Ref No:

Sri Krishna Institute of Technology, Bangalore

COURSE PLAN

Academic Year 2019-2020

Program:	B.E
Semester :	VI
Course Code:	17EE63
Course Title:	Digital Signal Processing.
Credit / L-T-P:	4/4-0-0
Total Contact Hours:	50
Course Plan Author:	M.Nagaraja

Academic Evaluation and Monitoring Cell

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A. COURSE INFORMATION

1. Course Overview

Degree:	B.E	Program:	UG
Semester:	VI	Academic Year:	2019-20
Course Title:	DSP	Course Code:	17EE63
Credit / L-T-P:	4/4-0-0	SEE Duration:	180 minutes
Total Contact Hours:	50	SEE Marks:	60
CIA Marks:	30	Assignment	10
Course Plan Author:	M.Nagaraja	Sign ..	
Checked By:		Sign ..	
CO Targets	CIA Target :20	SEE Target:	65

Note: Define CIA and SEE % targets based on previous performance.

2. Course Content

Content / Syllabus of the course as prescribed by University or designed by institute.

Module	Content	Teaching Hours	Blooms Learning Levels
1	**Discrete Fourier Transforms:** Definitions, properties-linearity, shift, symmetry Properties- circular convolution – periodic convolution, use of tabular arrays, circular arrays, Stock ham's method, linear convolution – two finite duration sequence, one finite & one infinite duration, overlap add and save methods	10	L2
2	**Fast Fourier Transforms Algorithms**: Introduction, decimation in time algorithm, first decomposition, number of computations, continuation of decomposition, number of multiplications, computational efficiency, decimation in frequency algorithms, Inverse radix – 2 algorithms.	10	L2
3	**Design of IIR Digital Filters**: Introduction, impulse invariant transformation, bilinear transformations, All pole analog filters- Butterworth & Chebyshev filters, design of digital Butterworth filter by impulse invariant transformation and bilinear transformation, Frequency transformations.	10	L5
4	**Design of IIR Digital Filters** (Continued): Design of digital Chebyshev –type 1filter by impulse invariant transformation and bilinear transformation, Frequency transformations. **Realization of IIR digital systems**: direct form, cascade form and parallel form, Ladder structures for equal degree polynomial .	10	L5
5	**Design of FIR Digital Filters**: Introduction, windowing, rectangular, modified rectangular. Hamming, Hanning, Blackman window, design of FIR digital filters by use of windows, Design of FIR digital filters-frequency sampling techniques. **Realization of FIR systems**: direct form, cascade form, linear phase form	10	L5
-	**Total**		

3. Course Material

Books & other material as recommended by university (A, B) and additional resources used by course teacher (C).

1. Understanding: Concept simulation / video ; one per concept ; to understand the concepts ; 15 – 30 minutes
2. Design: Simulation and design tools used – software tools used ; Free / open source
3. Research: Recent developments on the concepts – publications in journals; conferences etc.

Modules	Details	Chapters in book	Availability
A	**Text books (Title, Authors, Edition, Publisher, Year.)**	-	-
	Introduction to Digital Signal Processing Jhonny R. Jhonson Pearson 1 st Edition, 2016		
B	**Reference books (Title, Authors, Edition, Publisher, Year.)**	-	-
1	Digital Signal Processing – Principles, Algorithms, and Applications Jhon G. Proakis Dimitris G. Manolakis Pearson 4 th Edition, 2007.		
2	Digital Signal Processing A.NagoorKani McGraw Hill 2 nd Edition, 2012		
3	Digital Signal Processing Shaila D. Apte Wiley 2 nd Edition, 2009		
4	Digital Signal Processing Ashok Amberdar Cengage 1 st Edition, 2007		
5	Digital Signal Processing Tarun Kumar Rawat Oxford 1 st Edition, 2015		
C	**Concept Videos or Simulation for Understanding**	-	-
1	Introduction to DSP https://www.youtube.com/watch?v=6dFnpz_AEyA		
2	DFT https://www.youtube.com/watch?v=GDFTb-BwA0o		
3	Introduction to FFT https://www.youtube.com/watch?v=L4gpMr_OHnA		
4	IIR filter design procedure https://www.youtube.com/watch?v=N1eraFmDw1M		
5	FIR filter design by window method https://www.youtube.com/watch?v=nsK7mmRSTDY		
6	Realization of IIR and FIR Filter https://www.youtube.com/watch?v=SIAq_4bYwaA		
D	**Software Tools for Design**	-	-
	MATLAB, SCILAB		
E	**Recent Developments for Research**	-	-
	The breakthroughs in DSP include various advances and extensions from old techniques to new techniques. For example, signal processing techniques have moved from single-rate to multirate processing, from time-invariant to adaptive processing, from frequency-domain (the traditional Fourier transform, as we know it) to time-frequency analysis, and from linear to non-linear signal processing. Recent developments in these areas have not only renovated the theory of digital signal processing, they have also resulted in new tools that find applications in various domains. For instance, multirate signal processing has triggered recent advances in modem technology and speech/audio coding; adaptive filtering has made echo cancellation and noise suppression possible; time-frequency analysis has found its way into various applications in radar and medical signal processing; and non-linear processing has made engineers rethink various problems in speech recognition and image analysis		
F	**Others (Web, Video, Simulation, Notes etc.)**	-	-

1	DSP Notes https://mrcet.com/downloads/digital_notes/ECE/III%20Year/DIGITAL%20SIGNAL%20PROCESSING.pdf		
2	vidyarthiplus.com/vp/Thread-CS2403-Digital-Signal-Processing-Scanned-Lecture-Notes-All-Units		

4. Course Prerequisites

Refer to GL01. If prerequisites are not taught earlier, GAP in curriculum needs to be addressed. Include in Remarks and implement in B.5.
Students must have learnt the following Courses / Topics with described Content . . .

Modules	Course Code	Course Name	Topic / Description	Sem	Remarks	Blooms Level
1	15EC44	Signals & Sytems	Module1 Elementary signals, operations on signals	4		L1,L2
2	15EC44	Signals & Sytems	Module2 TD representation of LTI s/m	4		L1,L2
3	15EC44	Signals & Sytems	Module4 Fourier Transforms	4		L1,L2

5. Content for Placement, Profession, HE and GATE

The content is not included in this course, but required to meet industry & profession requirements and help students for Placement, GATE, Higher Education, Entrepreneurship, etc. Identifying Area / Content requires experts consultation in the area.
Topics included are like, a. Advanced Topics, b. Recent Developments, c. Certificate Courses, d. Course Projects, e. New Software Tools, f. GATE Topics, g. NPTEL Videos, h. Swayam videos etc.

Modules	Topic / Description	Area	Remarks	Blooms Level
1	DFT	Digital System	Required for Higher Education, Entrepreneurship	L2
2	FFT	Real Time	Industry & profession requirements	L3
3	FFT	Real Time	Industry & profession requirements	L3
4	FIR Filter	Communication	Industry & profession requirements	L2
5	IIR filter	Communication	Industry & profession requirements	L3

B. OBE PARAMETERS

1. Course Outcomes

Expected learning outcomes of the course, which will be mapped to POs.

Modules	Course Code.#	Course Outcome **At the end of the course, student should be able to . . .**	Teach. Hours	Instr Method	Assessment Method	Blooms' Level
1	17EE63.1	Compute the DFT of various signals using its properties and linear filtering of two sequences	10	Lecture	Slip Test	L2 Understand
2	17EE63.2	Apply fast and efficient algorithms for computing DFT and inverse DFT of a given sequence	10	Lecture	Assignment	L4
3	17EE63.3	Design infinite impulse response Butterworth digital filters using impulse invariant / bilinear transformation technique.	10	Lecture	Assignment and Slip Test	L5 Understand
4	17EE63.4	Realize a digital IIR filter by direct,	10	Lecture and	Assignme	L4

		cascade, parallel and ladder methods ofrealization		Tutorial	nt	Apply
5	17EE63.5	Design FIR filters by use of window function or by frequency sampling method	10	Lecture	Slip test	L5 Apply
-	**-**	**Total**	**50**	**-**	**-**	**-**

2. Course Applications

Write 1 or 2 applications per CO.
Students should be able to employ / apply the course learnings to . . .

Modules	Application Area Compiled from Module Applications.	CO	Level
1	Analog to Digital Conversion	CO1	L2
1	Digital to Analog conversion	CO1	L4
2	Ease of DFT Computation	CO2	L2
2	Real time Processing	CO2	L3
3	Filter Design in communication	CO3	L2
4	Realizing filters	CO4	L3
5	Design of FIR filter where linear phase is not a constraint	CO5	L3

3. Articulation Matrix

CO – PO Mapping with mapping level for each CO-PO pair, with course average attainment.

-	-	Course Outcomes	Program Outcomes															-
Modules	CO.#	**At the end of the course student should be able to . . .**	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3	Level
1	17EE63.1	Compute the DFT of various signals using its properties and linear filtering of two sequences	3	3							2			1				
2	17EE63.2	Apply fast and efficient algorithms for computing DFT and inverse DFT of a given sequence	3	3							2			1				
3	17EE63.3	Design infinite impulse response Butterworth digital filters using impulse invariant / bilinear transformation technique.	3	3							2			1				
4	17EE63.4	Realize a digital IIR filter by direct, cascade, parallel and ladder methods ofrealization	3	3							2			1				
5	17EE63.5	Design FIR filters by use of window function or by frequency sampling method	3	3							2			1				
-	**17EE63.**	Average	**3**	**3**							**2**			**1**				**-**
-	*PO, PSO*	*1.Engineering Knowledge; 2.Problem Analysis; 3.Design / Development of Solutions; 4.Conduct Investigations of Complex Problems; 5.Modern Tool Usage; 6.The Engineer and Society; 7.Environment and Sustainability; 8.Ethics; 9.Individual and Teamwork; 10.Communication; 11.Project Management and Finance; 12.Life-long Learning; S1.Software Engineering; S2.Data Base Management; S3.Web Design*																

4. Curricular Gap and Content

Topics & contents not covered (from A.4), but essential for the course to address POs and PSOs.

Modules	Gap Topic	Actions Planned	Schedule Planned	Resources Person	PO Mapping
1	Circular Convolution and correlation	Seminar	2nd week March 2020	Faculty	

2	Frequency Domain Analysis	Seminar	3d week March 2020	Faculty	
3	Decimation Concepts	Seminar	Sept 19 second week	Faculty	
4	Analog Filter Design	Seminar	Oct 19 First week	Faculty	
5	Digital Filter Design	Seminar	Oct 19 second week	Faculty	

C. COURSE ASSESSMENT

1. Course Coverage

Assessment of learning outcomes for Internal and end semester evaluation.

Modules	Title	Teach. Hours	No. of question in Exam						CO	Levels
			CIA-1	CIA-2	CIA-3	Asg	Extra Asg	SEE		
1	Discrete Fourier Transforms:	10	2	-	-	1	1	2	CO1, CO2	L1, L2
2	Fast Fourier Transforms Algorithms	10	2	-	-	1	1	2	CO3, CO4	L2, L3
3	Design of IIR Digital Filter	10	-	2	-	1	1	2	CO5, CO6	L2, L3
4	Realization of IIR digital systems	10	-	2	-	1	1	2	CO7, CO8	L2, L3
5	Design and realization of FIR Digital Filters	10	-	-	4	1	1	2	CO9, CO10	L2, L3
-	**Total**	**50**	**4**	**4**	**4**	**5**	**5**	**10**	**-**	**-**

2. Continuous Internal Assessment (CIA)

Assessment of learning outcomes for Internal exams. Blooms Level in last column shall match with A.2.

Modules	Evaluation	Weightage in Marks	CO	Levels
1, 2	CIA Exam – 1	30	CO1,CO2	L1,L2, L3
3, 4	CIA Exam – 2	30	CO3,CO4	L2, L3
5	CIA Exam – 3	30	CO5	L2, L3
1, 2	Assignment - 1	10	CO1,CO2	L1,L2, L3
3, 4	Assignment - 2	10	CO3,CO4	L2, L3
5	Assignment - 3	10	CO5	L2, L3
1, 2	Seminar - 1		-	-
3, 4	Seminar - 2		-	-
5	Seminar - 3		-	-
1, 2	Quiz - 1		-	-
3, 4	Quiz - 2		-	-
5	Quiz - 3		-	-
1 - 5	Other Activities – Mini Project	-		
	Final CIA Marks		**-**	**-**

D1. TEACHING PLAN - 1

Module - 1

Title:	**Discrete Fourier Transform (DFT)**	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
	Compute the DFT of various signals using its properties and linear filtering of	CO1	**L2**

	two sequences		
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
1	Definitions,	CO1	L2
2	properties-linearity, shift,	CO1	L2
3	symmetry Properties- circular convolution – periodic convolution,	CO1	L2
4	use of tabular arrays, circular arrays,	CO1	L2
5	Stock ham's method,	CO1	L2
6	Linear Convolution- definition and procedure	CO2	L2
7	linear convolution – two finite duration sequence,	CO2	L2
8	Linear convolution- one finite & one infinite duration,	CO2	L2
9	overlap and add method	CO2	L2
10	Overlap and save method	CO2	L2
c	**Application Areas**		
-	Students should be able employ / apply the Module learnings to . . .		
1	Analog to digital conversion and vice versa	CO1	L2
2	All Digital signal processing Applications	CO1	L2
d	**Review Questions**		
-			
1	Find the 4 point DFT of the sequence x(n)=(0, 1, 2, 3) plot IX(k)I and angle of X(k)	CO1	L3
2	Find the DFT of the sequence $x(n)=0.5^n$ U(n) for 0≤ n ≤3 by evaluating $x(n)=a^n$ for 0 ≤ n ≤ N-1	CO1	L3
3	Find the relation between DFT and Z transformation	CO1	L3
4	Find the 4 point DFT of the sequence x(n)=6 + cos(2π/N n)	CO1	L3
5	Find the 8 point DFT of the sequence x(n)=(1,1,1,1,1,1,0,0)	CO1	L3
6	Define N point DFT and IDFT of a sequence.	CO1	L3
7	An analog signal is sampled at 10KHZ and the DFT of 512 samples is computed Determine the frequency sampling between the spectral samples of DFT	CO1	L3
8	Compute the DFT of the sequence x(n)=cos(nπ/4) for N=4 and plot IX(k)I and angle of X(k)	CO1	L3
9	Find the IDFT of X(K)=(4,-2j, 0, 2j)	CO1	L3
10	Explain Linearity property of DFT with an example.	CO1	L3

Module – 2

Title:	**Fast Fourier Transform lgorithms**	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-		CO2	**L3**
	Apply fast and efficient algorithms for computing DFT and inverse DFT of a given sequence	CO2	L4
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
11	Introduction to FFT	CO2	L4
12	decimation in time algorithm, first decomposition, number of computations, continuation of decomposition, number of multiplications,	CO2	L4
13	computational efficiency,	CO2	L4

14	decimation in frequency algorithms, first decomposition, number of computations, continuation of decomposition, number of multiplications	CO2	L4
15	computational efficiency	CO2	L4
16	Inverse radix – 2 algorithms.	CO2	L4
17	Radix2 DIT FFT algorithm to compute DFT	CO2	L4
18	Radix2 DIT FFT algorithm to compute IDFT	CO2	L4
19	Radix2 DIF FFT algorithm to compute DFT	CO2	L4
20	Radix2 DIF FFT algorithm to compute IDFT	CO2	L4
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Real time filtering	CO2	L4
d	**Review Questions**	-	
-			L3
1	Explain with necessary diagrams and equations the concept of overlap - save method for linear filtering	CO2	L3
2	Write a note on Goertzel algorithm	CO2	L3
3	What is in-place computation? What is the total number of complex additions and multiplications required for N = 64 point, if DFT is computed directly and if FFT is used? Also find the number of stages required and its memory requirement.	CO2	L3
4	First five points of the 8 - point DFT of a real valued sequence is given by x(0) = 0, x(1) = 2 + 2j, x(2) = --4j, x(3) = 2 - 2j, x(4) = 0. Determine the remaining points. Hence find the original sequence x(n) using DIT - FFT algorithm.	CO2	L3
5	Find the 4 - pt circular convolution of x(n) = { 1, 1, 1, 1} and h(n) = {1, 0, 1, 0} using radix 2 DIF - FFT algorithm.	CO2	L3
6	In the direct computation of N-point DFT of x(n), how many i) Complex multiplications, ii) Complex additions iii) Real multiplications iv) Real additions and v) Trigonometric function evaluations are required	CO2	L3
7	Find the output y(n) of a filter whose impulse response h(n) ={1, 2} and input signal x(n) = {1, 2, -1, 2, 3, - 2, - 3, -1,1,1, 2, -1} using overlap save method	CO2	L3
8	Develop 8-point DIT-FFT radix-2 algorithm to compute DFT and draw the signal flow graph.	CO2	L3
9	Develop 8-point DIT-FFT radix-2 algorithm to compute IDFT and draw the signal flow graph.	CO2	L3
10	Develop 8-point DIF-FFT radix-2 algorithm to compute DFT and draw the signal flow graph.	CO2	L3
11	Develop 8-point DIF-FFT radix-2 algorithm to compute IDFT and draw the signal flow graph.	CO2	L3

E1. CIA EXAM – 1

a. Model Question Paper - 1

Crs Code:	17EE63	Sem:	VI	Marks:	30	Time:	90 minutes
Course:	DSP						

-	-	Note: Answer all questions, each carry equal marks. Module : 1, 2	Marks	CO	Level
1	a	Prove that the sampling of DTFT of a sequence x(n) result in N-point DFT	3	CO1	L2
	b	Find the 4 point DFT of the sequence x(n)=(0, 1, 2, 3) plot lX(k)l and angle of X(k)	4	CO1	L2
	c	Find the DFT of the sequence $x(n)=0.5^n$ U(n) for $0\le n \le 3$ by evaluating	4	CO1	L2

		$x(n)=a^n$ for $0 \le n \le N-1$			
	d	Find the relation between DFT and Z transformation	4	CO1	L2
2	a	Find the 4 point DFT of the sequence x(n)=6 + cos(2π/N n)	6	CO1	L2
	b	Find the 8 point DFT of the sequence x(n)=(1,1,1,1,1,1,0,0)	5	CO1	L2
	c	Define N point DFT and IDFT of a sequence	4	CO1	L2
3	a	What is in-place computation? What is the total number of complex additions and multiplications required for N = 64 point, if DFT is computed directly and if FFT is used? Also find the number of stages required and its memory requirement.	6	CO2	L3
	b	First five points of the 8 - point DFT of a real valued sequence is given by x(0) = 0, x(1) = 2 + 2j, x(2) = --4j, x(3) = 2 - 2j, x(4) = 0. Determine the remaining points. Hence find the original sequence x(n) using DIT - FFT algorithm.	9	CO2	L3
4	a	Develop 8-point DIT-FFT radix-2 algorithm to compute DFT and draw the signal flow graph.	6	CO2	L3
	b	Develop 8-point DIT-FFT radix-2 algorithm to compute IDFT and draw the signal flow graph.	5	CO2	L3

b. Assignment -1

Model Assignment Questions							
Crs Code:	17EC62	Sem:	VI	Marks:	30	Time:	90 minutes
Course:	ARM Microcontroller & Embedded System						

SNo	Assignment Description	Marks	CO	Level
1	Find the 4 point DFT of the sequence x(n)=(0, 1, 2, 3) plot IX(k)I and angle of X(k)	7	CO1	L2
2	Find the DFT of the sequence $x(n)=0.5^n$ U(n) for $0\le n \le 3$ by evaluating $x(n)=a^n$ for $0 \le n \le N-1$	8	CO1	L2
3	Find the relation between DFT and Z transformation	7	CO1	L2
4	Find the 4 point DFT of the sequence x(n)=6 + cos(2π/N n)	8	CO1	L2
5	Find the 8 point DFT of the sequence x(n)=(1,1,1,1,1,1,0,0)	7	CO1	L2
6	Define N point DFT and IDFT of a sequence.	8	CO1	L2
7	An analog signal is sampled at 10KHZ and the DFT of 512 samples is computed Determine the frequency sampling between the spectral samples of DFT	7	CO1	L2
8	Compute the DFT of the sequence x(n)=cos(nπ/4) for N=4 and plot IX(k)I and angle of X(k)	8	CO1	L2
9	Find the IDFT of X(K)=(4,-2j, 0, 2j)	7	CO1	L2
10	Explain Linearity property of DFT with an example.	8	CO1	L2
11	Explain with necessary diagrams and equations the concept of overlap - save method for linear filtering	7	CO2	L3
12	Write a note on Goertzel algorithm	8	CO2	L3
13	What is in-place computation? What is the total number of complex additions and multiplications required for N = 64 point, if DFT is computed directly and if FFT is used? Also find the number of stages required and its memory requirement.	7	CO2	L3
14	First five points of the 8 - point DFT of a real valued sequence	8	CO2	L3

	is given by x(0) = 0, x(1) = 2 + 2j, x(2) = --4j, x(3) = 2 - 2j, x(4) = 0. Determine the remaining points. Hence find the original sequence x(n) using DIT - FFT algorithm.			
15	Find the 4 - pt circular convolution of x(n) = { 1, 1, 1, 1} and h(n) = {1, 0, 1, 0} using radix 2 DIF - FFT algorithm.	7	CO2	L3
16	In the direct computation of N-point DFT of x(n), how many i) Complex multiplications, ii) Complex additions iii) Real multiplications iv) Real additions and v) Trigonometric function evaluations are required	8	CO2	L3
17	Find the output y(n) of a filter whose impulse response h(n) ={1, 2} and input signal x(n) = {1, 2, -1, 2, 3, - 2, - 3, -1,1,1, 2, -1} using overlap save method	7	CO2	L3
18	Develop 8-point DIT-FFT radix-2 algorithm to compute DFT and draw the signal flow graph.	8	CO2	L3
19	Develop 8-point DIT-FFT radix-2 algorithm to compute IDFT and draw the signal flow graph.	7	CO2	L3
20	Develop 8-point DIF-FFT radix-2 algorithm to compute DFT and draw the signal flow graph.	8	CO2	L3
21	Develop 8-point DIF-FFT radix-2 algorithm to compute IDFT and draw the signal flow graph.	7	CO2	L3

D2. TEACHING PLAN - 2

Module – 3

Title:	**Design of IIR Digital Filters**:	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
	Design infinite impulse response Butterworth digital filters using impulse invariant / bilinear transformation technique.	CO3	L5
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
21	Introduction to IIR filter,	CO3	L2
22	impulse invariant transformation,	CO3	L2
23	bilinear transformations,	CO3	L2
24	All pole analog filters- Butterworth Filter	CO3	L2
25	Chebyshev filters,	CO3	L2
26	Frequency transformations.	CO3	L2
27	design of digital Butterworth filter by impulse invariant transformation	CO3	L2
28	Problems	CO3	L2
29	design of digital Butterworth filter by bilinear transformation,	CO3	L2
30	Problems	CO3	L2
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Design of IIR filter where linear phase is not a constraint	CO3	L2
2	Communication Application.	CO3	
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Obtain direct form-I, direct form - II, cascade and parallel form realization for the following t t system: y(n) = 0.75y(n -1) - 0.125y(n - 2) + 6x(n) + 7x(n -1) + x(n - 2)	CO3	L5
2	Design an analog Chebyshev filter with the following specifications : Passband ripple : 1 dB for 0 Q 10 rad/sec Stopband attenuation : -60 dB for Q 50 rad/sec.	CO3	L5
3	Derive the expressions of order and cutoff frequency of a analog butter worth	CO3	L5

	filt		
4	Obtain Direct form I and II , Cascade and Parallel form realization for the following system Y(n)=0.75y(n-1)-0.125y(n-2) + 6x(n) + 7x(n-1) + x(n-2)	CO3	L5
5	Design a Chebyshev analog filter (low pass) that has a -3dB cutoff frequency of 100 rad/sce .9., O and a stopband attenuation 25dB or greater for all radian frequencies past 250 rad/sec	CO3	L5
6	Compare Butterworth and Chebyshev filters.	CO3	L5
7	Let H(s) = 2 1 represent the transfer function of LPF with a passband of 1 s + s +1 frequency transformation (Analog to Analog) to find the transfer function of fitter with passband 10 rad/sec and a centre frequency of 100 rad/sec	CO3	L5
8	Obtain block diagram of the direct form I and direct form II realization for a digital IIR fitter described by the system function. 8z3— 4z 2+11z — 2 H(z) = (10 Marks) (z— 1)(z2—z+ 1 2)	CO3	L5
9	Design a Chebyshev filter to meet the following specifications: i) Pass band ripple 2 db ii) Stop band attenuation 20 db iii) Pass band edge : 1 rad/sec iv) Stop band edge : 1.3 rad/sec	CO3	L5
10	Derive an expression for order of a low pass Butterworth filter.	CO3	L5
11	Explain how an analog filter is mapped on to a digital filter using impulse invariance method. What are the limitations of the method?	CO3	L5
12	Obtain direct form - I and lattice structure for the system described by the difference equation y(n) = x(n) + 2 x(n -1) + 3 x(n - 2) + 1 x(n-3).	CO3	L5

Module – 4

Title:	**Design of IIR Digital Filters**	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
	Realize a digital IIR filter by direct, cascade, parallel and ladder methods of realization	CO4	L4
b	***Course Schedule***		
Class No	**Portion covered per hour**	**-**	**-**
31	Design of digital Chebyshev –type 1 filter by impulse invariant transformation	CO4	L3
32	and bilinear transformation,	CO4	L3
33	Frequency transformations	CO4	L3
34	Realization of IIR digital systems: direct form,	CO4	L3
35	cascade form	CO4	L3
36	parallel form	CO4	L3
37	Cascade and parallel form	CO4	L3
38	Ladder structures for equal degree polynomial .	CO4	L3
39	Problems	CO4	L3
40	Problems	CO4	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1		CO4	L4
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Compare Butterworth and Chebyshev filters.	CO4	L4
2	Let H(s) = 2 1 represent the transfer function of LPF with a passband of 1 s + s +1 frequency transformation (Analog to Analog) to find the transfer function of fitter with passband 10 rad/sec and a centre frequency of 100 rad/sec	CO4	L4
3	Obtain block diagram of the direct form I and direct form II realization for a	CO4	L4

	digital IIR fitter described by the system function. 8z3— 4z 2+11z — 2 H(z) = (10 Marks) (z— 1)(z2—z+ 1 2)		
4	Design a Chebyshev filter to meet the following specifications: i) Pass band ripple 2 db ii) Stop band attenuation 20 db iii) Pass band edge : 1 rad/sec iv) Stop band edge : 1.3 rad/sec	CO4	L4
5	Derive an expression for order of a low pass Butterworth filter.	CO4	L4
6	Explain how an analog filter is mapped on to a digital filter using impulse invariance method. What are the limitations of the method?	CO4	L4
7	Obtain direct form - I and lattice structure for the system described by the difference equation y(n) = x(n) + 2 x(n -1) + 3 x(n - 2) + 1 x(n-3).	CO4	L4
8	How to convert Analog High pass filter to analog low pass filter,write the frequency transformation.	CO4	L4
9	How to convert Analog Low pass filter to analog low pass filter,write the frequency transformation.	CO4	L4
10	How to convert Analog Band pass filter to analog low pass filter,write the frequency transformation.	CO4	L4
11	How to convert Analog Band elimination filter to analog low pass filter, write the frequency transformation.	CO4	L4
12	What are the characteristics of Butterworth analog filter	CO4	L4
13	Write the design steps for design of IIR filter using Bilinear transformation.	CO4	L4
14	Write the design steps for design of IIR filter using Backward difference method	CO4	L4
15	Write the design steps for design of IIR filter using Impulse invariant method	CO4	L4
16	List the number of Adders required for direct form-1,direct form 2 method of IIR filter implementation.	CO4	L4
17	Compare direct form-1,direct form 2 method of IIR filter implementation.	CO4	L4
e	**Experiences**	-	-
1		CO7	L2
2			

E2. CIA EXAM – 2

a. Model Question Paper - 2

Crs Code:	17EE63	Sem:	VI	Marks:	30	Time	90 minutes
Course:	DSP						

-	-	**Note: Answer all questions, each carry equal marks. Module : 3, 4**	**Marks**	**CO**	**Level**
1	a	Obtain block diagram of the direct form I and direct form II realization for a digital IIR fitter described by the system function. $8z^3$— 4z/ Z^2+11z — 2	10	CO3	L1
	b	Obtain block diagram of the direct form I and direct form II realization for a digital IIR fitter described by the system function H(z) (z— 1)/(z^2—z+ 12)	5	CO3	L2
2	a	Obtain direct form - I and lattice structure for the system described by the difference equation y(n) = x(n) + 2 x(n -1) + 3 x(n - 2) + 1 x(n-3).	10	CO3	L2
	b	Obtain Direct form I and II , Cascade and Parallel form realization for the following system Y(n)=0.75y(n-1)-0.125y(n-2) + 6x(n) + 7x(n-1) + x(n-2)	5	CO3	L4
3	a	Derive the expressions of order and cutoff frequency of a analog butter worth filter	10	CO4	L2
	b	Compare Butterworth and Chebyshev filters.	5	CO4	L2
4	a	Explain how an analog filter is mapped on to a digital filter using impulse invariance method. What are the limitations of the method?	5	CO4	L3
	b	Explain the arm development tools in detail.	7	CO4	L3

b. Assignment – 2

Model Assignment Questions							
Crs Code:		Sem:		Marks:		Time:	
Course:							

SNo	Assignment Description	Marks	CO	Level
1	Obtain direct form-I, direct form - II, cascade and parallel form realization for the following t t system: y(n) = 0.75y(n -1) - 0.125y(n - 2) + 6x(n) + 7x(n -1) + x(n - 2)	7	CO3	L5
2	Design an analog Chebyshev filter with the following specifications : Passband ripple : 1 dB for 0 Q 10 rad/sec Stopband attenuation : -60 dB for Q 50 rad/sec.	8	CO3	L5
3	Derive the expressions of order and cutoff frequency of a analog butter worth filt	7	CO3	L5
4	Obtain Direct form I and II , Cascade and Parallel form realization for the following system Y(n)=0.75y(n-1)-0.125y(n-2) + 6x(n) + 7x(n-1) + x(n-2)	8	CO3	L5
5	Design a Chebyshev analog filter (low pass) that has a -3dB cutoff frequency of 100 rad/sce .9., O and a stopband attenuation 25dB or greater for all radian frequencies past 250 rad/sec	7	CO3	L5
6	Compare Butterworth and Chebyshev filters.	8	CO3	L5
7	Let H(s) = 2 1 represent the transfer function of LPF with a passband of 1 s + s +1 frequency transformation (Analog to Analog) to find the transfer function of fitter with passband 10 rad/sec and a centre frequency of 100 rad/sec	5	CO3	L5
8	Obtain block diagram of the direct form I and direct form II realization for a digital IIR fitter described by the system function. 8z3— 4z 2+11z — 2 H(z) = (10 Marks) (z— 1)(z2—z+ 1 2)	6	CO3	L5
9	Design a Chebyshev filter to meet the following specifications: i) Pass band ripple 2 db ii) Stop band attenuation 20 db iii) Pass band edge : 1 rad/sec iv) Stop band edge : 1.3 rad/sec	7	CO3	L5
10	Derive an expression for order of a low pass Butterworth filter.	8	CO3	L5
11	Explain how an analog filter is mapped on to a digital filter using impulse invariance method. What are the limitations of the method?	7	CO3	L5
12	Obtain direct form - I and lattice structure for the system described by the difference equation y(n) = x(n) + 2 x(n -1) + 3 x(n - 2) + 1 x(n-3).	8	CO3	L5
13	Compare Butterworth and Chebyshev filters.	7	CO4	L4
14	Let H(s) = 2 1 represent the transfer function of LPF with a passband of 1 s + s +1 frequency transformation (Analog to Analog) to find the transfer function of fitter with passband 10 rad/sec and a centre frequency of 100 rad/sec	8	CO4	L4
15	Obtain block diagram of the direct form I and direct form II realization for a digital IIR fitter described by the system function. 8z3— 4z 2+11z — 2 H(z) = (10 Marks) (z— 1)(z2—z+ 1 2)	7	CO4	L4
16	Design a Chebyshev filter to meet the following specifications: i) Pass band ripple 2 db ii) Stop band attenuation 20 db iii) Pass band edge : 1 rad/sec iv) Stop band edge : 1.3 rad/sec	8	CO4	L4
17	Derive an expression for order of a low pass Butterworth filter.	7	CO4	L4
18	Explain how an analog filter is mapped on to a digital filter using impulse invariance method. What are the limitations of the method?	8	CO4	L4
19	Obtain direct form - I and lattice structure for the system described by the difference equation y(n) = x(n) + 2 x(n -1) + 3 x(n - 2) + 1 x(n-3).	7	CO4	L4

20	How to convert Analog High pass filter to analog low pass filter,write the frequency transformation.	8	CO4	L4
21	How to convert Analog Low pass filter to analog low pass filter,write the frequency transformation.	7	CO4	L4
22	How to convert Analog Band pass filter to analog low pass filter,write the frequency transformation.	8	CO4	L4
23	How to convert Analog Band elimination filter to analog low pass filter, write the frequency transformation.	7	CO4	L4
24	What are the characteristics of Butterworth analog filter	8	CO4	L4
25	Write the design steps for design of IIR filter using Bilinear transformation.	7	CO4	L4
26	Write the design steps for design of IIR filter using Backward difference method	8	CO4	L4
27	Write the design steps for design of IIR filter using Impulse invariant method	7	CO4	L4
28	List the number of Adders required for direct form-1,direct form 2 method of IIR filter implementation.	8	CO4	L4
29	Compare direct form-1,direct form 2 method of IIR filter implementation.	7	CO4	L4

D3. TEACHING PLAN - 3

Module – 5

Title:	**Design and Realization of FIR Digital Filters**	Appr Time:	10 Hrs
a	***Course Outcomes***	**CO**	**Blooms**
-	At the end of the topic the student should be able to . . .	-	**Level**
	Design FIR filters by use of window function or by frequency sampling method .		L5
b	***Course Schedule***	-	-
Class No	**Portion covered per hour**	**-**	**-**
41	Introduction to FIR filter	CO5	L3
42	windowing, rectangular, modified rectangular. Hamming, Hanning, Blackman window,	CO5	L3
43	design of FIR digital filters by use of windows,	CO5	L3
44	Problem	CO5	L3
45	Design of FIR digital filters-frequency sampling techniques.	CO5	L3
46	Problem	CO5	L3
47	Realization of FIR systems: direct form	CO5	L3
48	cascade form realization	CO5	L3
49	linear phase form realization	CO5	L35
50	Problems	CO5	L3
c	**Application Areas**	**-**	**-**
-	Students should be able employ / apply the Module learnings to . . .	-	-
1	Design of FIR filter where linear phase is a requirement.	CO5	L3
2	Communication application.	CO5	L4
d	**Review Questions**	-	-
-	The attainment of the module learning assessed through following questions	-	-
1	Realize the linear phase FIR filter for the impulse response h(n)= ᄒ (n)+ ¼ ᄒ (n-1)- ½ᄒ (n-1)+ ¼ ᄒ (n-3)+ ᄒ (n-4) using direct form	CO5	L5

2	Describe the frequency sampling realization of FIR filter.	CO5	L5
3	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use rectangular window function. Find the frequency response $H(\omega)$ of the filter.	CO5	L5
4	Consider an FIR lattice filter with coefficients K1=0.65, K2=-0.34 and K3=0.8. Find its impulse response and draw the direct form structure.	CO5	L5
5	Determine the impulse response of an FIR filter to meet the specifications: Passband edge frequency of 1.5 KHz, Stopband edge frequency of 2 KHz, Sampling frequency of 8 KHz. Use the Hamming window function	CO5	L5
6	Compare the different window functions used in FIR filter design	CO5	L5
7	Design a normalized linear phase FIR filter having the phase delay of T 40 dB attenuation in the stopband. Also obtain the magnitude /frequency response Use rectangular window.	CO5	L5
8	Determine the frequency response of the FIR if Hamming window is used with N = 8.	CO5	L5
9	Compare IIR filter and FIR filters	CO5	L5
10	A FIR filter is given by, y(n) = x(n) + 2 x(n -1) + 3 x(n - 2) + x(n - 3). Draw the direct form I and lattice 4 structure .	CO5	L5
11	Design a linear phase low pass FIR filter with 7 taps and cutoff frequency of W_c, = 0.3pi rad, using the frequency sampling method.	CO5	L5
e	**Experiences**	-	-
1		CO10	L2
2		CO9	

E3. CIA EXAM – 3

a. Model Question Paper - 3

Crs Code:	17EE63	Sem:	VI	Marks:	30	Time:	75 minutes
Course:	DSP						

-	-	**Note: Answer any 2 questions, each carry equal marks.**	**Marks**	**CO**	**Level**
1	a	Consider an FIR Lattice filter with coefficients k1=0.65, k2=-0.34, k3=0.8. Find its impulse response and the direct form structure	8	CO5	L1
	b	Realize the FIR filter $H(Z)= ½ + 1/3\ Z^{-1} +Z^{-2} + ¼\ Z^{-3}+Z^{-4} + 1/3\ Z^{-5} +1/2\ Z^{-6}$ in Direct form	7	CO5	L2
2	a	Compare the different window functions Used in FIR filter design	8	CO5	L2
	b	Detremine the filter co-efficients of a FIR filter for the desired frequency response $Hd(w)=e^{-j3w}$, |w|< 0 3π/4< |w| < π Determine the frequency response of the FIR filter if Hamming window is used with N=7	7	CO5	L4
3	a	Determine the Impulse response of an FIR filter to meet the specifications a) Pass band edge frequency of 1.5KHZ, b) stop band edge frequency of 2KHz c) Sampling frequency of 8KHz. Use the Hamming window function.	8	CO5	L1
	b	The frequency response of an FIR filter is given by $H(w)=e^{-j3w}(1+1.8\cos 3w + 1.2\cos 2w + 0.5\cos w)$.Determine the coefficient of the impulse response of the FIR filter.	7	CO5	L2
4	a	Describe the frequency sampling realization of FIR filter.	8	CO5	L2
	b	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use rectangular window function. Find the frequency response $H(\omega)$ of the filter.	7	CO5	L2

b. Assignment – 3

Model Assignment Questions							
Crs Code:	17EE63	Sem:	6	Marks:		Time:	
Course:	Digital Signal Processing						

SNo	Assignment Description	Marks	CO	Level
1	Consider an FIR Lattice filter with coefficients k1=0.65, k2=-0.34, k3=0.8. Find its impulse response and the direct form structure	5	CO5	L5
2	Realize the FIR filter $H(Z)= ½ + 1/3\ Z^{-1} + Z^{-2} + ¼\ Z^{-3} + Z^{-4} + 1/3\ Z^{-5} + 1/2\ Z^{-6}$ in Direct form	5	CO5	L5
3	Compare the different window functions Used in FIR filter design		CO5	L5
4	Detremine the filter co-efficients of a FIR filter for the desired frequency response $Hd(w)=e^{-j3w}$, |w|< 0 3π/4< |w| < π Determine the frequency response of the FIR filter if Hamming window is used with N=7	5	CO5	L5
5	Determine the Impulse response of an FIR filter to meet the specifications a) Pass band edge frequency of 1.5KHZ, b) stop band edge frequency of 2KHz c) Sampling frequency of 8KHz. Use the Hamming window function.	10	CO5	L5
6	The frequency response of an FIR filter is given by $H(w)=e^{-j3w}(1+1.8\cos 3w + 1.2\cos 2w + 0.5\cos w)$.Determine the coefficient of the impulse response of the FIR filter.	10	CO5	L5
7	Describe the frequency sampling realization of FIR filter.	10	CO5	L5
8	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use rectangular window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
9	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Barlet window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
10	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Blackman window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
11	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Hamming window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
12	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Hanning window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
13	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Kaiser window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
14	Write the Rectangular window sequence and plot its magnitude and phase response	5	CO5	L5
15	Write the Barlet window sequence and plot its magnitude and phase response	5	CO5	L5
16	Write the Blackman window sequence and plot its magnitude and phase response	5	CO5	L5
17	Write the Hanning window sequence and plot its magnitude and phase response	5	CO5	L5

18	Write the Hamming window sequence and plot its magnitude and phase response	5	CO5	L5
19	Write the Kaiser window sequence and plot its magnitude and phase response	5	CO5	L5
20	Write the design steps to design FIR filter using rectangular window when window function is not given.	5	CO5	L5
21	Write the design steps to design FIR filter using rectangular window when window function is given.	5	CO5	L5
22	Explain lattice structure of FIR Filter realization.	5	CO5	L5
23	State and explain condition required for design of linear phase FIR filter.	5	CO5	L5
24	Realize the Linear phase FIR filter having the following impulse response $h(n)=\delta(n)+1/4\ \delta(n-1)-1/8\delta(n-2)+1/4\delta(n-3)$	10	CO5	L5
25	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use rectangular window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
26	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Barlet window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
27	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Blackman window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
28	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Hamming window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
29	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Hanning window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
30	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Kaiser window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
31	Write the Rectangular window sequence and plot its magnitude and phase response	5	CO5	L5
32	Determine the filter coefficients of an FIR filter for the desired frequency response $Hd(\omega)=e^{-j2w}$ w<pi/4 , $H_d(w)=0$ otherwise Use Kaiser window function. Find the frequency response $H(\omega)$ of the filter.	10	CO5	L5
33	Consider an FIR Lattice filter with coefficients k1=0.65, k2=-0.34, k3=0.8. Find its impulse response and the direct form structure	5	CO5	L5
34	Realize the FIR filter $H(Z)= ½ + 1/3\ Z^{-1} +Z^{-2} + ¼\ Z^{-3}+Z^{-4} + 1/3\ Z^{-5} +1/2\ Z^{-6}$ in Direct form	5	CO5	L5
35	Compare the different window functions Used in FIR filter design		CO5	L5
36	Detremine the filter co-efficients of a FIR filter for the desired frequency response $Hd(w)=e^{-j3w}$, $\|w\|< 0\ 3\pi/4< \|w\| < \pi$ Determine the frequency response of the FIR filter if Hamming window is used with N=7	5	CO5	L5
37	Determine the Impulse response of an FIR filter to meet the specifications a) Pass band edge frequency of 1.5KHZ, b) stop band edge frequency of 2KHz c) Sampling frequency of 8KHz. Use the Hamming window function.	10	CO5	L5
38	The frequency response of an FIR filter is given by $H(w)=e^{-j3w}(1+1.8\cos 3w + 1.2\cos 2w + 0.5\cos w)$.Determine the coefficient of the impulse response of the FIR filter.	10	CO5	L5

39	Describe the frequency sampling realization of FIR filter.	10	CO5	L5
40	Determine the filter coefficients of an FIR filter for the desired frequency response Hd(ω)=e^{-j2w} w<pi/4 , H_d(w)=0 otherwise Use rectangular window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
41	Determine the filter coefficients of an FIR filter for the desired frequency response Hd(ω)=e^{-j2w} w<pi/4 , H_d(w)=0 otherwise Use Barlet window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
42	Determine the filter coefficients of an FIR filter for the desired frequency response Hd(ω)=e^{-j2w} w<pi/4 , H_d(w)=0 otherwise Use Blackman window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
43	Determine the filter coefficients of an FIR filter for the desired frequency response Hd(ω)=e^{-j2w} w<pi/4 , H_d(w)=0 otherwise Use Hamming window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
44	Determine the filter coefficients of an FIR filter for the desired frequency response Hd(ω)=e^{-j2w} w<pi/4 , H_d(w)=0 otherwise Use Hanning window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
45	Determine the filter coefficients of an FIR filter for the desired frequency response Hd(ω)=e^{-j2w} w<pi/4 , H_d(w)=0 otherwise Use Kaiser window function. Find the frequency response H(ω) of the filter.	10	CO5	L5
46	Write the Rectangular window sequence and plot its magnitude and phase response	5	CO5	L5

Course Outcome Computation

Academic Year:

Odd / Even semester

INTERNAL TEST			**T1**						**T2**			
Course Outcome	**CO1**		**CO2**		**CO3**		**CO4**		**CO5**		**CO6**	
QUESTION NO	**Q1**	**LV**	**Q2**	**LV**	**Q3**	**LV**	**Q1**	**LV**	**Q2**	**LV**	**Q3**	**LV**
MAX MARKS	10	-	10	-	10	-	10	-	10	-	10	-
USN-1	5	2	10				10	3	9	3	4	1
USN-2	5	2	8	3								
USN-3	7	3	7	3	10	3	8	3	8	3	5	2
USN-4					4	1	10	3	8	3	6	2
USN-5	8	3	6	2	9	3	10	3	8	3		
USN-6							10	3	9	3	4	1
Average CO Attainment		2.5		2.75		2.33		3		3		1.5

LV Threshold : 3:>60%, 2:>=50% and <=60%, 1: <=49%
CO1 Computation :(2+2+2+3)/4 = 10/4=2.5

PO Computation

Program Outcome	PO1		PO3		PO3		PO1		PO12		PO12	
Weight of CO - PO	3		1		3		2		2		3	
Course Outcome	CO1		CO2		CO3		CO4		CO5		CO6	
Test/Quiz/Lab	T1						T2					
QUESTION NO	Q1	LV	Q2	LV	Q3	LV	Q1	LV	Q2	LV	Q3	LV
MAX MARKS	10	-	10	-	10	-	10	-	10	-	10	-
USN-1	5	2	10	3			10	3	9	3	4	1
USN-2	5	2	8	3								
USN-3	7	3	7	3	10	3	8	3	8	3	5	2
USN-4					4	1	10	3	8	3	6	2
USN-5	8	3	6	2	9	3	10	3	8	3		
USN-6							10	3	9	3	4	1
Average CO Attainment		2.5		2.75		2.33		3		3		1.5