KERALA TECHNOLOGICAL UNIVERSITY

ERNAKULAM – WEST CLUSTER

DRAFT

SCHEME AND SYLLABI

FOR

M. Tech. DEGREE PROGRAMME

IN

SIGNAL PROCESSING

(2015 ADMISSION ONWARDS)

SCHEME AND SYLLABI FOR M. Tech. DEGREE PROGRAMME IN SIGNAL PROCESSING

SEMESTER-1

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06SP 6011	Linear Algebra	4-0-0	40	60	3	4
B	06SP 6021	Probability &Random Processes	4-0-0	40	60	3	4
C	06SP 6031	Multirate Signal Processing	4-0-0	40	60	3	4
D	06SP 6041	DSP Algorithms & Processors	3-0-0	40	60	3	3
E	06SP 6X51	Elective I	3-0-0	40	60	3	3
	06SP 6061	Research Methodology	0-2-0	100	0	0	2
	06SP 6071	Seminar I	0-0-2	100	0	0	2
	06SP 6081	Signal Processing Lab I	0-0-3	100	0	0	1

Credits:23

	Elective I (06SP 6X51)
06SP 6151	Artificial Neural Networks
06SP 6251	Signal Compression Techniques
06SP 6351	Advanced Digital System Design
06SP 6451	Digital Communication Techniques

SEMESTER-II

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06SP 6012	Estimation & Detection Theory	4-0-0	40	60	3	4
B	06SP 6022	Adaptive & Nonlinear Signal Processing	3-0-0	40	60	3	3
C	06SP 6032	Digital Image Processing	3-0-0	40	60	3	3
D	06SP 6X42	Elective II	3-0-0	40	60	3	3
E	06SP 6X52	Elective III	3-0-0	40	60	3	3
	06SP 6062	Mini Project	0-0-4	100	0	0	2
	06SP 6072	Signal Processing Lab II	0-0-3	100	0	0	1

Credits:19

Elective II - **(**06SP 6X42)		Elective III- (06SP 6X52)	
06SP 6142	Theory of Transforms	06SP 6152	Spectral Analysis
06SP 6242	Wavelets : Theory and Applications	06SP 6252	Pattern Recognition and Analysis
06SP 6342	VLSI Architectures for DSP	06SP 6352	Optical Signal Processing
06SP 6442	Multidimensional Signal Processing	06SP 6452	Wireless Communication

SEMESTER-III

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
A	06SP 7X11	Elective IV	3-0-0	40	60	3	3
B	06SP 7X21	Elective V	3-0-0	40	60	3	3
	06SP 7031	Seminar II	0-0-2	100	0	0	2
	06SP 7041	Project (Phase 1)	0-0-12	50	0	0	6

Credits: 14

Elective-IV(**06**SP 7X11**)**		Elective-V(**06**SP 7X21**)**	
06SP 7111	Biomedical Signal Processing	06SP 7121	Machine Learning
06SP 7211	Digital Control Systems	06SP 7221	Array Signal Processing
06SP 7311	Linear &Nonlinear Optimization	06SP 7321	Speech and Audio Signal Processing
06SP 7411	DSP Architecture Design	06SP 7421	Information Hiding &Data Encryption

SEMESTER-IV

Exam Slot	Course No:	Name	L- T – P	Internal Marks	End Semester Exam		Credits
					Marks	Duration (hrs)	
	06SP 7012	Project (Phase 2)	0-0-21	70	30	0	12

Credits:12

Total Credits for all semesters: 68

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6011	**LINEAR ALGEBRA**	**4-0-0: 4**	**2015**

PRE – REQUISITES:

Calculus, Basics of matrix theory

COURSE OBJECTIVES:

To build all the necessary fundamental mathematical background in the processing, analysis and synthesis of signals and their transmissions and transformations.

SYLLABUS

Introduction to matrix theory, Applications of matrices, Vector spaces and Linear transformations, Inner product spaces.

COURSE OUTCOME:

The taker will be able to frame the mathematical tools to understand and research processing of signals.

Text Books:

1. K. Hoffman, R. Kunze, "Linear Algebra", Prentice Hall India
2. G. Strang, "Linear algebra and its applications", Thomson

References:

3. D. C. Lay, "Linear algebra and its applications", Pearson
4. Gareth Williams, "Linear algebra with applications", Narosa
5. Michael W. Frazier, "An Introduction to wavelets through linear algebra", Springer

COURSE NO: 06SP 6011	COURSE TITLE: LINEAR ALGEBRA	(L-T-P : 4-0-0) CREDITS:4
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE : 1 **Matrices:** Introduction to linear system, matrices, vectors, Gaussian elimination, matrix notation, partitioned matrices, multiplication of partitioned matrices, inverse of partitioned matrices, triangular factors and row exchanges (LU, LDU), row exchanges and permutation matrices, inverses (Gauss-Jordan method)	10	25
MODULE : 2 **Vector spaces:** Vector space, subspace, linear independence, span, basis, dimension, spanning set theorem, null space, column space, row space-(Matrix), basis and dimension of null space, column space, row space-(Matrix), rank nullity theorem, co-ordinate system, change of basis–(finite space)	12	25
First Internal Test		
MODULE : 3 **Linear transformation:** Linear transformation, Kernel and range of linear transformation, matrix representation of linear transform, inverse transform **Inner product spaces:** Inner product space, norm, Cauchy-Schwarz inequality, Triangular inequality, self adjoint and normal operators, orthogonality, Hilbert spaces, orthogonal complements, projection theorem, orthogonal projections, orthonormal basis, Gram-Schmidt orthogonalization.	18	25
MODULE : 4 **Selected topics:** Eigen values, eigen vectors, diagonalization, symmetric matrices, quadratic forms, classification of quadratic forms, least-square solution of inconsistent system, singular value decomposition.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6021	**PROBABILITY AND RANDOM PROCESSES**	4-0-0:4	**2015**

PRE – REQUISITES:

Calculus, Elementary matrix theory, Signals and Systems, Digital Signal Processing.

COURSE OBJECTIVES:

To learn the fundamental mathematical background in probability and random processes.

SYLLABUS

Introduction to Probability theory, Bayes' theorem, Random variables, Random vectors, conditional probability distributions, Random processes, limit theorems, Strict Sense Stationary (SSS) and Wide Sense Stationary (WSS) processes. Response of a Linear Time Invariant (LTI) system to WSS input. Selected topics in stochastic processes.

COURSE OUTCOME:

Students would have mastered the basics of probability and random processes and should be able to study other advanced topics in Signal Processing.

Text Books:

1. Henry Stark, John W. Woods, "Probability and random processes with application to signal processing", Pearson
2. Athanasios Papoulis, S. Unnikrishnan Pillai, "Probability, Random Variables and Stochastic Processes", TMH

References :

3. T. Veerarajan, "Probability, Statistics and random processes", McGraw-Hill
4. V. Sundarapandian, "Probability, statistics and Queueing theory", PHI
5. S. M. Ross, "Stochastic Process", John Wiley and sons

COURSE NO: 06SP 6021	COURSE TITLE: **PROBABILITY AND RANDOM PROCESSES**	(L-T-P : 4-0-0) CREDITS:4
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Introduction to Probability Theory:** Sample space and events, conditional probabilities, independent events, the law of total probability and Bayes' theorem. **Random variables :** Discrete and continuous random variables, distributions, expectation of a random variable, moment generating function, joint probability distributions, marginal probability distributions and random vectors.	14	25
MODULE 2: **Limit theorems**: Markov and Chebyshev inequalities, weak and strong law of large numbers, convergence concepts and central limit theorem. **Stochastic process** (definition), conditional probability distributions (continuous and discrete cases), computing mean and variances by conditioning.	14	25
First Internal Test		
MODULE 3: **Random Process:** classification of random process, special classes of random process, SSS and WSS, auto and cross–correlation, ergodicity, Mean ergodic process, power spectral density, unit impulse response system, response of a LTI system to WSS input, noise in communication system-white Gaussian noise, filters	14	25
MODULE 4: **Selected topics:** Poisson process-Properties, Markov process and Markov chain, Chapman-Kolmogorov theorem, classification of states of a Markov chain, Birth-death process, Wiener process.	14	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6031	**MULTIRATE SIGNAL PROCESSING**	**4-0-0: 4**	**2015**

PRE – REQUISITES: Signals & Systems, Digital Signal Processing

COURSE OBJECTIVES:

1. To understand the fundamentals of multirate signal processing and its applications.
2. To understand the concepts of filter banks and its applications.

SYLLABUS

Fundamentals of multirate signal processing, Perfect reconstruction (PR) QMF Bank, M-channel perfect reconstruction filter banks, tree structured filter banks, Paraunitary PR Filter Banks, Quantization Effects, Cosine Modulated filter banks.

COURSE OUTCOME:

1. Students will be able to apply the concepts of interpolation & decimation in real time applications.
2. Students will be able to design and analyze the various types of filter banks related with signal processing applications.

Text Books:

1 P. P. Vaidyanathan, “Multirate systems and filter banks”, Prentice Hall, PTR. 1993.
2 Sanjit K. Mitra, “Digital Signal Processing: A computer based approach”, McGraw Hill, 1998.
3 N. J. Fliege, “Multirate digital signal processing”, John Wiley.

References :

4 Fredric J. Harris, “Multirate Signal Processing for Communication Systems”, Prentice Hall, 2004.
5 Ljiljana Milic, “Multirate Filtering for Digital Signal Processing: MATLAB Applications”, Information Science Reference; 1/e, 2008.
6 R. E. Crochiere & L. R. Rabiner, “Multirate Digital Signal Processing”, Prentice Hall, Inc. 1983
7 J. G. Proakis & D. G. Manolakis, “Digital Signal Processing: Principles. Algorithms and Applications”, 3rd edition, Prentice Hall India, 1999

COURSE NO: 06SP 6031	COURSE TITLE: MULTIRATE SIGNAL PROCESSING	(L-T-P : 4-0-0) CREDITS:4

MODULES	Contact hours	Sem.Exam Marks;%
MODULE 1: **Fundamentals of Multirate Theory:** The sampling theorem - sampling at sub nyquist rate - Basic Formulations and schemes. Basic Multirate operations- Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank-Identities- Polyphase representation. Maximally decimated filter banks: Polyphase representation- Errors in the QMF bank- Perfect reconstruction (PR) QMF Bank - Design of an alias free QMF Bank.	14	25
MODULE 2: **M-channel perfect reconstruction filter banks:** Uniform band and non uniform filter bank - tree structured filter bank- Errors created by filterbank system- Polyphase representation- perfect reconstruction systems	14	25
First Internal Test		
MODULE 3: **Perfect reconstruction (PR) filter banks:** Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Two channel FIR paraunitary QMF Bank- Linear phase PR Filter banks- Necessary conditions for Linear phase property- Quantization Effects: -Types of quantization effects in filter banks. – coefficient sensitivity effects, dynamic range and scaling.	14	25
MODULE 4: **Cosine Modulated filter banks:** Cosine Modulated pseudo QMF Bank- Alias cancellation- phase - Phase distortion- Closed form expression- Polyphase structure- PR Systems	14	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6041	**DSP ALGORITHMS & PROCESSORS**	**3-0-0: 3**	**2015**

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

To give the student:-

- An introduction to various advanced architectures of DSP processors
- Practice in the programming of DSP processors

SYLLABUS

Fundamentals of DSP architecture; various architectures of processors; DSP benchmarks, Pipeline implementation; Instruction level parallelism; review of memory hierarchy; TMS320C6x DSP processor: architectural details; addressing modes; instruction set; peripherals; SHARC processor: architectural details, peripherals

COURSE OUTCOME:

Upon completion of this course student will be able to Understand various advanced architectures of DSP processors and DSP benchmarks; Learn the role of pipelining and parallelism in DSP processors; Understand the architectural details of TMS320C6x processor and SHARC processor; Apply the instructions of TMS320C6x processor in assembly and C programming.

Text Books:

1. Steven W Smith, Digital Signal Processing: A Practical guide for Engineers and scientists, Newness (Elsevier), 2003.
2. Rulf Chassaing, Digital Signal Processing and applications with the C6713 and C6416 DSK, Wiley- Interscience, 2005.

References:

3. Sen M Kuo, Bob H Lee, Real time Digital Signal Processing, , John Wiley and Sons, 2001.
4. Nasser Kehtarnawaz, Real Time Signal Processing Based on TMS320C6000, Elsevier,2004.
5. JL Hennesy, D.A. Patterson, Computer Architecture A Quantitative Approach; 3rd Edition, Elsevier India.

COURSE NO: 06SP 6041	COURSE TITLE: DSP ALGORITHMS & PROCESSORS	(L-T-P : 3-0-0) CREDITS:3

MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Introduction**: Need for special DSP processors, Von Neumann versus Harvard Architecture, Architectures of superscalar and VLIW fixed and floating point processors, review of Pipelined RISC, architecture and Instruction Set Design, Performance and Benchmarks- SPEC CPU 2000, EEMBC DSP benchmarks. Basic Pipeline: Implementation Details- Pipeline Hazards.	10	25
MODULE 2: **Instruction Level Parallelism (ILP)**: Concepts, dynamic Scheduling **-** reducing data hazards. Tomasulo algorithm, Dynamic Hardware Prediction- reducing Branch Hazards, Multiple Issue- hardware-based Speculation, limitations of ILP, review of memory hierarchy – Cache design, cache Performance Issues, improving Techniques.	10	25
First Internal Test		
MODULE 3: **TMS 320 C 6x:** Architecture, Functional Units, Fetch and Execute Packets, Pipelining, Registers, Linear and Circular Addressing Modes, Indirect Addressing, Circular Addressing,TMS320C6x Instruction Set, Types of Instructions, Assembler Directives, Linear Assembly, ASM Statement within C, C-Callable Assembly Function, Timers, Interrupts, Multichannel Buffered Serial Ports, Direct Memory Access, Memory Considerations, Fixed- and Floating-Point Formats, Code Improvement, Constraints.	14	25
MODULE 4: **SHARC Digital Signal Processor**: – Architecture, IOP Registers, peripherals, synchronous Serial Port, interrupts, internal/external/multiprocessor memory space, multiprocessing, host Interface, link Ports. Review of TMS 320 C 6x and SHARC digital signal processors based on DSP bench marks.	8	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6151	**ARTIFICIAL NEURAL NETWORKS**	**3-0-0:3**	**2015**

PRE – REQUISITES: Linear Algebra, Basics of Signal Processing.

COURSE OBJECTIVES: The objective of this course is to present an overview on the theory and applications of artificial neural networks. It aims to develop create an understanding of such neural network system models and their applications to solve engineering problems

SYLLABUS: Introduction to ANNs, Network architectures, Knowledge Representation, Applications, Learning methods, Statistical nature of the learning. Single and Multilayer Networks, Back-propagation, Associative learning, Hopfield memory, BAM. The CPN, RBFN, SVM, ART Networks, PNNs. SOMs, PCA, Information theoretic models, Simulated annealing for stochastic Neural Networks, Genetic algorithms in Neural Network Optimization.

COURSE OUTCOME: Student must be able to identify issues related to the implementation of ANNs. Apply Artificial Neuron Networks and its learning methods to develop machine learning systems.

Text Books:

1. Simon Haykin, Neural Networks - A comprehensive foundation, Pearson Education Asia, 2001.
2. Martin T. Hagan, Howard B. Demuth, Mark Beale, Neural Network Design, Cengage Learning, 2008

References:

3. Laurene Fausett, - Fundamentals of Neural Network, Architecture, Algorithms and Applications, Pearson Education 2012.
4. Mohammed H. Hassoun, - Fundamentals of Artificial Neural Networks, Prentice Hall of India,2002
5. Jacek M. Zurada, - Introduction to Artificial Neural Systems, Jaico Publishers, 2002

6. S. Rajasekharan, G.A. Vijayalakshmi Pai, Neural Networks, Fuzzy Logic & Genetic Algorithms, Synthesis and Applications, Prentice Hall of India, 2011.
7. Frederic M. Ham & Ivica Kostanic, Principles of Neuro-computing for Science and Engineering, Tata Mc Graw hill, 2002.
8. J.S.R. Jjang, C.T. Sun and E. Mizutani, Neuro fuzzy and Soft Computing : A computational approach to learning and machine intelligence, Prentice Hall of India,2002
9. David E Goldberg, Genetic Algorithms in Search, Optimization and Machine Learning. Pearson Education India.
10. Bill P. Buckles, Fed Petry, Genetic Algorithms, IEEE Computer Society Press, 1992.

COURSE NO: 06SP 6151	**COURSE TITLE:** **ARTIFICIAL NEURAL NETWORKS**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Introduction to neural networks. Artificial intelligence and neural networks. The biological neuron. Models of the single neuron. Network architectures. Knowledge representation in neural networks. Applications of neural networks. Types of learning methods. Classification of learning methods. Statistical nature of the learning process. Statistical learning theory. The Probably Approximately Correct (PAC) model.	12	25
MODULE 2: Learning in a single layer perceptron. Adaptive filtering and the LMS algorithm. Learning rate annealing techniques. Perceptron convergence theorem. Multilayer perceptron: the error back-propagation learning method. Accelerated convergence in back-propagation learning. Associative learning, associative memory. Hopfield memory. BAM.	10	25
First Internal Test		

MODULE 3: The counter-propagation network. Radial basis function network. Support vector machines. Optimal hyperplane for non-separable patterns. Building support vector machines. ART Networks. Probabilistic Neural Networks.	10	25
MODULE 4: Self Organizing Maps. Learning vector quantization. Principal component analysis (PCA). Hebbian based and lateral inhibition based adaptive PCA. Kernel based PCA. Information theoretic models. Maximum Entropy Principle. Mutual information and Kullback-Leibler divergence. Simulated annealing for stochastic Neural Networks, Genetic algorithms in Neural Network Optimization.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6251	**SIGNAL COMPRESSION TECHNIQUES**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Probability & Random Process, Linear Algebra, Basic communication

COURSE OBJECTIVES:

• To introduce the student to the various aspect of signal compression methods.
• Concept of vector quantization is introduced along with the differential encoding.
• Various transform coding, subband coding, audio coding techniques are introduced.

SYLLABUS:

Self information, average information, models, uniquely decodable codes, prefix codes, Kraft-McMillan inequality, Distortion criteria, conditional entropy, average mutual information, differential entropy, rate distortion theory, Vector Quantization, Differential Encoding, Transform Coding, Subband coding, Wavelet based compression.

COURSE OUTCOME:

• Understands the important concepts of signal compression.
• Understands the various quantization techniques.
• Understands the basic principle of different types of coding techniques.

Text Books:

1. Khalid Sayood, “Introduction to Data Compression”, 3/e, Elsevier.

2. David Salomon, “Data Compression: The Complete Reference”, Springer.

3. Thomas M. Cover, Joy A. Thomas, “Elements of Information Theory," Wiley India

References:

4. Ali N. Akansu, Richard A. Haddad, “Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets”, Academic Press, 1992.

5. Toby Berger, "Rate Distortion Theory: A Mathematical Basis for Data Compression", Prentice Hall, Inc., 1971

6. K.R.Rao, P.C.Yip, "The Transform and Data Compression Handbook", CRC Press., 2001.

7. R.G.Gallager, "Information Theory and Reliable Communication", John Wiley & Sons, Inc., 1968.

8. Martin Vetterli, Jelena Kovacevic, "Wavelets and Subband Coding", Prentice Hall Inc.,1988.

COURSE NO: 06SP 6251	**COURSE TITLE:** **SIGNAL COMPRESSION TECHNIQUES**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Lossless Compression:** self information, average information, models, uniquely decodable codes, prefix codes, Kraft-McMillan inequality, Huffman coding, extended Huffman coding, nonbinary Huffman coding; arithmetic coding – coding a sequence, generating a binary code; dictionary techniques –LZ77, LZ78, LZW; context-based compression – ppm, Burrows- Wheeler transform.	12	25
MODULE 2: **Lossy Coding:** distortion criteria, conditional entropy, average mutual information, differential entropy, rate distortion theory; rate distortion theorem, converse of the rate distortion theorem, models. **Scalar Quantization:** uniform, adaptive, nonuniform, entropy-coded quantization.	10	25
First Internal Test		
MODULE 3: **Vector Quantization:** advantages over scalar quantization, LBG algorithm, tree structured and structured vector quantizers, trellis-coded quantization **Differential Encoding**: basic algorithm, prediction in DPCM, adaptive DPCM, delta modulation, speech coding – G.726.	10	25

MODULE 4: **Transform Coding**: Introduction, Karhunen-Loeve transform, discrete cosine transform, discrete Walsh Hadamard transform, quantization and coding of transform coefficients, JPEG, MDCT **Subband coding:** filters, basic subband coding algorithm. **Wavelet Based Compression:** multiresolution analysis, image compression, EZW coder, SPIHT, JPEG 2000. **Audio coding:-** MPEG audio coding.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6351	**ADVANCED DIGITAL SYSTEM DESIGN**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Knowledge in Digital Electronics

COURSE OBJECTIVES:

To enable the students

- To understand the concept of standard combinational and sequential modules, programmable devices and modular approach
- To learn the analysis and design concepts of synchronous and asynchronous digital systems and implement using different standard modules.
- To identify the relevance of timing issues and solutions in digital systems

SYLLABUS

Standard combinational MSI and LSI modules and modular networks: Arithmetic circuits, comparators, Multiplexers, Decoders, Code converters, ROMs, Synchronous Sequential Circuit Design: Clocked Synchronous State Machine Analysis, Mealy and Moore machines, Finite State Machine design procedure Standard sequential modules and modular networks:- State register/Counters ROMs and combinational networks, Multimodule implementation of counters and registers Asynchronous sequential circuits:- Analysis and Design with SM charts, Timing Issues in Digital System Design Design of combinational logic using programmable devices

COURSE OUTCOME:

Students will be able to understand the concepts of Standard combinational and sequential MSI and LSI modules, programmable devices and design modular networks, learn the analysis and design procedure of combinational systems, synchronous and asynchronous finite state machines and implementation of these systems using standard modules.
Students will also be able to assess the relevance of various timing issues and synchronization methods in digital systems.

Text Books:

1. Charles H Roth- Fundamentals of Logic Design, Cengage Learning, 5th ed.
2. Milos D Ercegovac, Tomas Lang- Digital Systems and Hardware/Firmware Algorithms, John Wiley,1985

References:

3.William Fletcher- A systematic Approach to Digital Design, PHI 1996
4. N N Biswas- Logic Design Theory, PHI
5.Jan M. Rabaey, A Chandrakasan, B. Nikolic- Digital Integrated Circuits- A Design Perspective, PHI/Pearson
6. Zvi Kohavi- Switching and Finite Automata Theory, Tata McGraw Hill
7. Comer- Digital Logic State Machine Design, Oxford University Press.

COURSE NO: 06SP 6351	COURSE TITLE: ADVANCED DIGITAL SYSTEM DESIGN	(L-T-P : 3-0-0) CREDITS:3

MODULES	Contact hours	Sem.Exam Marks;%
MODULE 1: **Standard combinational MSI and LSI modules and modular networks**: Arithmetic circuits, comparators, Multiplexers, Decoders, Code converters, ROMs, cost, speed and reliability comparison aspects of modular networks, XOR and AOI gates Design of combinational logic using PAL and PLA, Implementation of switching functions using FPGA.	8	25
MODULE 2: **Synchronous Sequential Circuit Design**: Clocked Synchronous State Machine Analysis, Mealy and Moore machines, Finite State Machine design procedure – derive state diagrams and state tables, state assignments, state reduction methods. Implementing the states of FSM using different FFs, Incompletely specified state machines. **Standard sequential modules and modular networks**: - State register/Counters with combinational networks. ROMs and combinational networks in FSM design Multimodule implementation of counters- cascade and parallel, multimodule registers.	12	25
First Internal Test		
MODULE 3: **Asynchronous sequential circuits:-** Analysis- Derivation of excitation table, Flow table reduction, state assignment, transition table, Design of Asychronous Sequential Circuits, Race conditions and Cycles, Static and dynamic hazards, Methods for avoiding races and hazards, Essential hazards. **Designing with SM charts** –State machine charts, Derivation of SM charts, and Realization of SM charts	12	25
MODULE 4: **Timing Issues in Digital System Design**:- Timing classifications, skew and jitter, latch based clocking, self timed circuit design- self timed logic, completion signal generation, self timed signalling, synchronizers and arbiters **Sequential circuit design using PLAs, CPLDs, FPGAs.**	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6451	**DIGITAL COMMUNICATION TECHNIQUES**	**3-0-0:3**	**2015**

PRE – REQUISITES: Basics of Communication Engineering

COURSE OBJECTIVES:

1. To recollect the basics of random variables and random process and learn to apply them in design and analysis of communication systems.
2. To familiarise with the representation of signals and modulated signals.
3. To understand the coherent and non coherent communication and their performance
4. To learn equalization techniques in digital communication systems

SYLLABUS

Review of random variables and processes, Geometric representation of signals, Optimum waveform receiver in additive white Gaussian noise (AWGN) channels, Optimum receiver for coherent and noncoherent communication. Correlation receiver and matched filter receiver, Probability of error, Communication over band limited channels – Nyquist criteria for distortionless transmission – Equalization.

COURSE OUTCOME:

The students will able to apply the concepts of probability and stochastic process in communication systems, to emphasize the analysis of performance in the presence of noise, by calculating the probability of error for matched filter receiver and various digital modulation techniques, design an optimum receiver for digital communication systems and to select a proper equalization technique according to the modulation type.

Text Books:

1. J.G. Proakis, *“Digital Communication”*, MGH .
2. Marvin.K.Simon, Sami. M. Hinedi and William. C. Lindsey, *“Digital Communication Techniques”*, PHI.

References :

3. Bernard Sklar, *“Digital Communication”*, Pearson Education, 2001.
4. Simon Haykin, *“Digital communications”*, John Wiley and sons, 1998.
5. Athanasios Papoulis, S. Unnikrishna Pillai, *“Probability, Random Variables and Stochastic Processes”*, TMH

COURSE NO: 06SP 6451	COURSE TITLE: DIGITAL COMMUNICATION TECHNIQUES (L-T-P : 3-0-0) CREDITS:3	
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Review of Random variables:** Function of random variables - Sum of Random variables - Central limit Theorem, Chi square, Rayleigh and Rician distributions, Correlation, covariance matrix, Stochastic Process. **Characterization of Communication Signals And Systems:** Signal space representation - Orthogonal Expansion of signals - Representation of Band pass signals and system. Representation of Digitally Modulated Signals - Memoryless Modulation Methods.	12	25
MODULE 2: **Communication over Additive Gaussian Noise channel**: **Coherent Communication receivers** - Optimum waveform receiver in Additive White Gaussian Noise (AWGN) - correlation receiver, Matched filter receiver - Performance of optimum receiver - Probability of error for binary, M-ary signals**.**	10	25
First Internal Test		
MODULE 3: **Communication over Additive Gaussian Noise channel** : **Noncoherent communication Receivers** - Optimum Receiver for Signals with random phase in AWGN Channels - Optimum receiver for Binary Signals - Optimum receiver for M-ary orthogonal signals - Probability of error for envelope detection of M-ary Orthogonal signals**.** Optimum waveform receiver for coloured Gaussian noise channels-Karhunen Loeve expansion approach, whitening.	10	25
MODULE 4: **Communication through Band limited channels:** Signal design for band limited channel - Nyquist criteria for zero Inter Symbol Interference (ISI), Controlled ISI - Partial response signals, Equalization techniques, Linear equalization, Decision feedback Equalization, Adaptive Equalization.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6061	**RESEARCH METHODOLOGY**	**0-2-0:2**	**2015**

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

The primary objective of this course is to develop a research orientation among the scholars and to acquaint them with fundamentals of research methods. Specifically, the course aims at introducing them to the basic concepts used in research and to scientific social research methods and their approach. It includes discussions on sampling techniques, research designs and techniques of analysis. Some other objectives of the course are:

- To develop understanding of the basic framework of research process.
- To develop an understanding of various research designs and techniques.
- To identify various sources of information for literature review and data collection.
- To develop an understanding of the ethical dimensions of conducting applied research.
- Appreciate the components of scholarly writing and evaluate its quality.

SYLLABUS

Research methodology; Research Process; Application of results , ethics and intellectual property rights; Techniques of developing measurement tools; Processing and analysis of data; Interpretation and report writing-techniques of interpretation; Graphic & diagrammatic representation data; Defining research problem ; Experimental Designs; Sampling fundamentals; Testing of hypotheses.

COURSE OUTCOME:

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

- Understand some basic concepts of research and methodologies.
- To Identify appropriate research topics.
- Select and define appropriate research problem and parameters.
- Prepare a project proposal (to undertake a project) .
- Organize and conduct research (advanced project) in a more appropriate manner.
- Write a research report and thesis.
- Write a research proposal (grants).
- Attain basic knowledge of experimentation methods and statistical analysis

Text Books &References:

1. Garg, B.L., Karadia, R., Agarwal, F. and Agarwal, U.K., An introduction to Research Methodology, RBSA Publishers. 2002.
2. Kothari, C.R., Research Methodology: Methods and Techniques. New Age International. 1990.

3. Deepak Chawla and Neena Sondhi Research Methodology concepts and cases Vikas Publishing house pvt ltd, 2011
4. R. Paneerselvam , Research Methodology, PHI Learning, 2014
5. Sinha, S.C. and Dhiman, A.K., Research Methodology, EssEss Publications. 2 volumes., 2002.
6. Trochim, W.M.K., Research Methods: the concise knowledge base, Atomic Dog Publishing. 2005.
7. Wadehra, B.L. Law relating to patents, trade marks, copyright designs and geographical indications.Universal Law Publishing, 2000.
8. Day, R.A., How to Write and Publish a Scientific Paper, Cambridge University Press, 1992..
9. Fink, A., Conducting Research Literature Reviews: From the Internet to Paper. Sage Publications, 2009.
10. Leedy, P.D. and Ormrod, J.E., Practical Research: Planning and Design, Prentice Hall, 2004

COURSE NO: 06SP 6061	**COURSE TITLE:** **RESEARCH METHODOLOGY**	**(L-T-P : 0-2-0) CREDITS:2**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Research methodology: meaning of research, objectives, type of research approaches, research process, and criteria for good research. Concept of theory, empiricism, deductive and inductive theory. Characteristics of scientific method – Understanding the language of research – Concept, Construct, Definition, Variable. Research Process Application of results and ethics - Environmental impacts - Ethical issues - ethical committees -Commercialization – Copy right – royalty - Intellectual property rights and patent law – Trade Related aspects of Intellectual Property Rights – Reproduction of published material – Plagiarism -Citation and acknowledgement - Reproducibility and accountability.	7	25
MODULE 2:	7	25

Techniques of developing measurement tools – scaling – important scaling techniques. Methods of data collection–collection of primary data–observation method questionnaires –other methods of data collection. Processing and analysis of data – processing operations – editing – coding –classification – tabulation. Interpretation and report writing-techniques of interpretation – steps in report writing. Graphic & diagrammatic representation data - Purpose of Diagrams & Graphs, Bar diagrams (Simple, Component & Percentage), Pie Charts, Line Square Diagrams, Interpretations & Comparisons, Graphical Representation of Frequency Distribution, Histograms, Frequency Polygon, Frequency Curve		
First Internal Test		
MODULE 3: Defining research problem – research design, features of good design - different research designs, basic principle of experimental design developing a research plan. Experimental Designs - purpose of designing experiments, methods of increasing accuracy of experiments, replication, control & randomization and their objectives & advantages - basic ideas of completely randomized , randomized block, Factorial and Latin square designs.	7	25
MODULE 4: Sampling fundamentals – need for sampling – important sampling distribution: Sampling distribution of mean- sampling distribution of proportion – student's't' distribution – F distribution–Chi-square distribution – concept of standard error - – sample size and its determination. Testing of hypotheses – procedure for testing hypotheses - important parametric tests: Z test, t-test, chi- square test, F test and ANOVA. Software for statistical testing.	7	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6071	**SEMINAR – I**	**0-0-2:2**	**2015**

PRE – REQUISITES:

Basic knowledge in Digital Signal Processing,

COURSE OBJECTIVES:

- To introduce the students to latest research topics in the area of Signal Processing.
- To familiarize the students in reading & comprehending technical papers and implementing the algorithms/methods described in them.
- To develop the presentation skills of student.

SYLLABUS

Each student shall present a seminar on any topic of interest related to Signal Processing . He / she shall select the topic based on the references from recent international journals of repute, preferably IEEE/ACM journals. They should get the paper approved by the Programme Co-ordinator / Faculty member in charge of the seminar and shall present it in the class. Every student shall participate in the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report submitted.

COURSE OUTCOME:

- Student will develop the ability to comprehend technical papers in their selected areas.
- Students will learn to make technical presentations, prepare technical papers and reports.

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6081	**SIGNAL PROCESSING LAB – I**	**0-0-3:1**	**2015**

PRE – REQUISITES:

Basic knowledge in Digital Signal Processing.

COURSE OBJECTIVES:

Familiarization of the students to DSP hardware and to implement signal processing algorithms in MATLAB,

SYLLABUS

Part-A

Experiments to learn the concepts introduced in the courses Linear Algebra, Probability & Random Process and Multi rate signal processing using a numerical computing environment such as MATLAB or GNU Octave or any other equivalent tool.

Part-B

Familiarization of TMS320C6X based DSP kit and code composer studio IDE.
Programming to learn assembly coding and C coding.
Design and Realization of FIR, IIR Filters.
Experiments to do real time filtering.

COURSE OUTCOME:

Students will have the skills for practical implementation of algorithms in MATLAB as well as Digital signal processors.

Text Books:

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6012	**ESTIMATION & DETECTION THEORY**	**4-0-0: 4**	**2015**

PRE – REQUISITES:

Basics of Signals and Systems, Linear Algebra, Probability Theory, Random Processes and Statistics.

COURSE OBJECTIVES:

This course gives a comprehensive introduction to detection (decision-making) as well as parameter estimation and signal estimation (filtering) based on observations of discrete-time and continuous-time signals. This course has applications in many areas such as communications, radar, pattern recognition and imaging.

SYLLABUS

Detection Theory: Bayes' Detection, Min-Max Criterion, Neyman-Pearson Criterion, Composite Hypothesis Testing: Generalized likelihood ratio test (GLRT), Receiver Operating Characteristic Curves. **Estimation Theory:** Minimum variance unbiased(MVU) estimators, Cramer-Rao Lower Bound, Linear Modeling, Sufficient Statistics, Best Linear Unbiased Estimation, Least Squares Estimation, Likelihood and Maximum Likelihood Estimation, **Random Parameter Estimation:** Bayesian Philosophy,

COURSE OUTCOME:

Students will be able to cast a generic detection problem into a hypothesis testing framework and to find the optimal test for the given optimization criterion. They will also be capable of finding optimal estimators for various signal parameters, derive their properties and assess their performance.

Text Books:

1.Steven M. Kay, "Statistical Signal Processing: Vol. 1: Estimation Theory, Detection Theory," Vol. 2: Prentice Hall Inc., 1998.

References:

2. M D Srinath, P K Rajasekaran, R Viswanathan, "Introduction to Statistical Signal Processing with Applications", Pearson, 1995.

3.H. Vincent Poor, "An Introduction to Signal Detection and Estimation", 2nd Edition, Springer, 1994.

4. Jerry M. Mendel, "Lessons in Estimation Theory for Signal Processing, Communication and Control," Prentice Hall Inc., 1995.

COURSE NO: 06SP 6012	COURSE TITLE: ESTIMATION & DETECTION THEORY	(L-T-P : 4-0-0) CREDITS:4
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Fundamentals of Detection Theory Hypothesis Testing:** Bayes' Detection, MAP Detection, ML Detection, Minimum Probability of Error Criterion, Min-Max Criterion, Neyman-Pearson Criterion, Multiple Hypothesis, Composite Hypothesis Testing: Generalized likelihood ratio test (GLRT), Receiver Operating Characteristic Curves.	16	25
MODULE 2: **Fundamentals of Estimation Theory** Role of Estimation in Signal Processing, Unbiased Estimation, Minimum variance unbiased(MVU) estimators, Finding MVU Estimators, Cramer-Rao Lower Bound, Linear Modeling-Examples, Sufficient Statistics, Use of Sufficient Statistics to find the MVU Estimator	16	25
First Internal Test		
MODULE 3: **Estimation Techniques Deterministic Parameter Estimation:** Best Linear Unbiased Estimation, Least Squares Estimation-Batch Processing, Recursive Least Squares Estimation, Likelihood and Maximum Likelihood Estimation	12	25
MODULE 4: **Estimation Techniques (contd) Random Parameter Estimation:** Bayesian Philosophy, Selection of a Prior PDF, Bayesian linear model, Minimum Mean Square Error Estimator, Maximum a Posteriori Estimation	12	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6022	**ADAPTIVE & NONLINEAR SIGNAL PROCESSING**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Digital Signal Processing, Linear Algebra, Probability and Random Processes.

COURSE OBJECTIVES:

To learn the fundamentals of Statistical and Adaptive Signal Processing. Also to learn basics of non-linear signal processing.

SYLLABUS

MA, AR, ARMA processes. Yule Walker equations.Wiener filter, Kalman filter. Steepest descent and Newton's method. LMS filter, RLS filter, linear prediction, Levinson Durbin algorithm. Non-linear signal processing – Median Smoothers, Rank order filters

COURSE OUTCOME:

Students would have gained sufficient knowledge in various domains of statistical and adaptive signal processing. They would have learned the basics of non-linear signal processing. They will be well equipped to apply what they learned, in various application domains of advanced signal processing.

Text Books:

1. S. Haykin, "Adaptive Filters Theory", Prentice-Hall.
2. Monson Hayes, "Statistical Digital Signal Processing and Modelling", Wiley India Pvt. Ltd
3. J. Astola, P. Kuosmanen, "Fundamentals of non-linear digital filtering", CRC Press, 1997.
4. G. R. Arce , "Non-linear signal processing: A statistical approach", Wiley 2004.

References:

5. Dimitris G. Manolakis, Vinay K. Ingle, Stephan M Krgon, "Statistical and Adaptive Signal Processing", Mc Graw Hill (2000)
6. S. J. Orfanidis, "Optimum Signal Processing", Mc-Graw Hill..

7. Jones D. Adaptive Filters [Connexions Web site]. May 12, 2005. Available at: http://cnx.rice.edu/content/col10280/1.1/
8. Proakis & Manolakis, "Digital Signal Processing". PHI, New Delhi
9. Ifeacher," Digital Signal Processing," Addision Wesley
10. Sanjit K. Mitra, " Digital Signal Processing",TMH
11. A. V. Oppenheim & Ronald W. Schafer , "Discrete Time Signal processing", PHI, New Delhi.

COURSE NO: 06SP 6022	**COURSE TITLE:** **ADAPTIVE & NONLINEAR SIGNAL PROCESSING**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Review of discrete time Complex Gaussian processes, MA, AR, ARMA processes and their properties, MMSE predictors, LMMSE predictor, orthogonality theorem (concept of innovation processes), Wiener filter, FIR Wiener filter, IIR Wiener filter, Yule-walker equation. Kalman filter, recursions in Kalman filter.	14	25
MODULE 2: Filters with recursions based on the steepest descent and Newton's method, criteria for the convergence, rate of convergence. LMS filter, mean and variance of LMS, the MSE of LMS and misadjustment, Convergence of LMS.	10	25
First Internal Test		
MODULE 3: RLS recursions, assumptions for RLS, convergence of RLS coefficients and MSE. Filter based on innovations, generation of forward and backward innovations, forward and reverse error recursions. Implementation of Wiener, LMS and RLS filters using lattice filters, Linear Prediction, Levinson Durbin algorithm, reverse Levinson Durbin algorithm.	10	25

MODULE 4: Non-linear signal processing: Non-linear filters, Non-Gaussian models, Generalized Gaussian and stable distributions, Median smoothers, Rank/order filters, Weighted median smoother.	8	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6032	**DIGITAL IMAGE PROCESSING**	**3-0-0: 3**	**2015**

PRE – REQUISITES: Basics of Digital Signal Processing

COURSE OBJECTIVES:

To give the Student:-

- An understanding of fundamentals of images
- An understanding of various realms of imaging processing
- An ability to carry out image processing operations.
- An overview of applications of image processing

SYLLABUS

Digital Image fundamentals- representation, elements of visual perception, Image Enhancement ,Image restoration, Image Compression, Image Segmentation, Representation and Descriptions, Morphological Image Processing, and color image processing.

COURSE OUTCOME: Upon completion of this course th estudent will be able to under stand the formation of digital images, the various realms of image processing and apply the image processing techniques to various image processing applications.

Text Books:

1. Gonzalez and Woods, Digital Image Processing- Pearson education, 2002.
2. A K Jain, Fundamentals of Digital Image Processing –Pearson education, 2003.

References:

1. W K Pratt, Digital Image Processing- John Wiley, 2004
2. Tamal Bose, Digital Signal and Image Processing- John Wiley publishers.
3. J S. Lim, Two dimensional signal and Image Processing- Prentice Hall.

COURSE NO: 06SP 6032	COURSE TITLE: DIGITAL IMAGE PROCESSING	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Digital Image fundamentals**: representation, elements of visual perception, simple image formation model, image sampling and quantization, basic relationship between pixels, imaging geometry, image transformations -scaling , rotation and affine transformations. **Image Enhancement:** Spatial Domain Methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging. Spatial filtering- smoothing filters, sharpening filters, Frequency Domain methods- low pass filtering, high pass filtering, homomorphic filtering, generation of spatial masks from frequency domain specification.	11	25
MODULE 2: **Image restoration** :Degradation model, Algebraic approaches- Inverse filtering, Wiener filtering, Constrained Least Squares restoration, Interactive restoration, Geometric transformations **Image Compression:** Fundamentals, redundancy: coding, interpixel, psychovisual, fidelity criteria, Models, Elements of information theory, error free compression - variable length, bit plane, lossless predictive, lossy compression- lossy predictive, transform coding, Fundamentals of JPEG image compression, Wavelet based compression techniques-EZW, SPIHT,JPEG 2000.	10	25
First Internal Test		
MODULE 3: **Image Segmentation:** Detection of discontinuities- point, line, edge and combined detection, edge linking and boundary description, local and global processing using Hough Transform- Thresholding, Region oriented segmentation – basic formulation, region growing by pixel aggregation, region splitting and merging, use of motion in segmentation. **Representation and Description:** Representation, Boundary Descriptors, Regional Descriptors, Use of Principle Components for Description, Relational Descriptors.	11	25
MODULE 4: **Morphological Image Processing** : Basic set theory, Logic Operations involving binary images, dilation and erosion, Opening and closing, the	10	25

hit-or-miss transformation, Basic Morphological operations boundary extraction, region filling, extracted connected components, convex hull, thickening, thinning, Pruning ,skeletons **Color Image Processing:** color models- RGB, CMY, YIQ, HIS, Pseudo coloring, intensity slicing, gray level to color transformation.		
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6142	**THEORY OF TRANSFORMS**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Linear Algebra, Calculus, Basics of Signal Processing.

COURSE OBJECTIVES:

To present an integral theory on the construction of various integral transforms as an application of Hilbert Space.

SYLLABUS

Metric spaces,. Vector spaces, Normed Space, Banach Space, Linear Operators and Functionals, Hilbert Space, Generalized Functions and Dirac's Delta, Green's Functions as inverse of differential operators, Construction of Continuous and Discrete Fourier Transforms, Fractional Fourier transform, Laplace Transforms, Z Transforms. Lapped Transform, Biorthogonal transforms, Karhunen-Loeve transform. Reisz basis, Resolution of unity, Introduction to Continuous wavelet transform, Discrete Wavelet Transform. Definition of frames, frame operator, Multiresolution Analysis

COURSE OUTCOME:

Students will have knowledge of the basic underlying theory that is common to the construction of various integral transforms.

Text Books:

1. Erwin Kreyszig, "Introductory Functional Analysis with Applications," John Wiley and Sons, 1989.
2. Lokenath Debnath and Piotr Mikusinski, "Hilbert Spaces with Applications," 3rd Edition, Academic Press, Indian reprint 2006.

References:

3. Lokenath Debnath, Dambaru Bhatta, "Integral Transforms and Their Applications", Third Edition, 2014, CRC Press.
4. Stephane G. Mallat, "A Wavelet Tour of Signal Processing," 2nd Edition, Academic Press, 2000.
5. Ingrid Daubechies, "Ten Lectures on Wavelets," SIAM, 1990.
6. Malvar, *H. S.* (1992). "Signal Processing with Lapped Transforms". Artech House 1992.
7. Arch W. Naylor and George R. Sell, "Linear Operator Theory in Engineering and Science," 2nd Edition, Springer-Verlag, New York, 1982.

8. Gerald Kaiser, “A Friendly Guide to Wavelets,” Birkhauser/Springer International Edition, 1994, Indian reprint 2005.
9. Martin Vetterli & Jelena Kovacevic, Wavelets and Subband Coding, Prentice Hall, 2007.

COURSE NO: 06SP 6142	**COURSE TITLE:** **THEORY OF TRANSFORMS**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Metric spaces: Convergence, Cauchy sequence, Completeness. Vector spaces: Finite and Infinite Dimensional vector spaces. Normed spaces, Banach Spaces: Linear Operators and Functionals, Normed spaces of Operators. Inner product spaces, Hilbert spaces: Properties, Orthogonal and Orthonormal systems, Represenation of Functionals, Adjoint of an operator, Self-adjoint operators, Bessel’s inequality, Parseval’s identity, Reisz Representation Theorem. Spectral Theory: Basic Concepts**.**	12	25
MODULE 2: Generalized functions and the Dirac’s delta; Differential operators – Inverse differential operators and Green’s function. Construction of Fourier transform, Self-reciprocal functions and operators under Fourier transform, Construction of Fractional Fourier transform.	10	25
First Internal Test		
MODULE 3: Construction of Laplace transform, Discrete-time Fourier transform and Discrete Fourier transform, Z-transform, Discrete Cosine and Sine transforms. Lapped Transforms: Lapped orthogonal transforms and Biorthogonal transforms, Karhunen-Loeve transform.	10	25

MODULE 4: Reisz basis, Resolution of unity, Introduction to Continuous wavelet transform, Discrete Wavelet Transform. Definition of frames, frame operator, Multiresolution Analysis and Orthonormal Bases for Wavelets, Examples of orthonormal bases for wavelets.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6242	**WAVELETS: THEORY & APPLICATIONS**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Knowledge in signals and systems

COURSE OBJECTIVES:

- To enable the students to understand the concept of time frequency representation of signals .
- To understand the mathematical concept of different wavelet systems and their use in signal analysis and processing..
- To familiarize with the application of wavelet transform in signal processing

SYLLABUS

Continuous time frequency representation of signals, windowed Fourier transform, Uncertainty Principle and time frequency tiling, Wavelets, specifications, Continuous wavelet transform, Haar scaling and wavelet functions and function spaces, discrete wavelet transform , signal decomposition and signal reconstruction using orthogonal wavelet system and its filter bank implementation, signal decomposition and signal reconstruction using biorthogonal wavelet system and its filter bank implementation , Applications of wavelelet transform.

COURSE OUTCOME:

Students will be able to understand the concepts of time frequency analysis of signals , mathematical concept of different wavelet systems and their application in signal analysis and processing.

Text Books:

1. K P Soman and K I Ramachandran, Insight into wavelets: From theory to Practice- Prentice Hall of India
2. R M Rao and A S Bopardikar, Wavelet Transforms: Introduction to theory and applications Pearson

References:

3. G Strang and T Q Nguyen, Wavelets and filter banks- Wellesley Cambridge Press, 1998.
4. J C Goswamy and A K Chan, Fundamentals of Wavelets: Theory, Algorithms and Applications- Wiley- Interscience publications, John Wiley and sons, 1999
5. F Keinert, Wavelets and Multiwavelets- SIAM, Chapman and Hall/CRC, 2004
6. Ingrid Daubechies, Ten Lectures on Wavelets- SIAM, 1990

7. H L Resnikoff, R. O. Wells,Jr., Wavelet Analysis- The scalable structure of Information- Springer, 2004.
8. Stephane G. Mallat, “A Wavelet Tour of Signal Processing,” 2nd Edition, Academic Press, 2000
9. Gerald Kaiser, “A Friendly Guide to Wavelets,” Birkhauser/Springer International Edition, 1994, Indian reprint 2005.

COURSE NO: 06SP 6242	**COURSE TITLE:** **WAVELETS: THEORY & APPLICATIONS**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Continuous and Discrete Wavelet Transform:** Continuous time frequency representation of signals, The Windowed Fourier Transform, Uncertainty Principle and time frequency tiling, Wavelets, specifications, admissibility conditions, Continuous wavelet transform, Haar scaling functions and function spaces, nested spaces, Haar wavelet function, orthogonality, normalization of bases , refinement relations.	12	25
MODULE 2: **Orthogonal wavelet Transform:** Refinement relation for orthogonal wavelet system, restriction on filter coefficients, discrete wavelet transform and relation to filter banks, signal decomposition ,signal reconstruction , filter bank implementation, perfect matching filters, computation of coefficients.	12	25
First Internal Test		
MODULE 3: **Biorthogonal Wavelet transform:** Biorthogonality in vector space, biorthogonal wavelet systems, biorthogonal analysis and synthesis, filter bank implementation, wavelet construction using lifting scheme.	12	25
MODULE 4: **Applications:** Image Compression: wavelet transform of an image, quantization, entropy encoding, EZW Coding, SPIHT, Denoising using	8	25

wavelet shrinkage, shrinkage functions, shrinkage rules.		
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6342	**VLSI ARCHITECTURES FOR DSP**	**3-0-0:3**	**2015**

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

To introduce students to fundamental and advanced theoretical aspects of

. Pipelining and Parallel Processing of Filters, Retiming, Unfolding and Folding

. Algorithmic Strength reduction and fast convolution algorithms

. Scaling and Round off noise Computations of Digital Filters

. Digital Filter Structures, Bit Level Arithmetic Architectures and Canoniic Signed Digital Arithmetic

SYLLABUS

Pipelining and Parallel Processing of Filters; Retiming; Unfolding; Fast Convolution Algorithms and Algorithmic Strength Reduction; Scaling and Round Off Noise Computations in Digital Filters; Digital Filter Structuires; Bit Level Arithmetic Architectures; Canonic Signed Digital Arithmetic

COURSE OUTCOME:

Students who complete the course will have demonstrated ability to construct pipelined and parallel architectures for FIR and IIR filters, apply concepts and algorithms for retiming unfolding and folding of filters to construct parallel and serial versions of digital filters, apply algorithmic strength reduction techniques to minimise algorithmic computations and construct faster versions of digital filters and obtain structures with minimised problems of scaling and round off noise. He/She will be able to derive structures of digital basic lattice filters and handle canonic signed digital arithmetic with ease.

Text Books:

1. Keshab K Parhi, VLSI DSP Systems- Design and Implementation John Wiley, 2004.

References :

2. Uwe Meyer Baese, Digital Signal Processing with Field Programmable Gate Arrays - Springer Verlag 2001.
3. Sen M Kuo, Woon-Seng S. Gan, Digital Signal Processors : Architectures , Implementations and applications, Prentice Hall, 2004
4. Lars Wanhammar, DSP integrated circuits, Academic Press, 1999.

COURSE NO: 06SP 6342	COURSE TITLE: VLSI ARCHITECTURES FOR DSP	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Block Diagram and Graph Representations of DSP Algorithms – Signal Flow Graph, Data Flow Graph and Dependence Graphs – Algorithms for Shortest Path Computation - Pipelining and Parallel processing of filters - - Pipelining and parallel processing for Low Power. Retiming - Definitions and Properties - solving system of inequalities - Retiming techniques. Unfolding - algorithm for unfolding - Properties of unfolding - Critical path, Unfolding and retiming - Applications Folding - Folding transformation - Register minimization techniques - Register minimization in folded architectures.	12	25
MODULE 2: Fast convolution – Cook Toom and Winograd Algorithms – Modified Algorithms - Iterated convolution - Cyclic convolution - Algorithmic strength reduction in filters and transforms - Parallel FIR filters - Pipelined and parallel recursive and adaptive filters - pipeline interleaving in Digital filters - Pipelining in IIR digital filters - Parallel processing for IIR filters - Low power IIR filter design using Pipelining and Parallel processing.	10	25
First Internal Test		
MODULE 3: Scaling and Round off noise – Scaling and Round off noise - State variable description of Digital Filters - Scaling and Round off noise computation - Round off noise in Pipelined IIR filters - Round off noise computation using state variable description - SRP Transformation.	10	25
MODULE 4: Digital lattice filter structures - Schur Algorithm - Digital basic lattice filters, Derivation of one multiplier Lattice filter - Derivation of scaled-normalized lattice filter - Round off noise calculation in Lattice filters. Bit level arithmetic architectures - Parallel multipliers - Bit serial filter	10	25

design and implementation - Canonic signed digital arithmetic.		
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6442	**MULTIDIMENSIONAL SIGNAL PROCESSING**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Signals & Systems, Digital Signal Processing

COURSE OBJECTIVES:

- To introduce the student to the various aspect of multidimensional signal processing.
- Concept of sampling 2D signal and multidimensional DFT are introduced.
- Basic concept of multidimensional digital filter design is introduced.

SYLLABUS:

Fundamental operations on Multidimensional signals, Periodic sampling with rectangular geometry-sampling density, Aliasing effects created by sampling, Multidimensional discrete Fourier transform-Properties of DFT, Circular convolution- Calculation of DFT, Separable Filters- Linear phase filters-FIR Filters- Implementation of FIR filters - design of FIR filters using windows.

COURSE OUTCOME:

- Understands the important concepts of multidimensional signal processing.
- Understands the various concept of sampling 2D signal & multidimensional DFT.
- Understands the basic design principle of multidimensional digital filters.

Text Books:

1. John Woods, "Multidimensional signal, image, and video processing and coding", Academic Press, 2006.

2. Dudgeon Dan E., "Multidimensional Digital Signal Processing", Prentice Hall, Englewood Cliffs, New Jersey

References

3. P.P. Vaidyanathan. "Multirate systems and filter banks." Prentice Hall. PTR. 1993.

4. Jae S. Lim, "Two- Dimensional Signal and Image Processing", Prentice Hall Englewood Cliffs, New Jersey, 1990.

COURSE NO: 06SP 6442	COURSE TITLE: MULTIDIMENSIONAL SIGNAL PROCESSING	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Multidimensional systems** Fundamental operations on Multidimensional signals, Linear Shift - Invariant systems-cascade and parallel connection of systems- separable systems, stable systems- Frequency responses of 2D LTI Systems- Impulse response- Multidimensional Fourier transforms- z transform, properties of the Fourier and z transform.	10	25
MODULE 2: **Sampling continuous 2D signals** Periodic sampling with rectangular geometry- sampling density, Aliasing effects created by sampling - Periodic sampling with hexagonal geometry.	10	25
First Internal Test		
MODULE 3: **Multidimensional Discrete Fourier Transform** Multidimensional discrete Fourier transform- Properties of DFT, Circular convolution- Calculation of DFT- DFT for periodically sampled signals - Fast Fourier transform for periodically sampled signals.	10	25
MODULE 4: **Multidimensional Digital Filter Design** Separable Filters- Linear phase filters- FIR Filters- Implementation of FIR filters - design of FIR filters using windows- Two dimensional window functions, IIR Filters.	12	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6152	**SPECTRAL ANALYSIS**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Basic ideas about probability, random processes and signal processing

COURSE OBJECTIVES:

1. To deepen the knowledge in statistical signal processing
2. To learn the basics of energy and power estimation.
3. To understand the parametric and nonparametric approaches to power spectrum estimation techniques.
4. To understand the filter bank method of spectral analysis

SYLLABUS

Power Spectral Density **-** Energy spectral density of deterministic signals, Power spectral density of random signals, Properties of PSD. PSD Estimation - Non-parametric methods, PSD Estimation - Parametric methods **-** Parametric method for rational spectra**-** Parametric method for line spectra – AR, MA, ARMA models. Filterbank methods **-** Filterbank interpretation of periodogram

COURSE OUTCOME:

Students who complete this course will have an ability to understand the difference between the parametric and nonparametric problem of estimating the power spectra of random signals and will be able to decide what methods are suitable for specific problem. The student will be able to use this knowledge to solve the real world problems in the field of radar and sonar signal processing, geophysical signals etc.

Text

1. Stoica , Randolph L. Moses, *"Introduction to Spectral Analysis"* , Prentice Hall
2. Kay S M ,*"Modern Spectral Estimation Theory & Applications"* , Prentice Hall

References

3. Manolakis, Ingle and Kogon, *"Statistical and Adaptive Signal Processing"*, Tata McGraw Hill 2000.

4. Monson H. Hayes, *"Statistical Digital Signal Processing and Modelling"*, Wiley

COURSE NO: 06SP 6152	COURSE TITLE: **SPECTRAL ANALYSIS**	(L-T-P : 3-0-0) CREDITS:3

MODULES	Contact hours	Sem.Exam Marks;%
MODULE 1: **Basic Concepts:** Introduction, Energy Spectral Density of deterministic signals, Power spectral density of random signals, Properties of PSD, The Spectral Estimation problem.	10	25
MODULE 2: **PSD Estimation - Non-parametric methods:** Periodogram and Correlogram method, Computation via FFT, Properties of Periodogram, Blackman-Tuckey method, Window design considerations, Refined periodogram methods : Bartlet method, Welch method.	10	25
First Internal Test		
MODULE 3: **PSD Estimation - Parametric methods: Parametric method for rational spectra:** Covariance structure of ARMA process, AR signals - Yule-Walker method, Least square method - Levinson-Durbin Algorithm, MA signals, ARMA Signals - Modified Yule-Walker method, Two stage least square method, Burg method for AR parameter estimation. **Parametric method for line spectra:** Models of sinusoidal signals in noise, Non-linear least squares method, Higher order Yule-Walker method, MUSIC and Pisarenko methods, Min Norm method, ESPRIT method.	12	25
MODULE 4: **Filterbank methods:** Filterbank interpertation of periodogram, , refined filterbank method for higher resolution spectral analysis - Slepia base-band filters, Capon method, Filter Bank Reinterpretation of the periodogram.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6252	**PATTERN RECOGNITION & ANALYSIS**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Fundamentals of Calculus, Linear Algebra, probability theory, Statistics, & Signal Processing. Programming Knowledge in MATLAB.

COURSE OBJECTIVES:

To present the fundamental concepts and applications of pattern recognition, the concepts of feature selection and generation techniques, Bayes decision theory, linear and nonlinear classifiers, concepts of supervised learning and system evaluation, unsupervised learning and clustering algorithms.

SYLLABUS

Introduction - features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Bayes Decision theory. Pattern Recognition using Neural Networks: Linear & Non Linear Classifiers, Feature selection/generation: Context dependent classification: Markov Chain Model, The Viterbi Algorithm. Clustering, Clustering validity - basics .

COURSE OUTCOME:

Students are expected to develop an ability to design, conduct experiments for analyzing, and interpreting data, and work professionally in the area of pattern recognition.

Text Books:

1. Sergios Theodoridis, Konstantinos Koutroumbas, “Pattern Recognition”, Academic Press, 2006.
2. Christopher M Bishop, “Pattern Recognition and Machine Learning”, Springer 2007.

References:

3. Richard O. Duda and Hart P.E, and David G Stork, “Pattern classification” , 2nd Edn., John Wiley & Sons Inc., 2001

4. Robert Schalkoff, “Pattern Recognition – Statistical, Structural and Neural Approaches”, Wiley India
5. Earl Gose, Richard Johnsonbaugh, and Steve Jost; “Pattern Recognition and Image Analysis”, PHI Pvte. Ltd., NewDelhi-1, 1999.
6. K. Fukunaga; Introduction to Statistical Pattern Recognition (2nd Edition), Academic Press
7. Andrew R. Webb, “Statistical Pattern Recognition”, John Wiley & Sons, 2002.
8. Fu K.S., “Syntactic Pattern recognition and applications”, Prentice Hall, Eaglewood cliffs, N.J., 1982.

COURSE NO: 06SP 6252	**COURSE TITLE:** **PATTERN RECOGNITION & ANALYSIS**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact Hours**	**Sem.Exam Marks;%**
MODULE 1: Introduction: Features, Feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Classifiers based on Bayes Decision theory- introduction, discriminant functions and decision surfaces, Bayesian classification for normal distributions, Estimation of unknown probability density functions, the nearest neighbour rule.	12	25
MODULE 2: Pattern Recognition using Neural Networks: Single and Multilayer Perceptrons, MSE estimation, Logistic discrimination, Back propagation algorithm, Networks with Weight sharing, Polynomial classifiers, Radial Basis function networks, SVM classifiers – Linear and Nonlinear cases.	10	25
First Internal Test		

MODULE 3: Non Linear Classifiers: Decision trees, Combining classifiers. Boost approach to combine classifiers. Feature selection/generation: ROC, Class separability measures, Optimal feature generation, The Bayesian information criterion, KLT and SVD. Context dependent classification: Markov Chain Model, The Viterbi Algorithm.	10	25
MODULE 4: Clustering: Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms. Hierarchical algorithms - Agglomerative algorithms, Divisive algorithms. Schemes based on function optimization - Fuzzy clustering algorithms, Probabilistic clustering, K - means algorithm. Clustering algorithms based on graph theory , Competitive learning algorithms, Boundary detection methods, Valley seeking clustering, Kernel clustering methods. Clustering validity - basics .	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6352	**OPTICAL SIGNAL PROCESSING**	**3-0-0:3**	**2015**

PRE – REQUISITES:

Basics of digital signal processing

COURSE OBJECTIVES:

To give the student

- Knowledge about signal processing and optics
- Understanding of applications of acousto-optic devices, optical signal processors etc.

SYLLABUS

Basics of signal processing and optics , Basic laws of geometrical optics , Physical Optics: The Fresnel Transforms, the Fourier transform, Fourier transforms of aperture functions , Spectrum Analysis and Spatial Filtering, Acousto-optic cell spatial light modulators, Applications of acousto-optic devices

COURSE OUTCOME:

Upon completion of this course the student will be able to understand the basic of optics, different signal processing techniques and transforms for optics, and will be able to design spatial filters and optical signal processors for applications in optical signal processing

Text & References :

1.Anthony Vanderlugt, Optical signal processing: Wiley-Interscience
2. Dr. Hiroshi Ishikawa , Ultrafast All-Optical Signal Processing Devices: Wiley
3. Francis T. S. Yu, Suganda Jutamulia, Optical Signal Processing, Computing, and Neural Networks: Krieger Publishing Company
5. D. Casasent, Optical data processing-Applications, Springer-Verlag, Berlin
6. H.J. Caulfield, Handbook of holography, Academic Press New York
7. P.M. Dufffieux, The Fourier Transform and its applications to Optics, John Wiley and sons .
8. J. Horner , Optical Signal Processing Academic Press
9. Joseph W. Goodman, Introduction to Fourier Optics, second edition Mc Graw Hill.

COURSE NO: 06SP 6352	COURSE TITLE: OPTICAL SIGNAL PROCESSING	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact Hours**	**Sem.Exam Marks;%**
MODULE 1: Basics of signal processing and optics, Characterization of a General signal, examples of signals, Spatial signal. Basic laws of geometrical optics, Refractions by prisms, the lens formulas, General Imaging conditions, the optical invariant.	10	25
MODULE 2: Physical Optics: The Fresnel Transforms, the Fourier transform, Fourier transforms of aperture functions, the inverse Fourier transform, Extended Fourier transform analysis, Maximum information capacity and optimum packing density, System coherence.	12	25
First Internal Test		
MODULE 3: Spectrum Analysis and Spatial Filtering: Light sources, spatial light modulators, The detection process in Fourier domain, System performance parameters, Dynamic range. Spatial filtering- Some fundamentals of signal processing, Spatial Filters, Binary Spatial Filters, Magnitude Spatial Filters, Phase Spatial Filters, Real valued Spatial Filters, Interferometric techniques for constructing Spatial Filters. Optical signal processor and filter generator, some applications of optical signal processing.	10	25
MODULE 4: Acousto-optic cell spatial light modulators, Applications of acousto-optic devices. optical numerical processing, simple arithmetic, evaluation of polynomials, optical implementation of matrix vector multiplication, differentiation & integration, Optical neural network - associative memory and vector matrix multiplication, Hopfield net, optical implementation of neural networks.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO: 06SP 6452	COURSE TITLE **WIRELESS COMMUNICATION**	CREDITS 3-0-0:3	YEAR OF INTRODUCTION 2015

PRE – REQUISITES: Communication

COURSE OBJECTIVES:

1. To understand the basics of wireless communication channels
2. To understand the basics of spread spectrum techniques used in wireless communication
3. To familiarize various multiple access systems

SYLLABUS

Wireless channel models, Concepts of diversity, Cellular networks, Capacity analysis of cellular networks, Spread spectrum techniques, Capacity of Wireless Channels, MIMO systems, Capacity of MIMO channels, Communication standards.

COURSE OUTCOME:

1. Students will be able to model wireless communication channels
2. Students will be able to understand different multiple access techniques used in wireless communication
3. Students will be able to work with MIMO systems

Text Books:

1. Andrea Goldsmith, "Wireless Communications", Cambridge University press.
2. Simon Haykin and Michael Moher, "Modern Wireless Communications", Pearson Education.
3. T. S. Rappaport, "Wireless Communication, principles & practice", PHI, 2001.

References:

4. G. L. Stuber, "Principles of Mobile Communications", 2nd ed, Kluwer Academic Publishers.
5. Kamilo Feher, "Wireless digital communication", PHI, 1995.
6. R. L. Peterson, R. E. Ziemer and David E. Borth, "Introduction to Spread Spectrum Communication", Pearson Education.
7. A. J. Viterbi, CDMA- "Principles of Spread Spectrum", Addison Wesley, 1995.
8. D. Tse & P. Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

COURSE NO: 06SP 6452	**COURSE TITLE:** **WIRELESS COMMUNICATION**	**(L-T-P : 3-0-0)** **CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Fading and Diversity :** Wireless Channel Models: Path Loss and Shadowing Models, Statistical Fading Models, Narrow Band and Wideband Fading Models. Diversity: Time Diversity, Frequency and Space Diversity, Receive Diversity, Concept of Diversity Branches and Signal Paths, Performance Gains; Combining Methods: Selective Combining, Maximal Ratio Combining, Equal Gain Combining.	11	25
MODULE 2: **Cellular Communication:** Cellular Networks; Multiple Access: FDMA, TDMA, Spatial Reuse, Co-Channel Interference Analysis, Hand-off, Erlang Capacity Analysis, Spectral Efficiency and Grade of Service, Improving Capacity: Cell Splitting and Sectorization.	10	25
First Internal Test		
MODULE 3: **Spread spectrum and CDMA:** Motivation- Direct sequence spread spectrum- Frequency Hopping systems- Time Hopping.- Anti-jamming- Pseudo Random (PN) sequence- Maximal length sequences- Gold sequences- Generation of PN sequences.- Diversity in DS-SS systems- Rake Receiver- Performance analysis. Spread Spectrum Multiple Access- CDMA Systems-Interference Analysis for Broadcast and Multiple Access Channels- Capacity of cellular CDMA networks- Reverse link power control- Hard and Soft hand off strategies.	11	25
MODULE 4: **Capacity of Wireless Channels:** Fading Channel Capacity: Capacity of flat and frequency selective fading channels- Multiple Input Multiple output (MIMO) systems- Narrow band multiple antenna system model- Parallel Decomposition of MIMO Channels- Capacity of MIMO Channels. Cellular Wireless Communication Standards, Second generation cellular systems: GSM specifications and Air Interface - specifications, IS 95	10	25

CDMA- 3G systems: UMTS & CDMA 2000 standards and specifications.		
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6062	**MINI PROJECT**	**0-0-4:2**	**2015**

PRE – REQUISITES:

Basic knowledge in signal processing and theory and lab topics covered during first semester.

COURSE OBJECTIVES:

To develop the ability to work with DSP hardware and implementation of real time systems.

SYLLABUS

Design and development of a system using a hardware platform for processing real time input signals and result in real time output.

COURSE OUTCOME:

Students will have learned how to use the DSP processing kits for realizing real time outputs.

Text Books:

DSP kit manuals

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 6072	**SIGNAL PROCESSING LAB – II**	**0-0-3:1**	**2015**

PRE – REQUISITES:

Basic knowledge in signal processing and theory and lab topics covered during first semester.

COURSE OBJECTIVES:

To enhance the skills of using DSP hardware and MATLAB for signal processing applications.

SYLLABUS

Experiments to learn the concepts introduced in the courses Estimation and Detection Theory, Adaptive & Non linear signal processing and Digital Image Processing using a numerical computing environment such as MATLAB or GNU Octave or any other equivalent tool

Must include experiments related to Multirate Signal Processing, Speech Processing, Image Processing and Adaptive Filter Implementation.

COURSE OUTCOME:

Student will have the confidence to take up and implement advanced signal processing algorithms during phase -1, 2 of main projects.

Text Books:

1. DSP kit manuals
2. Rulf Chassaing, Digital Signal Processing and applications with the C6713 and C6416 DSK, Wiley- Interscience, 2005.
3. Nasser Kehtarnawaz, Real Time Signal Processing Based on TMS320C6000, Elsevier,2004.

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7111	**BIOMEDICAL SIGNAL PROCESSING**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Nil

COURSE OBJECTIVES:

To give the Student:-

- An introduction to biomedical signals;
- An idea to model biomedical signals;
- An exposure to various applications.

SYLLABUS

Introduction to biomedical signals; Tasks in biomedical signal processing; Concurrent, coupled and correlated processes; Modeling of Biomedical signals; Detection of biomedical signals in noise; Classification of biomedical signals; Cardio vascular applications; ECG parameters & their estimation; ECG Signal Processing; Neurological Applications; Modeling EEG; EEG applications; Analysis of EEG channels

COURSE OUTCOME:

Students who successfully complete this course will have demonstrated an ability to understand the fundamental concepts of biomedical signal processing; Choosing a class of signal model; Selecting a specific form of the model; Process the signal.

Text

1. Rangayyan, “Biomedical Signal Analysis”, Wiley 2002.
2. D.C. Reddy, “Biomedical Signal Processing: Principles and techniques” , Tata McGraw Hill, New Delhi, 2005

References

3. Willis J Tompkins, Biomedical Digital Signal Processing, Prentice Hall, 1993
4. Bruce, "Biomedical Signal Processing & Signal Modeling," Wiley, 2001
5. Sörnmo, "Bioelectrical Signal Processing in Cardiac & Neurological Applications", Elsevier
6. Semmlow, "Biosignal and Biomedical Image Processing", Marcel Dekker, 2004
7. Enderle, "Introduction to Biomedical Engineering," 2/e, Elsevier, 2005.

COURSE NO: 06SP 7111	**COURSE TITLE:** **BIOMEDICAL SIGNAL PROCESSING**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG etc - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials - Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random & Stochastic signals – spectral estimation - Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments .	10	25
MODULE 2: Concurrent, coupled and correlated processes - illustration with case studies – Adaptive and optimal filtering - Modeling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG - Muscle-contraction interference. Event detection - case studies with ECG & EEG - Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.	10	25
First Internal Test		
MODULE 3: Cardio vascular applications : Basic ECG - Electrical Activity of the heart- ECG data acquisition - ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise & Artifacts- ECG Signal Processing: Baseline Wandering, Power line	10	25

interference, Muscle noise filtering - QRS detection - Arrhythmia analysis - Data Compression: Lossless & Lossy- Heart Rate Variability - Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals .		
MODULE 4: Neurological Applications: The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modeling EEG- linear, stochastic models - Non linear modeling of EEG - artifacts in EEG & their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis – correlation analysis of EEG channels - coherence analysis of EEG channels.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7211	**DIGITAL CONTROL SYSTEMS**	**3-0-0: 3**	**2015**

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

To impart students,

1. The knowledge of sampling and reconstruction of signals and systems.
2. The ability to analyse the performance of digital control systems.
3. The ability to design various types of control systems in the digital domain.
4. The basic concepts of State Space analysis pertaining to digital control systems..

SYLLABUS

Sampling and reconstruction of analog signals, Review of Z transforms, solution of difference equations using Z transforms, Digital Control System- Pulse transfer function, Z transform analysis open loop and closed loop transfer functions, Stability analysis- tests for stability, design of digital controllers- compensation methods, PID controllers, Interrelations between Z Transform models and state variable models, controllability, observability, stability. Pole placement using state feedback- dynamic output feedback. Effect of finite word length.

COURSE OUTCOME: On successful completion of this course, the student would be able to understand the fundamental concepts of sampling and reconstruction of analog signals. He/she would acquire knowledge in analysing the performance and stability concepts of a digital control system in the Z domain. He/would be able to design and demonstrate various digital control strategies. He/ she would acquire knowledge to analyse and design digital control systems in state space approach.

Text Books:

1. Benjamin C Kuo, Digital Control systems, Saunders College publishing, 1997.
2. K. Ogata, Discrete Time Control Systems, Addison-Wesley Longman Pte. Ltd., Indian Branch, Delhi,1995.

References:

3. M Gopal, Digital control and state variable methods, Tata McGraw Hill publishers, 1997.
4. Constantine H Houpis and Gary B Lamont, Digital Control systems, McGraw Hill
5. C.L. Philips and H.T Nagle, Jr., Digital Control System Analysis and Design, Prentice Hall, Inc., Englewood Cliffs,N.J.,1984.

COURSE NO: 06SP 7211 **COURSE TITLE:** **DIGITAL CONTROL SYSTEMS** **(L-T-P : 3-0-0) CREDITS:3**		
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Introduction to Digital Control Systems:** Data conversion and Quantisation**:** Sampling process- continuous and sampled signal, uniform impulse sampling- time domain and frequency domain analysis, aliasing, sampling theorem, data reconstruction, zero order hold, first order hold. Review of Z transforms: Z transform definition- theorem, inverse Z Transform, mapping s plane to Z plane, linear constant coefficient difference equation, solution by recursion and Z transform method.	10	25
MODULE 2: **Analysis of digital control systems:** Digital Control systems-pulse transfer function- Z Transform analysis of closed loop and open loop systems- steady state accuracy- characteristic equation- stability, tests for stability- frequency domain analysis,-Bode diagrams- gain margin- phase margin- root locus techniques	10	25
First Internal Test		
MODULE 3: **Design of Digital Control Systems:** Cascade and feedback compensation using continuous data controllers, digital controller- design using bilinear transformation, root locus based design, digital PID controllers, Dead beat control design.	10	25

MODULE 4: **State variable methods:** State variable techniques for digital control systems, state space models-algebraic transformation-canonical forms. Interrelations between Z Transform models and state variable models, controllability, observability, stability. Response between sampling instants using state variable approach. State feedback- pole placement using state feedback-dynamic output feedback. Effect of finite word length on controllability and closed loop placement, case study examples using MATLAB/clones.	12	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7311	**LINEAR & NON-LINEAR OPTIMIZATION**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Linear Algebra, Elementary mathematical analysis, Calculus.

COURSE OBJECTIVES:

To learn the fundamentals of linear and non-linear optimization, both constrained and unconstrained.

SYLLABUS

Mathematical preliminaries. Classical Optimization techniques. Linear Programming- simplex method, interior point methods – Karmarakar's method. Non-linear programming – first order necessary conditions, second order conditions; Unconstrained optimization : Gradient methods – steepest descent method, Newton's method, Conjugate gradient method. Condstrained Optimization : Equality and inequality constraints; Lagrange multipliers, KKT optimality conditions.

COURSE OUTCOME:

The student would be able to apply the knowledge they gained in the course in a wide range of applications which involves optimization.

Text Books:

1. *David G Luenberger, Yinyu Ye*, .Linear and Non Linear Programming., 3rd Ed, Springer 2008
2. *S.S.Rao*, .Engineering Optimization.; Theory and Practice; Revised 3rd Edition, New Age International Publishers, New Delhi.

References:

3. *Fletcher R.*, Practical methods of optimization, John Wiley, 2nd Ed, 1987.
4. *E.K.P Chong, Stanislow H. Zak,* An introduction to optimization, Wiley , 4th Ed, 2013.
5. *Kalyanmoy Deb*, Optimization for Engineering: Design-Algorithms and Examples, Prentice Hall (India), 1998.
6. *Hillier and Lieberman,* Introduction to Operations Research, McGraw-Hill, 8th edition, 2005.
7. *Saul I Gass*, Linear programming, McGraw-Hill, 5th edition, 2005.
8. *Bazarra M.S., Sherali H.D. & Shetty C.M.*, Nonlinear Programming Theory and Algorithms, John Wiley, New York
9. *S. M. Sinha*, Mathematical programming: Theory and Methods, Elsevier, 2006.

COURSE NO: 06SP 7311	**COURSE TITLE:** **LINEAR & NON-LINEAR OPTIMIZATION**	**(L-T-P : 3-0-0)** **CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Mathematical Background: Sequences and Subsequences- Mapping and functions- Continuous functions- Infimum and Supremum of functions- Minima and maxima of functions- Differentiable functions. Vectors and vector spaces- Matrices- Linear transformation- Quadratic forms- Definite quadratic forms- Gradient and Hessian- Linear equations- Solution of a set of linear equations-Basic solution and degeneracy. Convex sets and Convex cones- Introduction and preliminary definition- Convex sets and properties- Convex Hulls- Extreme point- Separation and support of convex sets- Convex Polytopes and Polyhedra- Convex cones- Convex and concave functions- Basic properties- Differentiable convex functions.	10	25
MODULE 2: Introduction to Optimization - Classical optimization techniques: Single and multivariable problems-Types of constraints. Linear Programming: Standard form, Linear optimization algorithms - The simplex method -Basic solution and extreme point -Degeneracy-The primal simplex method -Dual linear programs - Primal, dual, and duality theory - The dual simplex method -The primal-dual algorithm. Interior Point Methods – Karmarkars's method.	12	25
First Internal Test		
MODULE 3: Nonlinear Programming: First order necessary conditions, Second order conditions, Minimization and maximization of convex functions- Local & Global optimum- Convergence-Speed of convergence. Unconstrained optimization: One dimensional minimization - Elimination method, Fibonacci & Golden section search. Gradient methods - Steepest descent method, Newton's method, Conjugate Gradient Method.	10	25
MODULE 4: Constrained optimization: Constrained optimization with equality and inequality constraints. Kelley's convex cutting plane algorithm - Gradient projection method - Penalty Function methods. Lagrange multipliers - Sufficiency conditions – Karush	10	25

Kuhn Tucker optimality conditions. Quadratic programming - Convex programming.		
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7411	**DSP ARCHITECTURE DESIGN**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Nil

COURSE OBJECTIVES:

To give the student:-

- An introduction to systematic approaches for mapping DSP algorithms to VLSI architectures
- Practice in the modeling and synthesis of DSP modules

SYLLABUS

Different hardware modeling styles; DSP Algorithm and Architecture Design: DSP representations; filter structures; fast filtering algorithms; retiming and pipelining; DSP Module Synthesis: distributed arithmetic; high performance arithmetic unit architectures; modeling for synthesis in HDL; Parallel algorithms and their dependence: mapping DSP algorithms onto processor arrays; data broadcast and pipelining.

COURSE OUTCOME:

Upon completion of this course student will be able to Apply various modeling styles including mixed style of modeling in DSP architecture design; Understand fast DSP algorithms for efficient hardware implementation; Optimize architectures for various parameters such as computation time, space and power consumption.

Text Books:

1. Sen M.Kuo , Woon-Seng S. Gan, Digal Signal Processors: Architectures, Implementations, and Applications Prentice Hall 2004.
2. Uwe Meyer-Baese, Digital Signal Processing with Field Programmable Gate Array, Springer-Verlag 2001.

References:

1.J Bhasker, VHDL Primer, Pearson Education asia, 3rd edition
2. Keshab K. Parhi, VLSI Signal Processing Systems, Design and Implementation, John Wiley & Sons,1999.
3. John G. Proakis , Dimitris Manolakis K, DSP Principles, Algorithms and Applications, Prentice Hall 1995.

COURSE NO: 06SP 7411	COURSE TITLE: DSP ARCHITECTURE DESIGN	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Hardware modeling**: Introduction to hardware description language, hardware abstraction, entity declaration, architecture body, behavioural modeling, process statement, signal assignment statement, dataflow modeling, concurrent signal assignment statement, structural modeling, component declaration, component instantiation statement, mixed modeling, Case study: mixed style of modeling of a full adder, modeling of a state register.	10	25
MODULE 2: **DSP Algorithm and Architecture Design:** DSP representations (data-flow, control-flow, and signal-flow graphs, block diagrams), filter structures (recursive, non recursive and lattice), behavioral modeling in HDL, system modeling and performance measures, fast filtering algorithms (Winograd's, FFT, short- length FIR), retiming and pipelining, block processing, folding, distributed arithmetic architectures, VLSI performance measures (area, power, and speed), structural modeling in VHDL.	10	25
First Internal Test		
MODULE 3: **DSP Module Synthesis:** distributed arithmetic (DA), advantageous of using DA, size reduction of look-up tables, canonic signed digit arithmetic, implementation of elementary functions Table-oriented methods, linear feedback shift register, high performance arithmetic unit architectures (adders, multipliers, dividers), bit-parallel, bit-serial, digit-serial, carry-save architectures, redundant number system, modeling for synthesis in HDL, synthesis place-and-route.	10	25
MODULE 4: **Parallel algorithms and their dependence:** Applications to some common DSP algorithms, system timing using the scheduling vector, projection of the dependence graph using a projection direction, the delay operator and z-transform techniques for mapping DSP algorithms onto processor arrays, algebraic technique for mapping algorithms, computation domain, dependence matrix of a variable, scheduling and	12	25

projection functions, data broadcast and pipelining, applications using common DSP algorithms.		
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7121	**MACHINE LEARNING**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Linear Algebra, Basics of Pattern Recognition and Artificial Neural Networks, Probability Theory, Statistics and Random Processes

COURSE OBJECTIVES:

To present the concepts of machine learning and to develop and understanding among the student about the underlying principles of machine learning algorithms and their applications. Student must be able to collect and effectively utilize quantitative data, make mathematical models to express causal relationships and make inferences from data.

SYLLABUS

Supervised, Unsupervised, Reinforcement Learning, Basic Concepts, Mixture Models & EM algorithm, Factor Analysis, Kernel functions, Gaussian Processes for regression and classification, Markov models, HMMs, Graphical Models, Conditional Independence Three example graph, D – Separation, Markov Random Fields. Inference in Graphical Models – Inference on a chain, Trees, Factor Graphs. Combining Models. Reinforcement Learning, Temporal Difference Learning, Generalization, Partially Observable states.

COURSE OUTCOME:

Students will have the ability to apply learning algorithms and techniques to solve issues related to analyzing and handling large data sets. Evaluate different machine learning techniques by comparing and assessing their computational results

Text Books:

1. *Kevin P. Murphy*, Machine Learning - A Probabilistic Perspective, The MIT Press - 2012.
2. *Christopher M. Bishop,* Pattern Recognition and Machine Learning, Springer - 2006.
3. *Ethem Alpaydin*, Introduction to Machine Learning 2nd Ed, MIT Press - 2010.

References:

4. *Daphene Koller* & *Nir Friedman* – Probabilistic Graphical Models, Principles and Techniques, MIT Press - 2010.
5. *Trevor Hastie, Robert Tibshirani, Jerome Friedman* – The Elements of Statistical Learning, Data Mining, Inference & Prediction 2nd Edition, Springer - 2009.

COURSE NO: 06SP 7121	COURSE TITLE: MACHINE LEARNING	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: Types of Machine Learning – Supervised, Unsupervised, Reinforcement Learning, Basic Concepts in Machine Learning, Brief review of probability – Common distributions, Monte Carlo approximation, & Information Theory.	12	25
MODULE 2: Mixture Models & EM algorithm – Mixtures of Gaussians, The EM Algorithm, Factor Analysis, ICA. Kernels – Kernel functions, Kernel Trick, Kernels for building generative models. Gaussian Processes for regression and classification. Markov models, HMMs, Inference in HMMs, Learning in HMMs.	10	25
First Internal Test		
MODULE 3: Graphical Models – Bayesian Networks – Generative models, Discrete models, Conditional Independence – Three example graph, D – Separation, Markov Random Fields. Inference in Graphical Models – Inference on a chain, Trees, Factor Graphs.	10	25
MODULE 4: Combining Models – Bayesian Model Averaging, Committees, Boosting. Reinforcement Learning – Single state case: K-Armed Bandit, Elements of RL, Model-Based Learning, Temporal Difference Learning, Generalization, Partially Observable states.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7221	**ARRAY SIGNAL PROCESSING**	**3-0-0: 3**	**2015**

PRE – REQUISITES:

Linear Algebra, Probability and Random process, Digital Signal Processing

COURSE OBJECTIVES:

• To introduce the student to the various aspect of array signal processing.
• Concept of Spatial Frequency is introduced along with the Spatial Sampling Theorem.
• Various array design methods and direction of arrival estimation techniques are introduced.

SYLLABUS:

Spatial Signals : Signals in space and time. Spatial frequency, Direction vs. Frequency, Sensor Arrays : Spatial sampling, Nyquist criterion. Sensor arrays, Spatial Frequency: Aliasing in spatial frequency domain, Direction of Arrival Estimation: Non parametric methods - Beam forming and Capon methods.

COURSE OUTCOME:

• Understands the important concepts of array signal processing.
• Understands the various array design techniques.
• Understands the basic principle of direction of arrival estimation techniques.

Text Books:

1. Dan E. Dugeon and Don H. Johnson, “:Array Signal Processing: Concepts and Techniques”. Prentice Hall, 1993.
2. Petre Stoica and Randolph L. Moses, “ Spectral Analysis of Signals”. Prentice Hall ,2005.

References :

3. Bass J, McPheeters C, Finnigan J, Rodriguez E. “Array Signal Processing” [Connexions Website].
4. H.L.Van Trees ,”Optimum Array Processing”, Wiley-Interscience
5. S.J Orfandis,” Electromagentic Waves and Antennas (website)
6.Manalokis, Ingle and Kogon, ”Statistical and Adaptive Signal Processing,” Artech House INC,2005

COURSE NO: 06SP 7221	COURSE TITLE: ARRAY SIGNAL PROCESSING	(L-T-P : 3-0-0) CREDITS:3
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Spatial Signals :** Signals in space and time. Spatial frequency, Direction vs. frequency. Wave fields. Far field and Near field signals.	10	25
MODULE 2: **Sensor Arrays** : Spatial sampling, Nyquist criterion. Sensor arrays. Uniform linear arrays, planar and random arrays. Array transfer (steering) vector. Array steering vector for ULA. Broadband arrays	10	25
First Internal Test		
MODULE 3: **Spatial Frequency:** Aliasing in spatial frequency domain. Spatial Frequency Transform, Spatial spectrum. Spatial Domain Filtering. Beam Forming. Spatially white signal	10	25
MODULE 4: **Direction of Arrival Estimation:** Non parametric methods - Beam forming and Capon methods. Resolution of Beam forming method. Subspace methods - MUSIC, Minimum Norm and ESPRIT techniques. Spatial Smoothing.	12	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7321	**SPEECH AND AUDIO SIGNAL PROCESSING**	**3-0-0: 3**	**2015**

PRE – REQUISITES: Basics of digital Signal Processing

COURSE OBJECTIVES:

To give the Student:-

▪The knowledge of basic characteristics of speech signal in relation to production and hearing of speech by humans.

▪Describe basic algorithms of speech analysis common to many applications.

▪An overview of applications (recognition, synthesis, coding) and to inform about practical aspects of speech algorithms implementation.

SYLLABUS

Speech Production: - Acoustic theory of speech production-Speech analysis-Digital representation. Speech Analysis: - Time domain-Frequency domain- Spectrogram- Cepstral analysis. Parametric Representation: - AR model- ARMA mode- LPC analysis- GMM- HMM. Speech Coding& Synthesis: - Sub band coding- Transform coding- Quantization based coding- Speech synthesis. Speech Processing: - Homomorphic speech processing- Convolution- Pitch extraction- Sound mixtures and separation- Speech recognition and segmentation.

COURSE OUTCOME:

The students will get familiar with basic characteristics of speech signal in relation to production and hearing of speech by humans. They will understand basic algorithms of speech analysis common to many applications. They will be given an overview of applications (recognition, synthesis, coding) and be informed about practical aspects of speech algorithms implementation. The students will be able to design a simple system for speech processing including its implementation into application programs.

Text Books:

1. Gold, B., Morgan, N.: Speech and Audio Signal Processing, John Wiley & Sons, 2000, ISBN 0-471-35154-7

2. Thomas F. Quatieri, Discrete-Time Speech Signal Processing: Principles and Practice, Prentice Hall; ISBN: 013242942X; 1st edition

3. Douglas O'Shaughnessy, Speech Communications : Human&Machine,IEEE Press, Hardcover 2nd edition, 1999; ISBN: 0780334493.

4. Rabiner and Schafer, Digital Processing of Speech Signals, Prentice Hall, 1978.

5.Rabiner, L., Juang, B.H.: Fundamentals of Speech Recognition, Signal Processing, Prentice Hall, Engelwood Cliffs, NJ, 1993, ISBN 0-13-015157-2

References:

6. Donald G. Childers, Speech Processing and Synthesis Toolboxes, John Wiley & Sons, September 1999; ISBN: 0471349593

7. Jayant, N. S. and P. Noll. Digital Coding of Waveforms: Principles and Applications to Speech and Video Signal ProcessingSeries, Englewood Cliffs: Prentice- Hall

8. Papamichalis P.E., Practical Approaches to Speech Coding, Texas Instruments, Prentice Hall

9. Thomas Parsons, Voice and Speech Processing, McGraw Hill Series

10. E. Zwicker and L. Fastl, Psychoacoustics-facts and models, Springer-Verlag., 1990

COURSE NO: 06SP 7321	**COURSE TITLE:** **SPEECH AND AUDIO SIGNAL PROCESSING**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact Hours**	**Sem.Exam Marks;%**
MODULE 1: Speech Production :- Acoustic theory of speech production- Excitation, Vocal tract model for speech analysis, Formant structure, Pitch. Speech Analysis :- Short-Time Speech Analysis, Time domain analysis - Short time energy, short time zero crossing Rate, ACF . Frequency domain analysis -Filter Banks, STFT, Spectrogram, Formant Estimation &Analysis. Cepstral Analysis	10	25
MODULE 2: Digital Speech Models :- AR Model, ARMA model. LPC Analysis - LPC model, Auto correlation method, Covariance method, Levinson-Durbin Algorithm, Lattice form. LSF, LAR, MFCC, Sinusoidal Model, GMM, HMM	12	25
First Internal Test		

MODULE 3: Speech coding :- Phase Vocoder, LPC, Sub-band coding, Adaptive Transform Coding , Harmonic Coding, Vector Quantization based Coders, CELP Speech processing :- Fundamentals of Speech recognition, Speech segmentation. Text-to –speech conversion, speech enhancement, Issues of Voice transmission over Internet.	10	25
MODULE 4: Audio Processing : Non speech and Music Signals - Modeling - Differential, transform and sub band coding of audio signals & standards - High Quality Audio coding using Psycho acoustic models - MPEG Audio coding standard. Music Production - sequence of steps in a bowed string instrument - Frequency response measurement of the bridge of a violin. Audio Data bases and applications – Content based retrieval.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7421	**INFORMATION HIDING & DATA ENCRYPTION**	**3-0-0: 3**	**2015**

PRE – REQUISITES: Nil

COURSE OBJECTIVES:

1. To have a basic idea about cryptography
2. To understand the basics of information hiding and steganography

SYLLABUS

Introduction to Cryptography, Data encryption standards, Key management, Curve Architecture and Cryptography, Introduction to Number Theory, Principle and Objectives of Watermarking and Steganography, Steganalysis of images and audio, Digital watermarking.

COURSE OUTCOME:

1. Students will be able to apply the basics of cryptography in real life problems
2. Students will have a good knowledge in steganographic and watermarking techniques

Text Books:

1. Stefan Katzenbeisser, Fabien A. P. Petitcolas, “Information Hiding Techniques for Steganography and Digital Watermarking”, Artech House Publishers, 2000.
2. Neal Koblitz, “A Course in Number Theory and Cryptography”, 2nd Edition, Springer
3. William Stallings, “Cryptography And Network Security – Principles and Practices”, Prentice Hall of India, Third Edition, 2003.

References :

4. Bruce Schneier, “Applied Cryptography”, John Wiley & Sons Inc, 2001.
5. Charles B. Pfleeger, Shari Lawrence Pfleeger, “Security in Computing”, Third Edition, Pearson Education, 2003.
6. H.S. Zuckerman , “An Introduction to the theory of Numbers”, 5th Edition, John Wiley & Sons
7. A.J. Menezes etc al, “Handbook of Applied Cryptography”, CRC Press.
8. Branislav Kisacanin, “Mathematical Problems and Proofs, Combinatorics, Number theory and Geometry”.
9. Atul Kahate, “Cryptography and Network Security”, Tata McGraw-Hill, 2003.

COURSE NO: 06SP 7421	**COURSE TITLE:** **INFORMATION HIDING & DATA ENCRYPTION**	**(L-T-P : 3-0-0) CREDITS:3**
MODULES	**Contact hours**	**Sem.Exam Marks;%**
MODULE 1: **Introduction to Cryptography :** OSI Security Architecture, Classical Encryption techniques, Cipher Principles, Data Encryption Standard, Block Cipher Design Principles and Modes of Operation, Evaluation criteria for AES, AES Cipher, Triple DES, Placement of Encryption Function , Traffic Confidentiality	11	25
MODULE 2: **Public Key Cryptography :** Key Management, Diffie-Hellman key Exchange, Elliptic Curve Architecture and Cryptography, Introduction to Number Theory, Confidentiality using Symmetric encryption, Public Key Cryptography and RSA. Practical implementation of Cryptography	10	25
First Internal Test		
MODULE 3: **Information Hiding:** Principle and Objectives of Watermarking and Steganography. Mathematical formulations, Public - Private Key Steganography, Information hiding in noisy data (adaptive and nonadaptive) and written texts.	11	25
MODULE 4: **Steganographic techniques:** Substitution and bitplane tools - transform domain tools - Spread Spectrum Techniques- Statistical methods- Distortion and Cover Generation methods. Steganalysis: - of images and audio. Watermarking:- techniques, methods, benchmarks for digital watermarking. Practical implementation of steganograpgy.	10	25
Second Internal Test		
End Semester Exam		

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7031	**SEMINAR - II**	**0-0-2: 2**	**2015**

PRE – REQUISITES:

Knowledge of topics studied during first and second semesters.

COURSE OBJECTIVES:

To improve and enhance skills for comprehending technical papers as well as presenting technical seminars**.**

SYLLABUS

Each student shall present a seminar on any topic of interest related to Signal Processing topics. He / she shall select the topic based on the references from recent international journals of repute, preferably IEEE/ACM journals. They should get the paper approved by the Programme Co-ordinator / Faculty member in charge of the seminar and shall present it in the class. Every student shall participate in the seminar. The students should undertake a detailed study on the topic and submit a report at the end of the semester. Marks will be awarded based on the topic, presentation, participation in the seminar and the report submitted.

COURSE OUTCOME:

Students will develop confidence to take up research oriented main projects

Text Books:

Nil

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7041	**PROJECT PHASE - 1**	**0-0-12: 6**	**2015**

PRE – REQUISITES:

Basic knowledge in the topics learned during the previous semesters

COURSE OBJECTIVES:

To prepare the student for the main project by

- Identifying research problems in different areas of Signal Processing.
- Preparing a detailed literature review for the same by reading research journals and conference papers.

SYLLABUS

In Master's Thesis Phase-I, the students are expected to select an emerging research area in the field of specialization. After conducting a detailed literature survey, they should compare and analyze research work done and review recent developments in the area and prepare an initial design of the work to be carried out as Master's Thesis. It is mandatory that the students should refer to recent National and International Journals and conference proceedings preferably IEEE/ACM while selecting a topic for their thesis. Emphasis should be given for introduction to the topic, literature survey, and scope of the proposed work along with preliminary work carried out on the thesis topic.

Students should submit a copy of Phase-I thesis report covering the content discussed above, highlighting the features of work to be carried out in Phase-II of the thesis.

The candidate should present the current status of the thesis work and the assessment will be made on the basis of the work and the presentation, by a panel of internal examiners in which one will be the internal guide. The examiners should give their suggestions to the students so that it should be incorporated in the Phase–II of the thesis
.

COURSE OUTCOME: Students will be able to identify their domains and prepare literature review for the main project.
Text Books: Nil

COURSE NO:	COURSE TITLE	CREDITS	YEAR OF INTRODUCTION
06SP 7012	**PROJECT PHASE 2**	**0-0-21: 12**	**2015**

PRE – REQUISITES:

Basic knowledge in the topics learned during the previous semesters

COURSE OBJECTIVES:

To enable the students to

- Work on research problems on an individual basis.
- Design, test and record the results on the problems chosen in their respective domains.
- Deduce inferences from the results and report them in scientific journals.

SYLLABUS

In the fourth semester, the student has to continue the thesis work as per the plan during Phase-1. After successfully finishing the work, he/she has to submit a detailed bounded thesis report. The evaluation of M Tech Thesis will be carried out by a panel of examiners which will include the internal guide. The work carried out should lead to a publication in a National / International Conference or Journal. The papers that are accepted for publication before the M.Tech evaluation will carry specific weightage.

COURSE OUTCOME:

The students will have the knowledge and skill set which makes them suitable to take up

1. Research
2. Academic professions
3. Industrial profession

in various areas of signal processing .

Text Books:

Nil