SIGNAL PROCESSING

M.Tech Programme

Electronics and Communication - Signal Processing

Curriculum and scheme of Examinations

SEMESTER I

Code No.	Name of Subject	Credits	Hrs /week	Exam duration	Marks			Remarks
					Continuous Assessment	University Exam	Total	
TSM 1001	Linear Algebra for Signal processing	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End semester exam is conducted by the University
TSC 1001	Random Processes and Applications	3	3	3	40	60	100	Do
TMC 1002	Advanced Digital Communication	3	3	3	40	60	100	Do
TSC 1002	DSP System Design	3	3	3	40	60	100	Do
TSC 1003	Digital Filter Design and Applications	3	3	3	40	60	100	Do
TSC 1004	Multirate Systems and Wavelets	3	3	3	40	60	100	Do
TSC 1101	DSP Systems Lab	1	2	-	100	-	100	No End Semester Examination
TSC 1102	Seminar	2	2	-	100	-	100	Do
	TOTAL	21	22					7 Hours of Departmental Assistance work

SEMESTER II

Code No.	Name of Subject	Credits	Hrs. / week	Exam Duration	Marks			Remarks
					Continuous Assessment	End Semester Exam	Total	
TSC 2001	Estimation and Detection Theory	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End semester exam is conducted by the University
TSC 2002	Digital Image Processing	3	3	3	40	60	100	Do
**	Stream Elective I	3	3	3	40	60	100	Do
**	Stream Elective II	3	3	3	40	60	100	Do
**	Department Elective	3	3	3	40	60	100	Do
TCC 2000	Research Methodology	2	2	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End Semester Exam is conducted by the Individual Institutions
TSC 2101	Thesis- Preliminary Part I	2	2	-	100	-	100	No End Semester Examination
TSC 2102	Image Processing Lab	1	2	-	100	-	100	Do
TSC 2103	Seminar	2	2	-	100	-	100	Do
	TOTAL	22	23	-				6 hrs of departmental assistance work

** Students can select a subject from the subjects listed under stream/department electives for the second semester as advised by the course coordinator.

STREAM ELECTIVES OFFERED IN SIGNAL PROCESSING FOR SEMESTER II

List of Stream Electives

Stream Elective I:

TSE 2001 Speech Signal processing
TSE 2002 Optical Signal processing
TSE 2003 Audio Signal processing

Stream Elective II:

TSE 2004 Biomedical Signal Processing and Systems
TSE 2005 Adaptive Signal Processing
TSE 2006 Pattern Recognition and Machine Learning

List of Department Electives (Common for all streams)

TCD 2001	Design of VLSI Systems
TCD 2002	Soft Computing
TCD 2003	Optimization Techniques
TCD 2004	Information Hiding & Data Encryption

SEMESTER III

Code No.	Name of Subject	Credits	Hrs / week	Exam duration	Marks			Remarks
					Continuous Assessment	End Semester Exam	Total	
**	Stream Elective III	3	3	3	40	60	100	Of the 40 marks of internal assessment 25 marks for test and 15 marks for assignment. End Semester Exam is conducted by the Individual Institutions
**	Stream Elective IV	3	3	3	40	60	100	Do
*	Non- Dept. (Interdisciplinary) Elective	3	3	3	40	60	100	Do
TSC 3101	Thesis- Preliminary Part II	5	14	-	200	-	200	No End Semester Examination
	TOTAL	14	23					6 hrs of departmental assistance work

** Students can select a subject from the subjects listed under stream electives III and IV for the third semester as advised by the course coordinator.

*Students can select a subject from the subjects listed under non department (Interdisciplinary) electives for the third semester as advised by the course coordinator.

STREAM ELECTIVES OFFERED IN SIGNAL PROCESSING FOR SEMESTER III

List of Stream Electives

Stream Elective III

TSE 3001 VLSI Structures for Digital Signal processing
TSE 3002 Space time Coding and MIMO Systems
TSE 3003 Computer Vision

Stream Elective IV

TSE 3004 Array Signal Processing
TSE 3005 Bio Informatics
TSE 3006 Secure Communication

SEMESTER IV

Code No	Subject Name	Credits	Hrs. /week	Marks					Remarks
				Continuous Assessment		University Exam		Total	
				Guide	Evaluation Committee	Thesis Eva.	Viva Voce		
TSC 4101	Thesis	12	21	150	150	200	100	600	5 % of the mark is earmarked for Publication in journal/conference
	Total	12	21						8 hrs of departmental assistance work

TSM 1001 LINEAR ALGEBRA FOR SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To develop the skills in abstract algebra
- To develop the skills to identify linear transformation and transforms and its role in linear systems
- To develop the skills to formulate linear transformation problems in matrix form

Learning Outcomes

- Understand the formulation of problems in abstract algebra framework
- Understand and represent linear transformations
- Understand the role of matrices in linear transformation representations

Module I

Algebraic Structures: - Sets -functions - Group -homomorphism of groups - Ring -Field - Vector Space -Subspaces -direct sum - metric space -inner product space -Lp space -Banach Space - Hilbert Space. Linear independence -basis -dimension -orthonormal basis - finite dimensional vector spaces -isomorphic vector spaces - Examples of finite and infinite dimensional vector spaces -R^N, C^N.

Module II

Linear Transformations :- Linear Transformations -four fundamental subspaces of linear transformation -inverse transformation - rank nullity theorem - Matrix representation of linear transformation -square matrices -unitary matrices - Inverse of a square matrix - Change of basis -coordinate transformation - system of liner equations -existence and uniqueness of solutions- projection -least square solution -pseudo inverse.

Module III

Matrix Methods and Transforms: - Eigen values, Eigen vectors, Generalized Eigen vectors - Diagonalizability-orthogonal diagonalization - Symmetric, Hermitian and Unitary matrices (transformations) - Jordan canonical form - Fourier basis - DFT as a linear transformation –- Translation invariant linear transformation -wavelet basis -wavelet transforms.

References

1. G.F.Simmons, *Topology and Modern Analysis* , McGraw Hill
2. Frazier, Michael W. *An Introduction to Wavelets Through Linear Algebra,* Springer Publications.
3. Hoffman Kenneth and Kunze Ray, *Linear Algebra*, Prentice Hall of India.
4. Reichard Bronson, Academic Press

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall contain 80% problems and 20% theory.

TSC 1001 RANDOM PROCESSES AND APPLICATIONS

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To provide necessary basic concepts in statistical signal analysis.
- To study about random processes and its properties
- Apply the basic concepts to various elementary and some advanced applications.

Learning Outcomes

- Have a fundamental knowledge of the basic probability concepts
- Have a good knowledge of standard distributions which can describe real life phenomena.
- Acquire skills in handling situations involving several random variable and functions of random variables
- Understand and characterize phenomena which evolve with respect to time in probabilistic manner

Module I

Introduction: Sets, Fields and Events, Definition of probability, Joint, Conditional and Total Probability, Bayes' Theorem and applications. Random Variable:- Definition, Probability Distribution Function, Probability Density function, Common density functions, Continuous, Discrete and Mixed random Variables, Conditional and Joint Distributions and densities, independence of random variables. Functions of Random Variables: One function of one random variable, one function of two random variables, two functions of two random variables.

Module II

Expectation: Fundamental Theorem of expectation, Moments, Joint moments, Moment Generating functions, Characteristic functions, Conditional Expectations, Correlation and Covariance, Jointly Gaussian Random Variables. Random Vector: - Definition, Joint statistics, Covariance matrix and its properties. Random Processes: -Basic Definitions, Poisson Process, Wiener Process, Markov Process, Birth- Death Markov Chains, Chapman-Kolmogorov Equations, Stationarity, Wide sense Stationarity, WSS Processes and LSI Systems, Power spectral density, White Noise, Periodic and cyclostationary processes.

Module III

Chebyshev and Schwarz Inequalities, Chernoff Bound, Central Limit Theorem. Random Sequences: Basic Concepts, WSS sequences and linear systems, Markov Random sequences, ARMA Models, Markov Chains, Convergence of Random Sequences: Definitions, Laws of large numbers. Advanced Topics: Ergodicity, Karhunen- Leove Expansion, Representation of Band limited and periodic Processes: WSS periodic Processes, Fourier Series for WSS Processes.

References

1. Henry Stark and John W. Woods "Probability and Random Processes with Applications to Signal Processing", Pearson Education, Third edition.
2. Athanasios Papoulis and S. UnnikrishnaPillai. Probability, Random Variables and Stochastic Processes, TMH
3. Gray, R. M. and Davisson L. D. , An Introduction to Statistical Signal Processing. Cambridge University Press, 2004
   (Available at: http://www.ee.stanford.edu/~gray/sp.html)

Structure of the Question Paper
There will be three questions from each module out of which two questions are to be answered by the students. It shall have 80% problems and 20% theory.

TMC 1002 ADVANCED DIGITAL COMMUNICATION

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To introduce to various aspects of Digital Communication over various Channels, from design through performance issues to application requirement.
- To have idea on the advances in Multichannel and Multicarrier Systems design

Learning Outcomes

- Understand the design issues of Digital Communication over Additive Gaussian Noise Channels, over Band limited Channels and Fading Multipath Channels
- Understand the design issues in spread spectrum and multi user communication systems.
- Understand various digital communication receivers, equalization and diversity techniques.

Module I

Digital Communication over Additive Gaussian Noise Channels-Characterization of Communication Signals and Systems- Signal space representation- Connecting Linear Vector Space to Physical Waveform Space- Scalar and Vector Communication over Memory less Channels- Optimum waveform receiver in additive white Gaussian noise (AWGN) channels - Cross correlation receiver- Matched filter receiver and error probabilities- Optimum Receiver for Signals with random phase in AWGN Channels- Optimum receiver for Binary Signals- Optimum receiver for M-ary orthogonal signals- Optimum waveform receiver for coloured Gaussian noise channels- Karhunen Loeve expansion approach- whitening.

Module II

Digital Communication over Band limited Channels- Optimum pulse shaping-Nyquist criterion for zero ISI- partial response signaling- Optimum receiver for channels with ISI and AWGN- Equalization Techniques- Zero forcing linear Equalization- Decision feedback equalization- Adaptive Equalization- Multichannel and Multicarrier Systems- FFT based multi carrier system- Spread Spectrum Signals- Model of Spread spectrum system- Direct sequence spread spectrum signals-Processing gain and jamming margin-Applications of DS-Spread spectrum-Generation of PN-Sequence- Frequency - Hopped spread spectrum signals-Performance of FH Spread spectrum in an AWGN channel- Synchronization of spread spectrum signals.

Module III

Digital Communication over Fading Multipath Channels-Characterization and model-Frequency-nonselective slowly fading channel- Digital signalling over a frequency-selective slowly fading channel- Diversity techniques- Multiuser Communications- Multiple access techniques- Capacity of multiple access methods- Code Division Multiple Access- Multi

User Detectors- Decorrelating Detector- Minimum mean square error detector- Random access methods.

References:

1. John G.Proakis, *Digital Communications,* 4/e, McGraw-Hill
2. Edward. A. Lee and David. G. Messerschmitt, “Digital Communication”, Allied Publishers (second edition).
3. Viterbi, A. J., and J. K. Omura. *Principles of Digital Communication and Coding.* NY:McGraw-Hill, 1979. ISBN: 0070675163.
4. Marvin K Simon, Sami M Hinedi, William C Lindsey - *Digital Communication Techniques –Signal Design & Detection*, PHI.
5. MIT Open Courseware, Electrical Engineering and Computer Science,Principles of Digital communication II, Spring 2006.
6. J.Viterbi, “CDMA- Principles of Spread Spectrum”, Addison Wesley, 1995.
7. Simon Haykin, “Digital Communication, 4th Edition.
8. Aazhang B. Digital Communication Systems [Connexions Web site]. 2008.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60 % problems and 40% theory.

TSC 1002 DSP SYSTEM DESIGN

Structure of the Course

Lecture	:	3 hrs/ Week	Credits: 3
Internal Continuous Assessment	:	40 Marks	
End Semester Examination	:	60 Marks	

Course Objectives

- To provide basic concepts in number representations.
- To study about issues in pipelining and DSP Processors.

Learning Outcomes

- Understand the fundamentals of DSP processor architecture.
- Have a good knowledge of Pipelining issues and numeric representations.

Module I

Introduction to Programmable DSP- MAC (Multiply and Accumulate), Multiple Access Memory, Multiported Memory .Numeric Representations and Arithmetic: Fixed Point and Floating Point. Computer Arithmetic –Signed Digit Numbers - Logarithmic and Residue Number System (LNS, RNS), Distributed Arithmetic, CORDIC Algorithm.

Module II

Basic Pipelining and Simple RISC Processors: Implementation Details -Pipeline hazards (based on MIPS) Instruction Level Parallelism: Concepts, Dynamic Scheduling - Reducing data hazards. Dynamic Hardware Prediction - Reducing branch hazards. Limitations of ILP. Memory hierarchy - Cache design, Cache Performance Issues & Improving Techniques.

Module III

Introduction to TMS 320 C 6X Processor - Architecture -Functional Units- Pipelining ,Peripherals, Linear and Circular addressing modes- Types of Instructions-Programming Examples, Typical DSP development system, support tools and files , compiler, assembler, Code composer studio.

References:

1. Digital Signal Processing and Application with C6713 and C6416 DSK, Rulph Chassaing, Worcester Polytechnic Institute, a Wiley Interscience Publication
2. DSP Processor and Fundamentals: Architecture and Features .Phil Lapsley, JBier, Amit Sohan, Edward A Lee; Wiley IEEE Press.
3. J L Hennessy, D A Patterson, Computer Architecture A Quantitative Approach : 3 Edition Elseivier India.
4. Sen M Kuo, Woon- Seng S Gan, Digital Signal Processors.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 50 % problems and 50% theory.

TSC 1003 DIGITAL FILTER DESIGN AND APPLICATIONS

Structure of the Course

Lecture	: 3 hrs./ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To design and implement various classes of digital filters
- To understand various schemes for digital filter implementations.
- To understand the basics of adaptive filter design.

Learning Outcomes

- The student should be able to design and implement various types of digital filters given a set of engineering specifications.

Module I

Review of Discrete time LTI Systems & Transforms: LTI systems as frequency selective filters. Invertibility of LTI systems. Minimum phase, maximum phase and mixed phase systems. All-pass filters. DFT as a linear transformation. Properties of DFT, Linear filtering methods based on DFT. Frequency analysis of signals using DFT. IIR and FIR filters, various types of Linear phase FIR filter, Zero locations of linear phase FIR filters. Filter design using pole-zero placement.

Module II

Design of linear phase FIR filters (LPF, HPF, BPF and BSF) using window functions, optimal and frequency sampling methods. Design of IIR filters (Butterworth, Chabyshev Type I and Type II and elliptical) using impulse invariance, Matched Z transformation and bilinear transformation. Frequency transformations: analog to analog and digital to digital. Lattice realizations of FIR and IIR filters. Effect of quantization and its statistical characterization.

Module III

Adaptive Digital Filters: Concepts -Wiener filter-LMS adaptive algorithm, convergence of LMS algorithm, Recursive least squares algorithm. Applications of Adaptive filters: Noise cancellation. Power Spectrum Estimation: Estimation of spectra from finite-duration signals. Nonparametric and Parametric methods for Power Spectrum Estimation.

References:

1. Emmanuel C Ifeachor, Barrie W.Jervis, Digital Signal Processing, A practical Approach, 2/e, Pearson Education.
2. Proakis, Manolakis, Digital Signal Processing: Principles, Algorithms, and Applications, 4/e, Pearson Education.
3. Johnny R. Johnson, Introduction to Digital Signal Processing,PHI,1992

4. Ashok Ambardar, Digital Signal Processing: A Modern Introduction, Thomson,IE,2007.
5. Douglas F. Elliott, Handbook of Digital Signal Processing- Engineering Application, Academic Press.
6. Robert J.Schilling, Sandra L.Harris, Fundamentals of Digital Signal Processing using MATLAB,Thomson,2005
7. Ingle, Proakis, Digital Signal Processing Using MATLAB, Thomson, 1/e
8. Jones D. Digital Filter Design [Connexions Web site]. June 9, 2005. Available at: http://cnx.rice.edu/content/col10285/1.1/

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 80 % problems and 20% theory.

TSC 1004 MULTIRATE SYSTEMS AND WAVELETS

Structure of the Course

Lecture	: 3 hrs./ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To understand the fundamentals of multirate signal processing and its applications
- To study the theory and construction of wavelets and its practical implementations.

Learning Outcomes

- To design perfect reconstruction filter bank systems
- To design and implement wavelet based systems.

Module I

Fundamentals of Multirate systems: Basic multirate operations and their spectral representation. Fractional Sampling rate alteration , Interconnection of building blocks, Noble identities, polyphase representations, Efficient structures for decimation and interpolation filters, Uniform DFT filter banks, efficient structures for fractional decimation, Multistage implementations, Applications of multirate systems, 2-channel QMF filterbanks, Errors in the QMF bank, conditions for perfect reconstruction, polyphase implementation, M- channel filterbanks.

Module II

Wavelet Transforms : Continuous wavelet transform and short time Fourier transform, uncertainty principle and time-frequency tiling, Discrete wavelet transform: Haar scaling and wavelet functions, Daubechies wavelets, designing orthogonal wavelet systems, Discrete wavelet transform and relation to filter banks, computing and plotting scaling and wavelet functions.

Module III

Biorthogonal wavelets: Biorthogonality in vector sace, biorthogonal wavelet systems, construction of biorthogonal wavelet systems. Frequency domain approach for designing wavelets: derivation of Daubechies wavelets, parametric design of orthogonal and biorthogonal wavelets, wavelet packet analysis, lifting schemes, Applications of wavelets in compression and denoising.

References:

1. PP Vaidyanathan, Multirate Systems & Filterbanks , Prentice Hall
2. K. P. Soman, K. I. Ramachandran, N. G. Resmi, PHI, Insight into wavelets from theory to practice
3. G Strang & T Nguyen , Wavelets and Filterbank,Wellesly-Cambridge
4. M Vetterli & J Kovacevic, Wavelets and sub band coding, Prentice Hall
5. Douglas F. Elliott, Handbook of Digital Signal Processing Engineering Application, Academic Press

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60 % problems and 40% theory.

TSC 1101 DSP SYSTEMS LAB

Structure of the Course

Lab	: 2 hrs/ Week	Credits: 1
Internal Continuous Assessment	: 100 Marks	

Course Objectives

- Attain ability to develop projects using DSP processors
- Familiarize the use of DSP processor based system for real time applications
- Develop skill to use higher level as well as assembly language for implementation of DSP based systems

Learning Outcomes

- Familiarization of DSP project development stages
- Ability to develop applications using DSP based systems
- Understand the use of DSP processors for real time signal processing

Development Environment

Familiarization to DSP project development stages. Study of the features of the processor used. Development environment.

High Level Language Project Development

Developing projects in a high level language and cross-compiling. Familiarization with the debugging facilities of the IDE.Profiling.Optimizations in C.

Assembly Optimizations

Assembly coding. Function calling conventions. Calling assembly functions from C. Optimization by coding core modules in assembly.

Memory Map

Understand the memory map of the processor. Optimizations by using internal memory.

Real Time Processing.

Using the ADC and DAC for signal acquisition and play back. Real time filtering.

Mini Project (Compulsory)

The student should do a Mini project based on the above area, and a report should be submitted along with the lab record. A viva–voce will be conducted at the end of semester.

References

1. Jones D. DSP Laboratory with TI TMS320C54x [Connexions Web site]. January 22, 2004. Available at: http://cnx.rice.edu/content/col10078/1.2/

TSC 1102 SEMINAR

Structure of the Course

Duration	: 2 hrs/ Week	Credits : 2
Continuous Assessment	: 100 Marks	

The student is expected to present a seminar in one of the current topics in Signal Processing. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject and submit seminar report at the end of the semester.

Marks:

Seminar Report Evaluation	: 50 Marks
Seminar Presentation	: 50 Marks

TSC 2001 ESTIMATION AND DETECTION THEORY

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Familiarize the basic concepts of detection theory, decision theory and elementary hypothesis testing
- Acquire knowledge about parameter estimation, and linear signal waveform estimation
- Get a broad overview of applications of detection and estimation

Learning Outcomes

- Understand Signal detection in the presence of noise
- Understand the basic concepts of estimation theory
- Ability to apply the concepts of estimation and detection in various signal processing applications

Module I

Detection Theory, Decision Theory, and Hypothesis Testing :Review of Probability Theory, Elementary hypothesis testing, Bayes rule, minimax rule, Neyman-Pearson rule; compound hypothesis testing; generalized likelihood-ratio test; Detection with unknown signal parameters, Signal detection in the presence of noise, Chernoff bound, asymptotic relative efficiency; sequential detection; nonparametric detection, sign test, rank test.

Module II

Parameter Estimation: Minimum Mean Squared error estimator, Maximum a Posteriori estimator, linear estimators, Maximum likelihood parameter estimator, invariance principle; estimation efficiency, Cramer-Rao lower bound, Fisher information matrix; least squares, weighted least squares, best linear unbiased estimation.

Module III

Linear Signal Waveform Estimation: Wiener and Kalman Filtering, Lattice filter structure, Levinson Durbin and innovation algorithms, Applications of detection and estimation**:** Applications in diverse fields such as communications, system identification, adaptive filtering, pattern recognition, speech processing, and image processing

References:

1. S.M. Kay, *Fundamentals of Statistical Signal Processing: Detection Theory,* Prentice Hall, 1998
2. S.M. Kay, *Fundamentals of Statistical Signal Processing: Estimation Theory,* Prentice Hall, 1993
3. H.L. Van Trees, *Detection, Estimation and Modulation Theory, Part I,* Wiley, 1968.
4. H.V. Poor*, An Introduction to Signal Detection and Estimation*, 2nd edition, Springer, 1994.
5. L.L. Scharf, Statistical *Signal Processing, Detection and Estimation Theory,* Addison-Wesley, 1990

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSC 2002 DIGITAL IMAGE PROCESSING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Understand the various steps in digital image processing.
- Get a thorough understanding of digital image representation and processing techniques.
- Ability to process the image in spatial and transform domain for better enhancement.

Learning Outcomes

- Understand various techniques for image representation
- Understand various low level image processing techniques including reconstruction from Projections
- Understand the fundamentals of high level image processing

Module I

Image representation - Gray scale and colour Images, image sampling and quantization. Two dimensional orthogonal transforms - DFT, FFT, WHT, Haar transform, KLT, DCT. Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering.

Module II

Edge detection - non parametric and model based approaches, LOG filters, localization problem. Image Restoration - PSF, circulant and block - circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods. Mathematical morphology - binary morphology, dilation, erosion, opening and closing, duality relations, gray scale morphology, applications such as hit-and-miss transform, thinning and shape decomposition.

Module III

Image and Video Compression Standards: Lossy and lossless compression schemes: Transform Based, Sub-band Decomposition, Entropy Encoding, JPEG, JPEG2000, MPEG Computer tomography - parallel beam projection, Radon transform, and its inverse, Back-projection operator, Fourier-slice theorem, CBP and FBP methods, ART, Fan beam projection. Image texture analysis - co-occurrence matrix, measures of textures, statistical models for textures. Hough Transform, boundary detection, chain coding, segmentation and thresholding methods.

References

1. Gonzalez and Woods, Digital image processing, Prentice Hall, 2002..
2. A. K. Jain, Fundamentals of digital image processing, Prentice Hall of India, 1989.
3. M. Haralick, and L.G. Shapiro, Computer and Robot Vision, Vol-1, Addison Wesley, Reading, MA, 1992.

Structure of the Question Paper
There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TCC 2000 RESEARCH METHODOLOGY

Structure of the Course

Lecture	: 2 hrs/ Week	Credits : 2
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

- To formulate a viable research question
- To distinguish probabilistic from deterministic explanations
- To analyze the benefits and drawbacks of different methodologies
- To understand how to prepare and execute a feasible research project

Learning Outcomes

Students are exposed to the research concepts in terms of identifying the research problem, collecting relevant data pertaining to the problem, to carry out the research and writing research papers/thesis/dissertation.

Module I

Introduction to Research Methodology - Objectives and types of research: Motivation towards research - Research methods *vs.*Methodology. Type of research: Descriptive *vs.*Analytical, Applied *vs.* Fundamental, Quantitative *vs.* Qualitative, and Conceptual*vs.* Empirical. Research Formulation - Defining and formulating the research problem -Selecting the problem - Necessity of defining the problem - Importance of literature review in defining a problem. Literature review: Primary and secondary sources - reviews, treatise, monographs, patents.Web as a source: searching the web. Critical literature review - Identifying gap areas from literature review - Development of working hypothesis. (15 Hours)

Module II

Research design and methods: Research design - Basic Principles- Need forresearch design — Features of a good design. Important concepts relating to research design: Observation and Facts, Laws and Theories, Prediction and explanation, Induction, Deduction. Development of Models and research plans: Exploration, Description, Diagnosis, Experimentation and sample designs.Data Collection and analysis: Execution of the research - Observation and Collection of data - Methods of data collection - Sampling Methods- Data Processing and Analysis strategies - Data Analysis with Statistical Packages - Hypothesis-Testing -Generalization and Interpretation. (15 Hours)

Module III

Reporting and thesis writing - Structure and components of scientific reports -Types of report - Technical reports and thesis - Significance - Different steps in the preparation, Layout, structure and Language of typical reports, Illustrations and tables, Bibliography, referencing and footnotes. Presentation; Oral presentation - Planning - Preparation -Practice - Making presentation - Use of audio-visual aids - Importance of effective communication.

Application of results of research outcome: Environmental impacts –Professional ethics - Ethical issues -ethical committees.Commercialization of the work - 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. (15 Hours)

References:

1. C.R Kothari, Research Methodology, Sultan Chand & Sons, New Delhi,1990
2. Panneerselvam, “Research Methodology”, Prentice Hall of India, New Delhi, 2012.
3. J.W Bames,” Statistical Analysis for Engineers and Scientists”, McGraw Hill, New York.
4. Donald Cooper, “Business Research Methods”, Tata McGraw Hill, New Delhi.
5. Leedy P D, "Practical Research: Planning and Design", MacMillan Publishing Co.
6. Day R A, *"How to Write and Publish a Scientific Paper"*, Cambridge University Press, 1989.
7. Manna, Chakraborti, “Values and Ethics in Business Profession”, Prentice Hall of India, New Delhi, 2012.
8. Sople,” Managing Intellectual Property: The Strategic Imperative, Prentice Hall of India, New Delhi, 2012.

Structure of the question paper:
There will be three questions from each module out of which two questions are to be answered by the students.

TSC 2101 THESIS PRELIMINARY: PART-I

Structure of the Course

Thesis	: 2 hrs/week	Credits : 2
Internal Continuous Assessment	: 100 Marks	

For the Thesis-Preliminary part-I the student is expected to start the preliminary background studies towards the Thesis by conducting a literature survey in the relevant field. He/she should broadly identify the area of the Thesis work, familiarize with the design and analysis tools required for the Thesis work and plan the experimental platform, if any, required for Thesis work. The student will submit a detailed report of these activities at the end of the semester.

Distribution of marks

Internal assessment of work by the Guide	: 50 marks
Internal evaluation by the Committee	: 50 Marks

TSC 2102 IMAGE PROCESSING LAB

Structure of the Course

Lecture	: 2 hrs. / Week	Credits: 1
Internal Continuous Assessment	: 100 Marks	

Course Objectives

- Implement the various image processing algorithms in MATLAB/C/C++.

Learning Outcomes

- Understand and implement the algorithms studied in the Digital Image Processing course using MATLAB/C /C++

Representation of Gray scale and colour images.

Image transformations: Grey level transformations, Histogram equalization and modifications, Geometric transformations, affine transformations.

Image Transforms: DFT, DCT, KLT, etc.

Image filtering: Fourier descriptors, linear and non-linear filtering operations in spatial and transform domain, Image convolutions, Separable convolutions, Sub-sampling and interpolation as convolution operations.

Edge detection: Edge enhancement by differentiation, Effect of noise, edge detection and canny implementation, Edge detector performance evaluation.

Segmentation: Thresholding algorithms, Performance evaluation and ROC analysis Connected components labelling, Region growing and region adjacency graph (RAG), Split and merge algorithms.

Morphological operation: Erode and dilate as max and min operators on binary images, open, close, thinning and other transforms.

Computed Tomography: Implementation of FBP and CBP algorithms for parallel beam tomography.

References:

1. Gonzales/ Woods/ Eddins, Digital Image Processing using MATLAB, 2nd edition

TSC 2103 SEMINAR

Structure of the Course

Duration	: 2 hrs. / Week	Credits: 2
Internal Continuous Assessment	: 100 Marks	

The student is expected to present a seminar in one of the current topics in Electronics, Communication, Instrumentation, Computers, Information Technology, Control systems and related areas with application of Signal Processing. The student will undertake a detailed study based on current published papers, journals, books on the chosen subject and submit seminar report at the end of the semester.

Marks:

Seminar Report Evaluation	: 50 Marks
Seminar Presentation	: 50 Marks

TSE 2001 SPEECH SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs. / Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Familiarize the basic mechanism of speech production and get an overview of articulatory and acoustic Phonetics
- Learn the basic concepts of methods for speech analysis and parametric representation of speech
- Acquire knowledge about various methods used for speech coding
- Get a overall picture about various applications of speech processing

Learning Outcomes

- Understand basic concepts of speech production, speech analysis, speech coding and parametric representation of speech and apply it in practical applications
- Ability to develop systems for various applications of speech processing

Module I

Speech Production: Acoustic theory of speech production (Excitation, Vocal tract model for speech analysis, Formant structure, Pitch). Articulatory Phonetics, and Acoustic Phonetics, 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

Module II

Parametric representation of speech: 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

Module III

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, Speaker Verification, Language Identification, Issues of Voice transmission over Internet.

References

1. Douglas O'Shaughnessy, *Speech Communications: Human & Machine*, IEEE Press, Hardcover 2nd edition, 1999; ISBN: 0780334493.
2. Nelson Morgan and Ben Gold, *Speech and Audio Signal Processing: Processing and Perception Speech and Music,* July 1999, John Wiley & Sons, ISBN: 0471351547
3. Rabiner and Schafer, *Digital Processing of Speech Signals,* Prentice Hall, 1978.
4. Rabiner and Juang, *Fundamentals of Speech Recognition*, Prentice Hall, 1994.
5. Thomas F. Quatieri, Discrete-*Time Speech Signal Processing: Principles and Practice,* Prentice Hall; ISBN: 013242942X; 1st edition
6. Donald G. Childers, *Speech Processing and Synthesis Toolboxes,* John Wiley & Sons, September 1999; ISBN: 0471349593

Structure of the Question Paper
There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 2002 OPTICAL SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Familiarize the basic theory of light propagation, concept of spatial frequency etc.
- Learn the transform domain approach of different optical components like slit, lens, free space etc.
- Acquire knowledge about various spectral analysis tools, filters and OSA
- Get a overall picture about various photo receivers

Learning Outcomes

- Understand basic concepts of light propagation, spatial frequency and Spectral analysis.
- Ability to develop optical filters, modulators and detectors for various applications of light processing

Module I

Need for OSP, Fundamentals of OSP, The Fresnel Transform, Convolution and impulse response, Transform of a slit, Fourier Transforms in Optics, Transforms of Aperture functions, Inverse Fourier Transform. Resolution criteria. A Basic Optical System, Imaging Transform conditions. Cascaded systems, scale of Fourier Transform Condition. Maximum information capacity and optimum packing density. Chirp _ Z transform and system Coherence.

Module II

Spectrum Analysis, Spatial light Modulators, special detector arrays. Performance parameters for spectrum analyzers. Relationship between SNR and Dynamic range. The 2 D spectrum analyzer. Spatial Filtering, Linear Space Invariant systems, Parseval's theorem, Correlation, input/output Spectral Densities, Matched filtering, Inverse Filtering. Spatial Filters. Interferometers. Spatial filtering systems. Spatial Modulators .Applications of Optical Spatial Filtering, Effects of small displacements.

Module III

Heterodyne systems. Temporal and spatial interference. Optimum photo detector size, Optical radio. Direct detection and Hetero dyne detection. Heterodyne spectrum Analysis. Spatial and temporal Frequencies. The CW signal and a short pulse. Photo detector geometry and bandwidth. Power spectrum analyzer using a CCD array.

References:

1. Anthony VanderLugt, *Optical Signal Processing*, John Wiley & Sons. 2005.
2. D. Casasent, *Optical data processing-Applications* Springer-Verlag, Berlin, 1978
3. P.M. Dufffieux, *The Fourier Transform and its applications to Optics*, John Wiley and sons 1983
4. J. Horner, Optical Signal Processing Academic Press 1988

Structure of the Question Paper
There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 2003 AUDIO SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Study of Perception of Sound
- Study of Audio Compression Schemes
- Study of Audio Classification
- Study of Hearing impairment and Hearing aids

Learning Outcomes

- Learn Signal processing models of sound perception and application of perception models in audio signal processing.
- Acquire ability to implement audio compression algorithms and standards.
- Acquire knowledge of audio classification algorithms.
- To understand the signal processing algorithms for hearing aids.

Module I

Signal Processing Models of Audio Perception

Basic anatomy of hearing System : Outer ear, middle ear and inner ear, Cochlea and signal processing in cochlea, Auditory Filter Banks, Gamma-tone filters, Bark Scale, Mel frequency scale,

Psycho-acoustic analysis

Critical Band Structure, Absolute Threshold of Hearing, Simultaneous Masking, Temporal Masking, Quantization Noise Shaping, MPEG psycho-acoustic model.

Spatial Audio Perception and rendering

The physical and psycho-acoustical basis of sound localization and space perception. Head related transfer functions, Source localization and beam forming with arrays of microphones. Stereo and multi-channel audio, Sound Filed Synthesis, Spatial audio standards

Room acoustics:

Sound propagation in rooms. Modeling. The influence of short and long term reverberation. Modeling room impulse responses and head related impulse responses.

Module II

Audio compression methods

Sampling rate and bandwidth requirement for digital audio, Redundancy removal and perceptual irrelevancy removal, Loss less coding, sub-band coding, sinusoidal coding, Transform coding.

Transform coding of digital audio

MPEG2-AAC coding standard, MDCT and its properties, Pre-echo and pre-echo suppression, psycho-acoustic modeling, adaptive quantization and bit allocation methods, Loss less coding methods.

Parametric Coding of Multi-channel audio

Mid- Side Stereo, Intensity Stereo, Binaural Cue Coding,

Audio quality analysis:

Objective analysis methods- PEAQ, Subjective analysis methods - MOS score, MUSHRA score.

Module III

Music Classification

Music features: Genre, Timbre, Melody, Rhythm, Audio features for Music Classification, Low-level, Mid- Level and Song level classification features, Similarity measures for classification , Supervised Classifiers : k NN, GMM, HMM, and SVM based classifiers.

Hearing aids

Hearing loss, digital hearing aids, Cochlear implants: Electrode design, Simulation methods, transmission link and signal processing, Types of cochlear implants, Performance analysis of cochlear implants.

References:

1. Audio Signal Processing and Coding, by Andreas Spanias, Ted Painter and Venkittaram Atti, Wiley-Inter Science publication, 2006
2. Zhouyu Fu; Guojun Lu; Kai Ming Ting; Dengsheng Zhang; , "A Survey of Audio-Based Music Classification and Annotation," *Multimedia, IEEE Transactions on*, vol.13, no.2, pp.303-319, April 2011doi: 10.1109/TMM.2010.2098858
3. Scaringella, N.; Zoia, G.; Mlynek, D.; "Automatic genre classification of music content: a survey," *Signal Processing Magazine, IEEE*, vol.23, no.2, pp.133-141, March 2006 doi:10.1109/MSP.2006.1598089
4. Loizou, P. (1998). "Mimicking the human ear," *IEEE Signal Processing Magazine*, 15(5), 101-130.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 2004 BIOMEDICAL SIGNAL PROCESSING AND SYSTEMS

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To develop innovative techniques of signal processing for computational processing and analysis of biomedical signals.
- To extract useful information from biomedical signals by means of various signal processing techniques.

Learning Outcomes

- Understands how basic concepts and tools of science and engineering can be used in understanding and utilizing biological processes.
- Hands-on approach to learn about signal processing and physiological signals through the application of digital signal processing methods to biomedical problems.

Module I

Genesis and significance of bioelectric potentials and their monitoring and measurement, spectral analysis, digital and analog filtering, correlation and estimation techniques. EOG and EMG.

Module II

ECG: Pre-processing, wave form recognition, morphological studies and rhythm analysis, automated diagnosis based on decision theory, evoked potential estimation.
EEG: Evoked responses, average techniques, pattern recognition of alpha, beta, theta and delta waves in EEG waves, sleep stages, epilepsy detection and wave pattern studies.

Module III

Biomaterials: Practical aspects of biomaterials, Sterilization of implants and Devices, Implant and device failure, Co-relation, surfaces and biomaterials, science, implant retrieval and evaluation. Biometrics.

References:

1. Willis J Tompkins, *Biomedical Signal Processing* - ED, Prentice -Hall, 1993
2. Buddy D. Ratner, Allan S. Hoffman, Frederick J. Schoen and Jack E. Lemens, *An introduction to materials in Medicine*- Elsevier Publication.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 2005 ADAPTIVE SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Introduction to the various techniques used to predict the outcomes of a random process
- Ability to appreciate the various filters, their inherent assumptions and the statistics they require
- Get a overall picture about applications of adaptive filters in various fields

Learning Outcomes

- Understand basic concepts of adaptive signal processing
- Top-level understanding of the convergence issues, computational complexities and optimality of different filters
- Ability to develop adaptive systems for various applications

Module I

Recap of fundamentals: Correlation matrix and its properties, its physical significance.
Eigen analysis of matrix, structure of matrix and relation with its eigen values and eigen vectors.Spectral decomposition of corr.matrix, positive definite matrices and their properties their physical significance. Complex Gaussian processes, MA, AR, ARMA processes and their properties, method of Lagrange multipliers.
LMMSE Filters: Goal of adaptive signal processing, some application scenarios, problem formulation, MMSE predictors, LMMSE predictor, orthogonality theorem (concept of innovation processes), Weiner filter, Yule-walker equation, unconstrained Weiner filter (in z domain), and recursive Weiner filter (using innovation process). Kalman filter, recursions in Kalman filter, Extended Kalman filter, comparison of Kalman and weiner filters.

Module II

Adaptive filters: 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 misadjusment, Convergence of LMS.RLS recursions, assumptions for RLS, convergence of RLS coefficients and MSE.
Lattice filters : Filter based on innovations, generation of forward and backward innovations, forward and reverse error recursions. Implementation of Weiner, LMS and RLS filters using lattice filters, Levinson Durbin algorithm, reverse Levinson Durbin algorithm.

Module III

Tracking performance of the time varying filters : Tracking performance of LMS and RLS filters. Degree of stationarity and misadjustment, MSE derivations.
Applications: System identification, channel equalization, noise and echo cancellation. Applications in array processing, beam forming.

References:

1. S. Haykin. (1986). *Adaptive Filters Theory*. Prentice-Hall.
2. Dimitris G. Manolakis, Vinay K. Ingle, Stephan M Krgon*: Statistical and Adaptive Signal Processing*, McGraw Hill (2000)
3. Jones D. *Adaptive Filters* [Connexions Web site]. May 12, 2005. Available at: http://cnx.rice.edu/content/col10280/1.1/

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

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TSE 2006 PATTERN RECOGNITION AND MACHINE LEARNING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

This course will introduce the concepts, techniques, design and applications of machine learning to pattern recognition. The course is expected to enable students to understand and implement classical algorithms in pattern recognition and machine learning.

Learning Outcomes

- Understand and compare the various approaches to machine learning and pattern recognition implementations
- Describe and utilize a range of techniques for designing machine learning and pattern recognition systems for real-world applications

Module I

Introduction to Probability Theory, Decision Theory and Information Theory. Concepts of learning, Supervised and unsupervised learning, Curse of dimensionality. Probability distributions, Parametric and Non-parametric methods, Gaussian distribution, Maximum-Likelihood estimation, Bayesian inference, Mixture of Gaussians, Nearest-neighbour methods.

Module II

Hidden Markov models for sequential data classification - Discrete hidden Markov models, Continuous density hidden Markov models. Dimension reduction methods - Fisher discriminant analysis, Principal component analysis. Non-parametric techniques for density estimation - Parzen-window method, K-Nearest Neighbour method. Non-metric methods for pattern classification - Non-numeric data or nominal data, Decision trees.

Module III

Linear models for regression and classification, Perceptron, Artificial Neural networks, Support Vector Machines. Unsupervised learning, Clustering - Criterion functions for clustering, Algorithms for clustering: K-means and Hierarchical methods.

References:

1. C.M.Bishop, Pattern Recognition and Machine Learning, Springer
2. R.O.Duda, P.E.Hart and D.G.Stork, Pattern Classification, John Wiley
3. Tom Mitchell, Machine Learning, McGraw-Hill.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 80% problems and 20% theory.

TCD 2001 DESIGN OF VLSI SYSTEMS

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Understand the basics of CMOS Inverter and other Logic Design Techniques
- Get a feel of current design technology
- In-depth knowledge about various memory elements

Learning Outcomes

- Understand the basics of VLSI Design
- Understand the working of high speed adders and multipliers
- Understand , various methods in the design of memory elements

Module I

CMOS Inverter - Static Behaviour, Performance of CMOS Inverter - Dynamic Behaviour, Power Energy and Energy Delay, CMOS Circuit and Logic Design-CMOS Logic structures. Advanced techniques in CMOS Logic Circuits-Mirror circuits, Pseudo NMOS, Tri-state circuits, Clocked CMOS, Dynamic CMOS Logic circuits, Dual Rail Logic Networks.

Module II

Arithmetic Circuits in CMOS VLSI-Bit Adder Circuits, Ripple Carry Adder, Carry Look Ahead Adders, Other High speed adders-Multiplexer based fast binary adders, Multipliers-Parallel multiplier, Wallace Tree and Dadda multiplier, Low power design- Scaling Versus Power consumption, Power reduction techniques

Module III

Designing Memory and Array Structures - Memory classification, Memory Core - Read Only Memories, Non-volatile Read Write Memories, Read Write Memories, Content - Addressable or Associative Memories, Memory Peripheral Circuits - Address Decoders, Sense Amplifiers.

References

1. John P. Uyemura, Introduction to VLSI Circuits and Systems, John Wiley & Sons 2002
2. Kesshab K. Parhi, VLSI DIGITAL SIGNAL PROCESSING SYSTEMS, John Wiley & Sons 2002
3. Neil H. E. Weste, Kamran Eshranghian, Principles of CMOS Design, Pearson Education Asia 2000
4. Jan M. Rabaey and et al, DIGITAL INTEGRATED CIRCUITS, Pearson Edn. Inc. 2003

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TCD 2002 SOFT COMPUTING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To familiarize various components of soft computing.
- To give an overview of fuzzy Logic
- To give a description on artificial neural networks with its advantages and application.

Learning Outcomes

- Identify and describe soft computing techniques and their roles in building intelligent machines
- Recognize the feasibility of applying a soft computing methodology for a particular problem
- Apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems

Module I

Basics of Fuzzy Sets: Fuzzy Relations – Fuzzy logic and approximate reasoning – Design. Methodology of Fuzzy Control Systems – Basic structure and operation of fuzzy logic control systems. Concepts of Artificial Neural Networks: Basic Models and Learning rules of ANN's. Single layer perceptron networks – Feedback networks – Supervised and unsupervised learning approaches – Neural Networks in Control Systems.

Module II

Integration of Fuzzy and Neural Systems: Neural Realization of Basic fuzzy logic operations – Neural Network based fuzzy logic inference – Neural Network based Fuzzy Modelling – Types of Neural Fuzzy Controllers. Data clustering algorithms - Rule based structure identification-Neuro-Fuzzy controls - Simulated annealing.

Module III

Survival of the Fittest - Fitness Computations - Cross over - Mutation -Reproduction - Rank method–Rank space method AI search algorithm - Predicate calculus - Rules of interference – Semantic networks - Frames - Objects - Hybrid models - Applications.

References:

1. Jyh Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, (1997), *Neuro-Fuzzy and Soft Computing*: A Computational Approach to Learning and Machine, Prentice Hall,.
2. Chin –Teng Lin and C.S. George Lee,(1996) "*Neural Fuzzy Systems*" – A neuro fuzzy synergism to intelligent systems, Prentice Hall International
3. Yanqing Zhang and Abraham Kandel (1998), *Compensatory Genetic Fuzzy Neural Network and Their Applications*, World Scientific.
4. T. J. Ross (1995)- *Fuzzy Logic with Engineering Applications*, McGraw-Hill, Inc.
5. Nih J.Nelsson, "*Artificial Intelligence - A New Synthesis*", Harcourt Asia Ltd., 1998.

6. D.E . Goldberg, "*Genetic Algorithms: Search, Optimization and Machine Learning*", Addison Wesley,N.Y, 1989

Structure of the Question Paper
There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TCD 2003 OPTIMIZATION TECHNIQUES

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To familiarize the students with the need of optimization in engineering.
- To introduce the students with the different types of optimization algorithms
- To enable the students to select the suitable optimization technique for the particular problem.

Learning Outcomes

- Understand the role of optimization in engineering design.
- Understand the working principle of optimization algorithms.
- Understand the formulation of the problem and usage of optimization algorithms.

Module I

One dimensional – necessary and sufficient conditions, Search methods- Fibonacci search, golden section search, Gradient methods- Newton- Raphson method, cubic search. Multivariable- necessary and sufficient conditions, Search methods- Evolutionary method, Hook-Jeevs pattern search, Gradient based methods- steepest descent, Newton's method, conjugate gradient method.

Module II

Linear Programming - Systems of linear equations & inequalities, Formulation of linear programming problems, Theory of Simplex method, Simplex Algorithm, Two phase method- Duality, Dual Simplex method. Non Linear Programming- Kuhn-Tucker conditions- Necessary and Sufficiency theorem – transformation method – penalty function method search method –random search method, linearized search - Frank-Wolf method.

Module III

Meta-heuristic optimization Techniques- (Principle and implementation steps for examples related to engineering (signal processing, communication, control system) optimization of the following) Differential Evolution (DE), Harmony Search Algorithm (HSA), Artificial Bee Colony Algorithm (ABC).

References:

1. Optimization for Engineering Design, Algorithms and Examples. -PHI, ISBN -978-81-203-0943-2, Kalyanmoy Deb, IIT Kanpur.
2. Unit - 4 Corresponding publications.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TCD 2004 INFORMATION HIDING & DATA ENCRYPTION

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- The ability to do Cryptography, watermarking and Steganalysis
- Should be able to use various Data Hiding techniques
- Ability to apply encryption techniques in dataforvarious applications

Learning Outcomes

- Understand Cryptography, watermarking and Steg analysis
- Understand capabilities of encryption techniques in data for various applications
- Understand, Analyse various Data Hiding techniques

Module I

Introduction to Complexity theory, Elementary Number theory, Algebraic Structures- Groups, Rings and Finite Fields, Polynomials over Finite Fields (Fq). Classical Cryptography, Stream Ciphers, Public Key Cryptography: based on Knapsack problem, AES. Digital Signature, Zero Knowledge Proofs.

Module II

Information Hiding: Watermarking, Steganography. Objectives, difference, requirements, types (Fragile and robust).Parameters and metrics (BER, PSNR, WPSNR, Correlation coefficient, MSE, Bit per pixel). LSB, additive, spread spectrum methods. Applications: Authentication, annotation, tamper detection and Digital rights management. Hiding text and image data, mathematical formulations.

Module III

Hiding in 1D signals: Time and transform techniques-hiding in Audio, biomedical signals, HAS Adaptive techniques. Hiding in 2D signals: Spatial and transform techniques-hiding in images, ROI images, HVS Adaptive techniques. Hiding in video: Temporal and transform domain techniques, Bandwidth requirements. Steganalysis: Statistical Methods, HVS based methods, SVM method, Detection theoretic approach.

References:

1. Neal Koblitz, *A Course in Number Theory and Cryptography*, 2nd Edition, Springer
2. Stefan Katzenbeisser, Fabien A. P. Petitcolas, *Information Hiding Techniques for Steganography and Digital Watermarking,* Artech House Publishers, 2000.
3. Neil F Johnson et al Kluwer, *Information hiding: steganography and watermarking attacks and countermeasures* Academic Publishers London.
4. Ingmar J Cox eta al *Digital Watermarking*, Morgan Kaufman Series, Multimedia information and system.
5. Ira S Markowitz, Proceedings, *4^{th}international workshop*, IH 2001, Pittsburg, USA April 2001 Eds: 2. AVISPA package homepage, http:/ www.avispaproject.org/
6. Handbook of Applied Cryptography, AJ Menezesetc al, CRC Press

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TTC 3101 THESIS PRELIMINARY: PART II

Structure of the Course

Thesis	: 14 hrs/week	Credits: 5
Internal Continuous Assessment	: 200 Marks	

The Thesis Preliminary Part - II is an extension of Thesis Preliminary Part - I. Thesis Preliminary Part II comprises preliminary thesis work, two seminars and submission of Thesis - Preliminary report. The first seminar would highlight the topic, objectives and methodology and the second seminar will be a presentation of the work they have completed till the third semester and the scope of the work which is to be accomplished in the fourth semester, mentioning the expected results.

Distribution of marks

Internal assessment of work by the Guide : 100 Marks

Internal evaluation by the Committee : 100 marks

TSE 3001 VLSI STRUCTURES FOR DIGITAL SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs./ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- The ability to do Pipelining, and Parallel processing.
- Should be able to implement DCT based on architecture transformations.

Learning Outcomes

- Understand Pipelining, and Parallel processing.
- Understand Scaling and round off noise.
- Understand evolution of programmable DSP processors.

Module I

Pipelining of FIR digital filters -parallel processing for FIR systems -combined pipelining and parallel processing of FIR filters for low power -Pipelining in IIR filters -parallel processing for IIR filters -combined pipelining and parallel processing of FIR filters.

Module II

Parallel FIR filters -discrete time cosine transform -implementation of DCT based on algorithm -architecture transformations -parallel architectures for rank order filters.
Scaling and round off noise -round off noise in pipelined IIR filters -round off noise in lattice filters -pipelining of lattice IIR digital filters -low power CMOS lattice IIR filters.

Module III

Evolution of programmable DSP processors -DSP processors for mobile and wireless communications -processors for multimedia signal processing -FPGA implementation of DSP processors.

References:

1 Keshab K. Parhi, *VLSI Digital signal processing Systems: Design and Implementation,* John Wiley & Sons, 1999.
2 Uwe meyer- Baes, *DSP with Field programmable gate arrays,* Springer, 2001

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 3002 SPACE TIME CODING AND MIMO SYSTEMS

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- To introduce diversity techniques, space time coding and receiver design

Learning Outcomes

- Understand channel models and diversity techniques
- Understand space time coding
- Understand receiver design

Module I

Review of SISO communication- MIMO channel models Transmission model for MIMO channels, Multidimensional channel modeling, Capacity of MIMO channels, Outage capacity, Diversity-Principle, array and diversity gains, Diversity methods, Combining methods-maximum ratio combining, selection combining.

Module II

Space-time code design criteria - Rank and determinant criteria, Trace criterion, Maximum mutual information criterion. Orthogonal space-time block codes – Alamouti code, Maximum-likelihood decoding and maximum ratio combining, and orthogonal designs. Quasi-orthogonal space-time block codes- Pairwise decoding, Rotated QOSTBCs. Space time trellis codes.

Module III

Spatial multiplexing and receiver design-Introduction, Spatial multiplexing, Sphere decoding, Using equalization techniques in receiver design, V-BLAST , D-BLAST, Turbo-BLAST, Combined spatial multiplexing and space-time coding, MIMO OFDM

References

1. H. Jafarkhani,"Space Time Coding Theory and Practice" Cambridge University Press.
2. E. G. Larsson and P. Stoica, "Space Time Block coding for wireless communication". Cambridge University Press.
3. C. Oesteges and B. Clerckx, MIMO wireless communications from real world world propogation to space time code design. Academic press.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 3003 COMPUTER VISION

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- Introduce the standard computer vision problems and identify the solution methodologies.

Learning Outcomes

- Understand and implement various image processing algorithms for feature matching, segmentation, etc.
- Understand and implement the algorithms for 3D reconstruction from various cues.
- Understand and implement the various objection detection/recognition methods.

Module I

Image Formation: Geometric primitives and transformation, Photometric image formation, The digital camera. Feature detection and matching: Points and patches, Feature detectors and descriptors, Feature matching and tracking, Edge detection and edge linking. Hough transforms vanishing points. Segmentation: Region splitting and region merging, K-means and mixture of Gaussians, Mean shift, Graph cuts and energy-based methods.

Module II

Structure from motion: Triangulation, Projective reconstruction, self-calibration, Factorization, Bundle adjustment, constrained structure and motion. Dense motion estimation: translational alignment, parametric motion, optical flow, multi frame motion estimation.

3D reconstruction: shape from X, shape from shading, photometric stereo, texture and shape from focus. Surface representation, point based volumetric and model based representations.

Module III

Object Detection and Recognition: Face detection, Pedestrian detection, Face recognition, Eigen faces, Active appearance and 3D shape models, Instance recognition, Category recognition, Bag of words, Part-based models, and recognition with segmentation, Context and scene understanding.

References:

1. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer 2010
2. Computer vision: A modern approach, by Forsyth and Ponce. Prentice Hall, 2002.
3. Computer & Machine Vision: Theory Algorithms Practicalities, E. R. Davies, ELSEIVER, Academic Press, 2012

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 3004 ARRAY SIGNAL PROCESSING

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

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.

Learning Outcomes

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

Module I

Spatial Signals: Signals in space and time, Spatial Frequency vs. Temporal Frequency, Review of Co-ordinate Systems, Maxwell's Equation, and Wave Equation. Solution to Wave equation in Cartesian Co-ordinate system -Wavenumber vector, Slowness vector, Wavenumber -Frequency Space Spatial Sampling: Spatial Sampling Theorem-Nyquist Criteria, Aliasing in Spatial frequency domain, Spatial sampling of multidimensional signals.

Module II

Sensor Arrays: Linear Arrays, Planar Arrays, Frequency - Wavenumber Response and Beam pattern, Array manifold vector, Conventional Beamformer, Narrowband beamformer. Uniform Linear Arrays: Beam pattern in θ, u and ψ -space .Uniformly Weighted Linear Arrays. Beam Pattern Parameters: Half Power Beam Width, Distance to First Null, Location of side lobes and Rate of Decrease, Grating Lobes, Array Steering

Module III

Array Design Methods: Visible region, Duality between Time -Domain and Space -Domain Signal Processing, Schelkunoff's Zero Placement Method, Fourier Series Method with windowing, Woodward -Lawson Frequency-Sampling Design, Narrow-beam low-side lobe design methods Narrow Band Direction of Arrival Estimation: Non parametric method -Beam forming, Delay and sum Method, Capons Method. Subspace Methods -MUSIC, Minimum Norm and ESPIRIT techniques.

References:

1. Harry L. Van Trees; Optimum Array Processing; Wiley-Interscience
2. Dan E Dugeon and Don H Johnson; Array Signal Processing: Concepts and Techniques; Prentice Hall
3. PetreStoica and Randolph L. Moses; Spectral Analysis of Signals; Prentice Hall
4. Sophocles J Orfandis ; Electromagnetic Waves and Antennas.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 3005 BIO INFORMATICS

Structure of the Course

Lecture	: 3 hrs/ Week	Credits: 3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objectives

- The ability to analyse bio-sequences computationally
- Should be able to use various tools for sequence study.
- Should be able to model biological systems.

Learning Outcomes

- Understand the basics of genomes and proteomes
- Understand how various algorithms and tools could be made use of for sequence analysis.
- Understand the properties and modeling of biological systems.

Module I

The cell as basic unit of life-Prokaryotic cell and Eukaryotic cell - Central Dogma: DNA-RNA-Protein, Human Genome Project, SNP, Bioinformatics databases, Homologus, orthologus & paralogus sequences. Scoring matrices- PAM and BLOSUM matrices, pairwise sequence alignments: Needleman & Wuncsh, Smith & Waterman algorithms for pairwise alignments. BLAST and FASTA. Multiple sequence alignments (MSA)- CLUSTALW. Basic concepts of phylogeny

Module II

Computational approaches for bio-sequence analysis - Mapping bio-sequences to digital signals -various approaches -indicator sequences -distance signals -use of clustering to reduce symbols in amino acid sequences - analysis of bio-sequence signals -case study of spectral analysis for exon location, chaos game representation of bio-sequences

Module III

Systems Biology: System Concept- Properties of Biological systems, Self organization, emergence, chaos in dynamical systems, linear stability, bifurcation analysis, limit cycles, attractors, stochastic and deterministic processes, continuous and discrete systems, modularity and abstraction, feedback, control analysis, Mathematical modeling; Biological Networks- Signaling pathway, GRN, PPIN, Flux Balance Analysis, Systems biology v/s synthetic biology

References

1. Claverie & Notredame, Bioinformatics - A Beginners Guide, Wiley-Dreamtech India Pvt.
2. Uri Alon, An Introduction to Systems Biology Design Principles of Biological Circuits, Chapman & Hall/CRC
3. MarketaZvelebil and Jeremy O. Baum, Understanding Bioinformatics, Garland Science.
4. Bryan Bergeron, Bioinformatics Computing, Pearson Education, Inc., Publication.
5. D. Mount, Bioinformatics: Sequence & Genome Analysis, Cold spring Harbor press.
6. C. A. Orengo, D.T. Jones and J. M. Thornton, Bioinformatics- Genes, Proteins and Computers, Taylor & Francis Publishers.

7 Achuthsankar S. Nair et al. Applying DSP to Genome Sequence Analysis: The State of the Art, CSI Communications, vol. 30, no. 10, pp. 26-29, Jan. 2007.
8. Resources at web sites of NCBI, EBI, SANGER, PDB etc.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSE 3006 SECURE COMMUNICATION

Structure of the Course

Lecture	: 3 hrs/ Week	Credits:3
Internal Continuous Assessment	: 40 Marks	
End Semester Examination	: 60 Marks	

Course Objective

As a graduate level course on secure communication, this course assure to deliver the students, a sound understanding of the number theoretic methods and algorithms used in classical and modern cryptography and their cryptanalysis.

Learning Outcome

- Learn theorems on the number and abstract algebra and develops the mathematical proof witting skills.
- Learn mathematics behind the cryptography and the cryptographic standards.
- Learn the algorithms used in cryptanalysis and their merits.
- Initiate the talented students to propose and analyze new algorithms and methods in cryptology.

Module I

Basics, Mathematical proofs and methods. Complexity theory: Computational Complexity Classes P, NP- NP-Complete, NP-Hard, BPP. Number theory: primes, divisibility, linear Diophantine equations, congruences, systems of congruence equation, quadratic congruences. Wilson theorem, Fermat's little theorem, Euler's theorem. Multiplicative functions, Primitive roots, Quadratic residues, Legendre symbol, Continued fractions. Elementary Algebraic Structures: Groups- subgroups, order, homomorphism, cyclic groups, generators. Rings-characteristics, Finite Fields. Polynomial Rings and their algebra over finite fields, multiplicative inverses. Discrete logarithm over groups.Elliptic Curves: as a group defined over finite field, number of points, order and algebra of rational points on elliptic curves.

Module II

Classical Cryptography: Affine ciphers, hill ciphers, digraphs, enciphering matrices.; Linear Feedback Shift Registers for PN sequences. Public key Cryptography: One way functions, Hash functions, Knapsack cryptosystems, RSA, Deffie Helman Key Exchange system, El Gamal's Public key crypto system. Elliptic curve crypto system. Cryptographic standards: DES, AES, MD5, Digital Signature, Zero Knowledge Protocol.

Module III

Cryptanalysis, Algorithms: Modular exponentiation, Fast group operations on Elliptic curves. Primality test- Fermat's pseudo primality test, Strong prime test, Lucas Pseudo prime test, Elliptic curve test. Integer Factorization- Trial division, Fermat's method, CFRAC. Quadratic and Number Field Sieves. Algorithms for Discrete Logarithms: Baby-step Giant-step alg. Algorithms for Discrete Logarithm on Elliptic curves.

References:

1. A Course in Number Theory and Cryptography, Neal Koblits, Springer, 2e.
2. Number Theory for Computing, Song Y Yan, Springer, 2e.

3. Elementary Number Theory with Applications, Thomas Koshy, Elsiever, 2e.
4. Fundamentals of Cryptology, Henk CA van Tilborg, Kluwer Academic Publishers.
5. Primality Testing and Integer Factorization in Public Key Cryptography, Song Y Yan, Springer, 2e.
6. Public Key Cryptography, ArtoSalomaa, Springer, 2e.
7. An Introduction to Theory of Numbers, I Niven, HS zuckerman etc.., John Wiley and Sons, 5e.
8. How to Prove it- A structured Approach, Daniel J Velleman, Cambridge University Press, 2e.

Structure of the Question Paper

There will be three questions from each module out of which two questions are to be answered by the students. It shall have 60% problems and 40% theory.

TSC 4101 **THESIS**

Structure of the Course

Thesis	: 21 hrs/week	Credits: 12
Internal Continuous Assessment	: 300 Marks	
End Semester Examination	: 300 Marks	

The student has to continue the thesis work done in second and third semesters. There would be an interim presentation at the first half of the semester to evaluate the progress of the work and at the end of the semester there would be a pre-Submission seminar before the Evaluation committee for assessing the quality and quantum of work. This would be the qualifying exercise for the students for getting approval from the Department Committee for the submission of Thesis. At least once technical paper is to be prepared for possible publication in Journals/Conferences. The final evaluation of the Thesis would be conducted by the board of examiners constituted by the University including the guide and the external examiner.

Distribution of marks

Internal evaluation of the Thesis work by the Guide : 150 Marks

Internal evaluation of the Thesis by the Evaluation Committee : 150 Marks

Final evaluation of the Thesis Work by the Internal and External Examiners:

[Evaluation of Thesis: 200 marks *+ Viva Voce: 100 marks (**5% of the marks is ear marked for publication in Journal/Conference*)] TOTAL – 300 Marks