SIGNAL PROCESSING
# M.Tech Programme

**Electronics and Communication - Signal Processing**

## Curriculum and scheme of Examinations

### SEMESTER I

<table>
<thead>
<tr>
<th>Code No.</th>
<th>Name of Subject</th>
<th>Credits</th>
<th>Hrs./week</th>
<th>Exam duration</th>
<th>Marks</th>
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- TSM 1004: Multirate Systems and Wavelets
- TSC 1101: DSP Systems Lab
- TSC 1102: Seminar

**Remarks**

- Do
- No End Semester Examination

**Total Credits:** 21

**Total Hrs./week:** 22

**Total Exam duration:** 7 Hours

**Total Marks:** 100
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<th>Code No.</th>
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<th>Exam Duration</th>
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** 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

<table>
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<th>Code No.</th>
<th>Name of Subject</th>
<th>Credits</th>
<th>Hrs / week</th>
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** 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
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TSM 1001  LINEAR ALGEBRA FOR SIGNAL PROCESSING

Structure of the Course

Lecture : 3 hrs/ Week  
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


Module II


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
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

Module II

Module III
References


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  
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

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:

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

Module II

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

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

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<th>Component</th>
<th>Credits:</th>
<th>Marks:</th>
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<tbody>
<tr>
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<tr>
<td>End Semester Examination</td>
<td>60 Marks</td>
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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


Module II


Module III


References:

7. Ingle, Proakis, Digital Signal Processing Using MATLAB, Thomson, 1/e

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
Internal Continuous Assessment: 40 Marks
End Semester Examination: 60 Marks
Credits: 3

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 space, 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

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


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  
Continuous Assessment : 100 Marks  
Credits : 2

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


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:


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
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Credits: 3

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


References

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 for research 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

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
Internal Continuous Assessment : 100 Marks

Credits : 2

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:
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


References

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

<table>
<thead>
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<td>40 Marks</td>
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<tr>
<td>End Semester Examination</td>
<td>60 Marks</td>
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</tbody>
</table>

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


Module II


Module III


References:

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
Internal Continuous Assessment: 40 Marks
End Semester Examination: 60 Marks

Credits: 3

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:


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:

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
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Credits: 3

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

References:

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


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 misadjustment, Convergence of LMS.RLS recursions, assumptions for RLS, convergence of RLS coefficients and MSE.


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:

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 2006  PATTERN RECOGNITION AND MACHINE LEARNING

Structure of the Course
Lecture : 3 hrs/ Week  
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

Module II

Module III

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

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
Internal Continuous Assessment: 40 Marks
End Semester Examination: 60 Marks
Credits: 3

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

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
2. Kesshab K. Parhi, VLSI DIGITAL SIGNAL PROCESSING SYSTEMS, John Wiley & Sons 2002

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

<table>
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<th>Component</th>
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<td>End Semester Examination</td>
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</table>

Credits: 3

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


Module II


Module III


References:


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
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


Module II


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:

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  
Internal Continuous Assessment : 40 Marks  
End Semester Examination : 60 Marks

Credits: 3

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 data for various 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

Module II

Module III

References:

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  
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:
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

3. C. Oesteges and B. Clerckx, MIMO wireless communications from real world propagation 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

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:

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
Internal Continuous Assessment : 40 Marks
End Semester Examination : 60 Marks

Credits: 3

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

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

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. Petre Stoica and Randolph L. Moses; Spectral Analysis of Signals; Prentice Hall

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

2. Uri Alon, An Introduction to Systems Biology Design Principles of Biological Circuits, Chapman & Hall/CRC
5. D. Mount, Bioinformatics: Sequence & Genome Analysis, Cold spring Harbor 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 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 writing 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

Module II

Module III

References:
3. Elementary Number Theory with Applications, Thomas Koshy, Elsiever, 2e.
5. Primality Testing and Integer Factorization in Public Key Cryptography, Song Y Yan, Springer, 2e.
7. An Introduction to Theory of Numbers, I Niven, HS zuckerman etc., John Wiley and Sons, 5e.

**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*

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</tr>
<tr>
<td>End Semester Examination</td>
<td>300 Marks</td>
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</tbody>
</table>

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 |  |