and Maintenance</li></ul>	0.5				
<b>THERE MUST BE TUTORIAL SESSION (T) IN EACH UNIT. Teachers must give students related numerical problems in each unit (Unit 1 to Unit 7) to solve as a Tutorial session</b>								

**References :**

1. Alan V. Oppenheim, Ronald W. Schaffer, John R. Buck, "Discrete-Time Signal Processing", Pearson Education.
2. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing", Prentice Hall.
3. Fundamentals of Digital Signal Processing – Loney Ludeman, John Wiley.
4. Digital Signal Processing – Fundamentals and Applications – Li Tan, Elsevier.
5. Fundamentals of Digital Signal Processing using MATLAB – Robert J. Schilling, Sandra L. Harris, b Thomson
6. Discrete Systems and Digital Signal Processing with MATLAB – Taan S. ElAli, CRC press.
7. Digital Signal Processing – A. Nagoor Kani, TMG.

**Digital Signal Processing and Analysis****EX 304****Year/Part: III/I**

QN	Question	Marks	Unit
(1)	Define energy signal. Check the signal $x[n]=\text{Cos}(2\pi n/5) + \text{Sin}(\pi n/3)$ is periodic or not.	[1+2=3]	1
(2)	Find the output of the LTI system having impulse response $h[n]$ with $h[2] = 1$ , $h[0] = 2$ , $h[1] = 3$ and input signal $x[n]$ with $x[0] = 1/2$ , $x[2] = 2$ , $x[3] = 3$ . Also check the answer.	[3+2=5]	1
(3)	Find the inverse Z-transform: - $X(z) = \frac{1 + 2z^{-1} + z^{-2}}{1 - \frac{3}{2}z^{-1} + \frac{1}{2}z^{-2}} = \frac{(1 + z^{-1})^2}{\left(1 - \frac{1}{2}z^{-1}\right)(1 - z^{-1})}, \quad  z  > 1$ using the partial fraction method.	[4]	2
(4)	Given $H(z)$ for a system with the following difference equation: $y(n) = x(n) + x(n-2)$ Plot its poles and zeros in Z plane. Determine its magnitude response. Also, determine whether the system is causal and stable.	[1+3+2=6]	3
(5)	Determine the Direct Form I and Direct Form II realization of the following system. $y(n) = -0.1y(n-1) + 0.2y(n-2) + 3x(n) + 3.6x(n-2) + 0.6x(n-2)$	[2+2=4]	4
(6)	Compute the lattice coefficients and draw the lattice structure of the following FIR system. $H(z) = 1 + 2z^{-1} + z^{-2}$	[4]	4
(7)	Design a low pass FIR filter having Pass band edge frequency $\omega_p = 0.3\pi$ , Stop band edge frequency $\omega_s = 0.5\pi$ and Stop band attenuation $\alpha_s = 40$ dB using any suitable window function.	[8]	5
(8)	What is optimum filter? Describe the Remez exchange algorithm for FIR filter design with flow chart.	[1+3=4]	5
(9)	Design a low pass discrete IIR filter by Bilinear Transformation method to an approximate Butterworth filter having specifications as below Pass band edge frequency ( $\omega_p$ ) = $0.27 \pi$ radians Stop band edge frequency ( $\omega_s$ ) = $0.58 \pi$ radians Passband ripple ( $\delta_p$ ) = 0.11 Stopband ripple ( $\delta_s$ ) = 0.21 Consider the sampling frequency of 0.5 Hz.	[12]	6
(10)	Find the circular convolution between $x[n] = \{1, 2\}$ and $y[n] = u[n] - u[n-4]$ . Discuss the application of digital signal processing in electrical engineering.	[3+2=5]	7,8
(11)	Draw the butterfly diagram and compute the value of $x(7)$ using 8-pt DITFFT for the following sequences: $x(n) = \{1, 0, 0, 0, 0, 0, 0, 0\}$	[5]	7

*Note: Number of questions and distribution of marks are indicative only.*