University of Pune

COURSE STRUCTURE FOR M.E. (E & TC) (Signal Processing)
(w. e. f. June – 2013)

SEMESTER I

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
504401	Image Processing and Analysis	4	50	50	-	-	100	4
504402	Signal Processing Techniques	4	50	50	-	-	100	4
504403	Mixed Signal Processing Systems and Design	4	50	50	-	-	100	4
504104	Research Methodology	4	50	50	-	-	100	4
504405	Elective I	5	50	50	-	-	100	5
504406	Lab Practice I	4	-	-	50	50	100	4
Total		25	250	250	50	50	600	25

SEMESTER II

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
504407	Speech Signal Processing	4	50	50	-	-	100	4
504408	Architecture for Signal Processing Algorithms	4	50	50	-	-	100	4
504409	Biomedical signal processing	4	50	50	-	-	100	4
504410	Elective II	5	50	50	-	-	100	5
504411	Lab Practice II	4	-	-	50	50	100	4
504412	Seminar I	4	-	-	50	50	100	4
Total		25	200	200	100	100	600	25

SEMESTER III

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
604401	Statistical Signal Processing	4	50	50	-	-	100	4
604402	Still image and Moving picture Compression Standards	4	50	50	-	-	100	4
604103	Elective III	5	50	50	-	-	100	5
604404	Seminar II	4	-	-	50	50	100	4
604405	Project Stage I	08	-	-	50	50	100	8
Total		25	150	150	100	100	500	25

SEMESTER IV

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME				CREDITS
		Lect./ Pr	Paper	TW	Oral/ Presentation	Total	
604406	Seminar III	5	-	50	50	100	5
604407	Project Work Stage II	20	-	150	50	200	20
Total		25	-	200	100	300	25

Note: Syllabus for Elective III is common for all disciplines.

Elective I	1. Mathematics for Signal Processing 2. Soft Computing 3. Artificial Intelligence 4. Estimation and Detection theory 5. *LATEX
Elective II	1. Computer Vision 2. RF and high speed circuits 3. Acoustic Signal Processing 4. Satellite Communication and Signal Processing 5. *Software Tools
Elective- III	1.Value Education, Human Rights and Legislative Procedures 2. Environmental Studies 3. Energy Studies 4. Disaster Management 5. Knowledge Management 6. Foreign Language 7. Economics for Engineers 8. Engineering Risk – Benefit Analysis 9. Technology Play 10. Optimization Techniques 11. Fuzzy Mathematics 12. Design and Analysis of Algorithms 13. CUDA

504401	Image Processing and Analysis	
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**
Module I		
Digital image fundamentals: Simple image formation model, Image sampling and quantization - basic relationships between pixels - imaging geometry. Elements of human visual perception, Image statistics.		
Module II		
Image transforms: 2D-DFT, FFT, 2D-DCT, KL, Hadamard and Wavelet transforms. **Image Enhancement**: Spatial domain methods: point processing - intensity transformations, histogram processing, image subtraction, image averaging; Image zooming, Spatial filtering - smoothing filter, sharpening filter. Frequency domain filtering: low pass filtering, high pass filtering, and Homomorphic filtering.		
Module III		
Image restoration: Degradation model - Inverse filtering - Wiener filter - Constrained Least squares restoration **Image segmentation** Detection of discontinuities - point, line and edge and combined detection, Edge linking Region oriented segmentation - basic formulation, region growing by pixel aggregation, region splitting and merging, Thresholding		
Module IV		
Region and boundary descriptors - Hough transform, Fourier descriptors, chain code **Morphological image processing** - Basics, SE, Erosion, Dilation, Opening, Closing, Hit-or-Miss Transform, Boundary Detection, Hole filling, Connected components, thinning, thickening, skeletons, pruning,		
Module V		
Image compression: Image compression using DCT, zig-zag scanning, still image compression standard - baseline JPEG, **Color Image Processing:** Color models - RGB, CMY, YIQ, HIS, Pseudo - coloring,		

References:

1. Gonzalez and Woods, "Digital Image Processing", Pearson Education,
2. Pratt William K. "Digital Image Processing", John Wiley & sons
3. S. Jayaraman, S. Esakkiraian “Digital Image Processing”, Tata McGraw-Hill Education

Image Processing and Analysis

Laboratory Assignments/Experiments:(MATLAB/ JAVA platform)

1. Implementation of filters: The case study consisting of application of nearly all kind of filters for enhancing of the image
2. Implementation of Encoding and decoding scheme in JPEG image compression standard. The entropy coding step can be excluded. The performance of the JPEG with different quality factors should be analyzed.
3. A case study for measuring various parameters such as area, perimeter, shape of the objects in an image. This also includes counting the number of different objects in an image. The complete process involves edge detection for segmentation/ segmentation using techniques like thresholding, region growing etc, morphological operations

Course Outcomes:

1. Graduates will have background of Human Visual perception
2. Graduates will know how to process two dimensional image data
3. Graduates will have knowledge of Image transform and their properties
4. Graduates will have understanding of image processing algorithms for image enhancement, image restoration, compression ,segmentation
5. Graduates will be able to implement image processing algorithms for given application

504402	Signal Processing Techniques	
Teaching Scheme: Lectures 4 Hrs/ Week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

FIR and adaptive FIR filter, filter specifications, design using Fourier series method, windowing, frequency sampling method, Adaptive FIR filter design, steepest descent algorithm, least mean square algorithm, optimal ripple FIR design.

Module II

IIR and adaptive IIR filter design, impulse invariant method, Bilinear transformation method, Pade approximation method, Least squares Design methods, Wiener filter design, recursive least squares design, Deczky‟s method.

Module III

Multirate DSP: Decimation by a factor D, Interpolation by a factor I, Sampling rate conversion by a rational factor I/D, efficient implementation of decimator and interpolator, poly phase filter structure, multistage filter design, application of multirate DSP for sub band coding of speech and oversampling ADC/DAC

Module IV

DSP processor Hardware [Not specific to any Manufacture – should be generalized]

DSP Architectures: von Neumann Architecture, Harvard Architecture, Super Harvard Architecture, VLIW Architecture, Multiple access memory, multiport memory, circular buffering, MC unit, Barrel shifter, Booth‟s multiplication algorithm, VLSI architecture- Parallel processing and pipelining, retiming, unfolding, folding,

Implementation of FIR, IIR filters, Decimation, interpolation algorithm

References:

1. John G. Proakis, Oimitris G. Manolakis-Digital Signal Processing-Principles, algorithms & applications, PHI, 1997.
2. Advanced Digital Signal Processing-Wiley India Publication by May 2012, Dr. Shaila D. Apte
3. S.K.Mitra, Digital Signal Processins- TMH, 1998.
4. Proakis-Advanced Digital Signal Processing Macmillan publishing company, 1992.
5. P. Vaidyanathan- Multirate signal Processing.
6. Avtarsingh & S. Srinivasan-Digital Signal Processing

Signal Processing Techniques

Laboratory Assignments/Experiments

1. To design an FIR filter for given specifications using Fourier series method.
2. To design an IIR filter using bilinear transformation method for given specifications.
3. Implementation of Decimator by a factor of 2 and 3.
4. Implementation of FIR filter using DSP processor.
5. Implementation of sub band coding for speech signal.

Course Outcomes:

1. The student would be able to understand how to analyze a given signal or system using tools such as Fourier transform and Z transform
2. The student would be able to understand what kind of characteristics should we analyze to know the property of a signal or system
3. The student would be able to understand how to process signals to make them more useful
4. The student would be able to understand how to design a signal processor (digital filter) for a given problem

504403	Mixed Signal Processing Systems and Design	
Teaching Scheme: Lectures 4 Hrs/ Week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

Switched Capacitor filters: Introduction to Analog and Discrete Time signal processing, sampling theory, Nyqist and over sampling rates, Analog filters, analog amplifiers, lock in amplifiers, analog integrated and discrete time switched capacitor filters, non idealities in switched capacitor filters, architectures for switched capacitor filters and their applications and design. Switched capacitor amplifiers.

Module II

Data converters: Basics of data converters, Types of data converters, types of ADCs, Successive approximation, dual slope, Flash type, pipelined ADCs, hybrid ADCs, high resolution ADCs, parallel path ADCs like time-interleaved and multi-channel converters. Types of DACs and their architectures, binary weighted DACs. Performance metrics of data converters, SNR, SFDR, SNDR. Background and foreground techniques to improve performance of data converters, Green data converters (low power design).

Module III

Frequency synthesizers and synchronization: Analog PLLs, Digital PLLs design and architectures, Delay locked loops design and architectures. Direct Digital Synthesis.

References:

1. CMOS mixed-signal circuit design by R. Jacob Baker Wiley India, IEEE press, reprint 2008
2. Switched-Current Signal Processing and A/D Conversion Circuits: Design and Implementation, R. Jacob Baker, Wiley India IEEE press 2008.
3. Mixed Signal Systems: a guide to CMOS circuit design, Andrzej Handkiewicz, IEEE computer Society Press.
4. Mixed Signal and DSP Design techniques, Engineering Analog Devices Inc, Engineering Analog Devices Inc, Walt Kester, Publisher Newnes.
5. Digital Frequency Synthesis Demystified, Bar-Giora Goldberg, Elsevier. Published by Newnes

Mixed Signal Processing Systems and Design

Laboratory Assignments/Experiments

1. Generate SPICE code for 8-bit ideal ADC and 8-bit ideal DAC. You may use WinSPICE or any other spice model compatible tools.

2. Find the SNR, SNDR, SFDR for some given reference voltages, sampling frequencies and input voltages. Comment on the performance enhancement of practical ADCs and DACs against clock jitter, noise etc.

Course Outcomes:

1. Would be able to understand the challenges in mixed signal design.
2. Would be able to analyze the requirements of mixed analog and digital designs.
3. Would be able to design basic building blocks of mixed signal applications
4. Would be able to identify the mixed signal building blocks for implementation of DSP algorithms

504104	Research Methodology	

Teaching Scheme: Lectures 4Hrs/ Week		Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4

Module I

Research Problem

Meaning of research problem, Sources of research problem, Criteria / Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem **Basic instrumentation-** Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP in collected data which contains noise.

Module II

Applied statistics

Regression analysis, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis

Module III

Modelling and prediction of performance. Setting up a computing model to predict performance of experimental system, Multiscale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity theory and applications.

Module IV

Developing a Research Proposal

Format of research proposal, Individual research proposal, Institutional proposal. Proposal of a student – a presentation and assessment by a review committee consisting of Guide and external expert only. Other faculty members may attend and give suggestions relevant to topic of research.

References

1. „Research methodology: an introduction for science & engineering students", by Stuart Melville and Wayne Goddard
2. „Research Methodology: An Introduction" by Wayne Goddard and Stuart Melville
3. „Research Methodology: A Step by Step Guide for Beginners", by Ranjit Kumar, 2nd Edition
4. „Research Methodology: Methods and Trends", by Dr. C. R. Kothari
5. „Operational Research" by Dr. S.D. Sharma, Kedar Nath Ram Nath & co.
6. Software Engineering by Pressman

Research Methodology

Laboratory Assignments/Experiments:

1. Design a typical research problem using scientific method
2. Design a data collection system using digital computer system.
3. Study the various analysis techniques.
4. Design and develop a computing model to predict the performance of experimental system.
5. Develop the following research proposal

A. Individual B. Institutional

Course Outcomes:

1. The student will learn research problem & its scope, objectives, and errors.
2. The student will learn the basic instrumentation schemes & data collection methods.
3. The student will study the various statistical techniques.
4. The students will study modeling and predict the performance of experimental system.
5. The student will learn to develop the research proposals.

504405	Mathematics for Signal Processing	
ELECTIVE-I		
Teaching Scheme: **Lectures 4Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Matrices - Inverse matrix to solve system of linear equations, Rank of a matrix, use of echelon form and canonical form of a matrix to find rank, Concept of Linear dependence / independence, classification of real and complex matrices, matrix inversion techniques, trace, Linear operators, Linear equations, singularity, characteristic vectors, Cayley-Hamilton theorem, quadratic form, matrix differnetiation and matrix integration, LDU decomposition

Module II

Some Important Classes of Linear Systems:-Shift Invariant Systems and Topelitz Matrices, Operators and Square Matrices, Self Adjoint Operators and Hermitian Matrices, idempotent matrices and unitary matrices, Gram-Schmidt Orthogonalization. **Vector Space** -Definition and properties of vector space; Definition and properties of vector sub-space; Algebra of subspaces; basis of a vector space; finite dimensional vector space; Linear independence of vectors.

Module III

Random variable- probability, relative frequency, Joint and conditional probability, Bayes‟ theorem, Independent events, permutations and combinations, Random variables, Probability density function, histogram, Cumulative distribution function, standard probability density functions, Gaussian variable, uniform exponential and Rayleigh distribution, Binomial and Poisson distribution, fitting a distribution function to a random variable, Chi square test, K_S test

Module IV

Random processes- random processes, stationary and independence, wide sense and strict sense stationary, time averages and ensemble averages, ergodicity, autocorrelation and cross correlation, measurement of correlation functions, spectral characteristics of random processes, Power density spectrum and its properties, relation between power density spectrum and autocorrelation, Power spectrums of discrete time processes.

References

1. K.Hoffman & R.Kunze, Linear Algebra- PHI, 1996
2. S.Andrilli & D.Hecker-Elementary linear Algebra-Else verinc 2003.
3. Advanced Digital Signal Processing" By "Dr. Shaila D. Apte" publication- Wiley India

4. Paul R. Halmos, Finite-Dimensional Vector Spaces, Springer
5. Matrix Analysis- . R. Horn and C. Johnson, Cambridge U.P
6. Monson Hayes "Stastical Signal Processing".
7. A. Popoulis, Pillai-Probability, Random Variables & stochastic processors-TMH, 2004.
8. H.Stark& J.W.Woods-Probability, Random variables & eitimation theory for Engineer PHI-1994.
9. Kishor S. Trivedi - Probability, Random Variables & Random processors- Prentice hall
10. Simon Haykins - Communication system.
11. Taub & Schilling "Taubs Principals of Communication Systems" TMH 3rd edition.

Laboratory Assignments/Experiments:

1. To solve simultaneous equations of 3 variables using matrices.
2. To find the Eigen values and Eigen vectors of a matrix.
3. To calculate and plot the CDF and PDF of a given problem.
4. To find the mean, variance, standard deviation, autocorrelation, covariance and covariance coefficient of a given problem

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Course Outcomes:

1. After studying this subject a student will we able to build a mathematical model for any signal processing application.
2. The students can analyze and model the given problem using the concepts of Probability theory and Random processes.
3. Using the concepts of Linear algebra, algorithm development involving arrays and matrix operations can be solved.
4. The student can analyze different signal processing algorithms.

504405	Soft Computing	
ELECTIVE-I		
Teaching Scheme: **Lectures 4Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Introduction to soft computing: Hard Computing versus soft computing.
Soft computing techniques: artificial neural networks, fuzzy logic and fuzzy control, genetic algorithms, hybrid systems (ANFIS, CANFIS) (history and general applications areas).

Module II

Artificial neural networks-I: Biological neuron, Artificial neuron model, concept of bias and threshold, McCulloch-Pits Neuron Model , implementation of logical AND, OR, XOR functions, Topologies of neural networks, learning paradigms: supervised, unsupervised, reinforcement, Linear neuron model : concept of error energy , gradient descent algorithm and application of linear neuron for linear regression, Activation functions : binary , bipolar (linear, signum, log sigmoid, tan-sigmoid),Learning mechanisms: Hebbian, Delta Rule, Perceptron and its limitations**,** Multilayer perceptron (MLP) and backpropagation algorithm**,** Application of MLP for classification and regression.

Module III

Artificial neural networks-II: Self-organizing Feature Maps, k-means clustering**,** Learning vector quantization**,** Radial Basis Function networks: Cover‟s theorem, mapping functions(Gaussian, Multi-quadrics, Inverse multi-quadrics**,** Application of RBFN for classification and regression**,** Hopfield network, associative memories**,** Boltzmann machine.

Module IV

Fuzzy logic: Concept of Fuzzy number, fuzzy set theory(continuous, discrete)**,** Operations on fuzzy sets**,** Fuzzy member-ship functions , primary and composite linguistic terms**,** Concept of fuzzy relation, composition operation**,** Concept of fuzzy inference**,** Fuzzification and de-fuzzification**,** Mamdani inference rule, Sugeno inference rule**,** Simple example of fuzzy control in contrast with traditional PID control.
Adaptive Neuro-fuzzy inference systems: ANFIS architecture**,** Hybrid Learning Algorithm**,** Co-active neuro-fuzzy inference systems**,** Application of ANFIS/CANFIS for regression
Genetic algotithms: Concept of genetic evolution, parent, child, chromosome, mutation from biological perspective**,** Comparison of Biological and GA Terminology

References

1. Introduction to the theory of neural computation, John Hertz, Anders Krogh, Richard Palmer, Addison –Wesley Publishing Company, 1991
2. Neural Networks-A comprehensive foundation, Simon Haykin,Prentice Hall International Inc.,1999
3. Neural and Adaptive Systems: Fundamentals through Simulations, José C. Principe , Neil R. Euliano , W. Curt Lefebvre ,John-Wiley & Sons, 2000
4. Learning and Soft Computing-Support Vector Machines, Neural Networks, and Fuzzy Logic Models,Vojislav Kecman, The MIT Press,2001
5. Pattern Classification, Peter E. Hart, David G. Stork Richard O. Duda,Second Edition , 2000
6. Pattern Recognition, SergiosTheodoridis , KonstantinosKoutroumbas,Fourth Edition, Academic Press, 2008
7. Neuro-Fuzzy and Soft Computing ,J.S. Jang, C.T. Sun, E. Mizutani, PHI Learning Private Limited
8. Introduction to Genetic Algorithms,S. N. Sivanandam, S. N. Deepa, Springer-Verlag Berlin Heidelberg,2008

Laboratory Assignments/Experiments: (Use MATLAB base code only)

1. Implement simple artificial neural network models
2. Implement a simple linear regressor with a single neuron model
3. Implement and test MLP trained with back propagation algorithm
4. Implement and test RBF network
5. Implement SOFM for character recognition
6. Implement FIS with Mamdani inferencing mechanism
7. Solve simple optimization (maximization) problem with genetic algorithms
8. A small project: may include classification or regression problem , using any soft computing technique studied earlier.

Course Outcomes:

1. The student will be able to solve complex real world problems.
2. The student will be able to solve conventional problems regarding image/ signal processing, pattern recognition/classification, control systems using soft computing techniques

504405	Artificial Intelligence	
ELECTIVE-I		
Teaching Scheme: **Lectures 4Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Introduction- Intelligent Agents – Agents and environments - Good behavior – The nature of environments – structure of agents - Problem Solving - problem solving agents – example problems – searching for solutions – uniformed search strategies - avoiding repeated states – searching with partial information.

Module II

Searching techniques - Informed search and exploration – Informed search strategies – heuristic function – local search algorithms and optimistic problems – local search in continuous spaces – online search agents and unknown environments - Constraint satisfaction problems (CSP) – Backtracking search and Local search for CSP – Structure of problems - Adversarial Search – Games – Optimal decisions in games – Alpha – Beta Pruning – imperfect real-time decision – games that include an element of chance.

Module III

Knowledge representation -First order logic – representation revisited – Syntax and semantics for first order logic – Using first order logic – Knowledge engineering in first order logic - Inference in First order logic – prepositional versus first order logic – unification and lifting – forward chaining – backward chaining - Resolution - Knowledge representation - Ontological Engineering - Categories and objects – Actions - Simulation and events - Mental events and mental objects.

Module IV

Learning - Learning from observations - forms of learning - Inductive learning - Learning decision trees - Ensemble learning - Knowledge in learning – Logical formulation of learning – Explanation based learning – Learning using relevant information – Inductive logic programming - Statistical learning methods - Learning with complete data - Learning with hidden variable - EM algorithm - Instance based learning - Neural networks - Reinforcement learning – Passive reinforcement learning - Active reinforcement learning - Generalization in reinforcement learning. and applications.

References

Texts:

1. Stuart Russell, Peter Norvig, "Artificial Intelligence – A Modern Approach", 2nd Edition, Pearson Education / Prentice Hall of India, 2004.

References:

1. Nils J. Nilsson, "Artificial Intelligence: A new Synthesis", Harcourt Asia Pvt. Ltd., 2000.
2. Elaine Rich and Kevin Knight, "Artificial Intelligence", 2nd Edition, Tata McGraw-Hill, 2003.
3. George F. Luger, "Artificial Intelligence-Structures and Strategies For Complex Problem Solving", Pearson Education / PHI, 2002

Artificial Intelligence

Laboratory Assignments/Experiments:

1. Implementation of A* algorithm for puzzle solving.
2. Implementation of Unification algorithm by considering Resolution concept.
3. Implementation of Mini expert systems..

Course Outcomes:

1. Would be able to understand application of artificial intelligence.
2. Would be able to understand representation of knowledge and computational methods for reasoning.
3. Would be able to understand different learning techniques

504405	Estimation & Detection Theory	
ELECTIVE-I		
Teaching Scheme: **Lectures 4Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Fundamentals of Estimation Theory

Role of Estimation in Signal Processing, Unbiased Estimation, Minimum variance unbiased(MVU) estimators, Finding MVU Estimators, Maximum likelihood estimation, Cramer - Rao Lower Bound, Bayes estimator (MMSE), Linear Modeling - Examples, Sufficient Statistics, Use of Sufficient Statistics to find the MVU Estimator.

Module II

Estimation Techniques

Deterministic Parameter Estimation: Least Squares Estimation-Batch Processing, Recursive Least Squares Estimation, Best Linear Unbiased Estimation, Likelihood and Maximum Likelihood Estimation, estimation efficiency, weighted least squares, best linear unbiased estimation. Random Parameter Estimation: Bayesian Philosophy, Selection of a Prior PDF, Bayesian linear model, Minimum Mean Square Error Estimator, Maximum a Posteriori Estimation

Module III

State Estimation

Prediction, Single and Multistage Predictors

Module IV

Fundamentals of Detection Theory

Bayes‟ Detection, MAP Detection, ML Detection, Minimum Probability of Error Criterion, Min-Max Criterion, Neyman-Pearson Criterion, Multiple Hypothesis, Composite Hypothesis Testing: Generalized likelihood ratio test (GLRT), Receiver Operating Characteristic Curves.

Detection of Signals in White Gaussian Noise (WGN), Binary Detection of Known Signals in WGN, M-ary Detection of Known Signals in WGN, Matched Filter Approach, Detection of signals with Random Parameters

Applications of detection and estimation

Applications in communications, system identification, pattern recognition, speech processing, and image processing.

References

1. S.M. Kay, Fundamentals of Statistical Signal Processing: Detection Theory, Prentice Hall, 1998
2. Dr. Shaila Apte, "Advanced Digital Sgnal processing" Wiley India 2013.
3. S.M. Kay, Fundamentals of Statistical Signal Processing: Estimation Theory, Prentice Hall, 1993
4. H.V. Poor, An Introduction to Signal Detection and Estimation, 2nd edition, Springer, 1994.
5. Jerry M. Mendel, "Lessons in Estimation Theory for Signal Processing, Communication and Control," Prentice Hall Inc., 1995
6. Ralph D. Hippenstiel, "Detection Theory- Applications and Digital Signal Processing", CRC Press, 2002.
7. Bernard C. Levy, "Principles of Signal Detection and Parameter Estimation", Springer, New York, 2008.
8. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling," John Wiley & Sons Inc., 1996.

Estimation & Detection Theory

Laboratory Assignments/Experiments:

1. Implementation of Likelihood and Maximum likelihood estimator.
2. Detection of Known signals in White Gaussian Noise.
3. Implementation of Minimum mean Square estimator.
4. Verification of the probability of false alarm empirically for a real-valued signal in white Gaussian noise.
5. Implementation of least Square technique for the given data points.
6. To make Bayesian inferences for a logistic regression model.

Course Outcomes:

1. To be able to apply detection techniques in given problem
2. To be able to estimate parameters for given application
3. To be able to design optimum filters for the given application

504405	*LATEX	
ELECTIVE-I		
Teaching Scheme: **Theory 1 Hrs/ Week**		**Examination Scheme:** **Credits :1**
LaTeX /Document Structure, Document classes, Packages, The document environment, Book structure.		
References:		
http://miktex.org/ http://www.winedt.com/		
*For each Subject under Elective I the student Shall study LATEX for 1 credit.		

504106	Lab Practice I	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Lab Practice I: The laboratory work will be based on completion of minimum two assignments/experiments confined to the courses of that semester.		

SEMESTER-II

504407	Speech Signal Processing	
Teaching Scheme: Lectures 4 Hrs/ Week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

Basics of speech production, LTI model, LTV model, voiced and unvoiced decision making, speech parameters, pitch and formants, pitch frequency measurement using AMDF and autocorrelation, Parallel processing approach, pitch period measurement using spectral domain, cepstral domain, relation between formants and LPC, evaluation of formants using cepstrum, log spectrum and Power spectral density estimate,

Module II

Features of speech, Homomorphic processing, Cepstral analysis, mel scale, MFCC block schematic and function of each block, Perceptual linear prediction, STFT and wavelet analysis of speech, Linear prediction of speech, Forward linear prediction, autocorrelation method, Levinson Durbin algorithm, Burg algorithm Line spectral pair frequencies, transformation from LPC to LSP and LSP to LPC.

Module III

Speech quantization and coding, Uniform and non uniform quantizers, companded quantizer, forward and backward adaptive quantizers, waveform coding of speech, PCM, companded PCM, ADPCM, DM etc. Speech & audio coding standards.- G.726, LPC-10, DTW, HMM, speech enhancement techniques for periodic, wide band and interfering speech.

Module IV

Speech processing applications - speech recognition, speaker recognition and speaker verification, Introduction to text –to- speech conversion system, speech morphing and transformation, speech enhancement, echo cancellation, speech evaluation standards – subjective (PESQ) and objective, ITU standards.

References

1. R Rabiner and S.W. Schafer, “Digital processing of speech signals”; Pearson Education.
2. Dr. Shaila Apte- “Speech and audio processing”, Wiley India Publication, 2013
3. Thomas F. Quateri 1ed, “Discrete Time Speech Signal Processing: Principles and Practice”
4. Deller J. R. Proakis J. G. and Hanson J.H., “Discrete Time Processing of Speech Signal”, Macmillian.
5. L.R Rabinar and B.H. Juang and Yegnanarayana, “Fundamentals of Speech

Recognition", Pearson Publishers
6. Saeed V. Vaseghi " Advanced digital signal processing and noise reduction" Willey, 4th edition

Speech Signal Processing

Laboratory Assignments/Experiments:

1. Record a speech file in your own voice. Use AMDF to find pitch period for a voiced part of the segment. Write a MATLAB program for tracking pitch contour using AMDF method.
2. Write a program to find the impulse response coefficients for a vocal tract. Execute it and interpret your results. Use cepstral domain processing.
3. Write a program to track unvoiced part of utterance and use the program for Levinson Durbin recursion to find LPC for unvoiced signal.
4. Record 5 different words in your voice by uttering each word 10 times. Find LPC for each pitch synchronous segment and track 2nd LPC contour for all utterances. Use dynamic time warping for template matching. Find recognition rate.
5. Use NOIZEUS speech database. Use babble noise and try to eliminate it using modification of real part of DFT of each segment. Draw spectrogram to check if the noise is removed.

Course Outcomes:

1. After studying this subject the student will be able to analyze a speech signal.
2. The student will be able to implement speech coding and speech classification techniques.
3. Implementation of algorithms on speech modeling, noise reduction, speech enhancement, speech transformation is possible.

504408	Architecture for Signal Processing Algorithms	

Teaching Scheme: Lectures 4 Hrs/ Week		Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4

Module I

Review of DSP algorithms: Discrete Fourier Transform, properties of DFT, Decimation in time and decimation in frequency FFT, 2-D DFT and its applications, Linear filtering using DFT- overlap and save & overlap and add algorithms, Goertzel algorithm,

Module II

Typical DSP algorithms and representation : Challenges in designing architectures for DSP algorithms, DCT, DWT and filter banks, Vector Quantization, Block diagram, signal flow graph, data flow graph and dependence graph. DSP application demands and CMOS technologies, Loop bound and iteration bound and their computation. Fast Convolution and Iterated convolution.

Module III

Architecture Design: Pipelining of FIR Digital filters, parallel FIR digital filters, combined pipelining and parallel processing. Retiming, Properties of retiming, Retiming techniques for clock minimization and register minimization. Folding and Unfolding, properties and applications of folding and unfolding. 2D Systolic arrays, matrix multiplication, array processor architectures for FIR filters. Algorithm-Architecture transformation.

Module IV

Bit level and byte level arithmetic architectures: Parallel multipliers, Baugh Wooley carry save multiplier, Booth Wallace Tree multipliers, Bit serial multipliers, Bit serial FIR filter. Carry free radix-2 addition and subtraction, Floating point arithmetic. Galois Field arithmetic and composite field arithmetic for multiplication and their architectures. Canonic Signed Digit arithmetic.

References

1. "VLSI Digital Signal Processing Systems, Design and Implementation" by Keshab Parhi, John-Wiley & sons.
2. "Digital Signal Processing with Field Programmable Gate Arrays", U. Meyer-Baese, second edition Springer.
3. "Algorithms and Parallel VLSI architectures", M. Moonen, Marc S. Moonen, Francky Catthoo, Elsevier.
4. "High Performance VLSI-signal Processing: Algorithms and architectures", K.J. Ray Liu, IEEE Press

5. “Advanced Digital Signal Processing” Dr. Shaila Apte, Wiley India 2013.

Architecture for Signal Processing Algorithms

Laboratory Assignments/Experiments:

1. Write a Matlab program to compute the iteration bound using Longest Path Matrix (LPM) algorithm.
2. Write a Matlab program to compute the iteration bound using Minimum Cycle Mean (MCM) algorithm.
3. Write a Matlab program to determine if the system of inequalities has a solution, and find a solution if one exists using
    a. the Bellman-Ford algorithm and
    b. the Floyd-Warshall algorithm
4. Write a Matlab program to retime a DFG for clock period minimization. Use program written in assignment no. 3 as a function in this program to find out shortest path matrix and to solve system of inequalities.

Course Outcomes:

1. Would be able to represent DSP algorithms in graphical forms.
2. Would be able to design the architecture for DSP algorithms.
3. Would be able to identify the techniques, to be applied to optimize the implementations for speed, power and area.

504409	Biomedical Signal Processing	

Teaching Scheme: Lectures 4 Hrs/ Week		Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4

Module I

Introduction to bio-medical signals and their acquisition: Origin of bio-signal, action potential, nerve and muscle cells and their electrical activity, electrical activity of the heart, genesis of ECG, ECG lead systems, electrical activity of the brain, EEG signal and its acquisition, EMG signals and its acquisition. Sources of contamination and variation of bio-signals.

Module II

Analog signal processing of bio-signals: Biomedical instrumentation systems, biomedical transducers, electrodes and their characteristics, instrumentation amplifier, isolation amplifier, active filters(commonly used topologies), ADC, aliasing effect, anti-aliasing filters, grounding, shielding, bonding and EMI filters: Principles and types of grounding, shielding and bonding with reference to Biomedical equipment.

Module III

Digital Signal processing of bio-signals: Review of FIR, IIR Filters, Weiner filters, adaptive filters.
Model-based spectral analysis, AR, Eigen analysis spectral analysis, Time-frequency methods: Spectrogram, Wigner-Ville and other methods, Principal Component Analysis, Independent Component Analysis, Continuous Wavelet Transform, and Discrete Wavelet transform, Electrocardiogram: Signal analysis of event related potentials, morphological analysis of ECG waves, Envelope extraction and analysis of activity, application- Normal and Ectopic ECG beats, Phonocardiography

Module IV

Diagnostic Biomedical Imaging: Types of Medical Images, CT, PET, and SPECT, MRI, Functional MRI, ultrasonic diagnostic imaging. Fan Beam Geometry, Radon Transform, Inverse Radon Transform: Parallel Beam Geometry
Soft computing approaches for biomedical signal and image diagnostics: Artificial Neural networks, (Multilayer perceptron, Radial basis function networks) as classifiers.

References

1. Jaakko Malmivuo & Robert Plonsey, Bioelectromagnetism - Principles and Applications of Bioelectric and Biomagnetic Fields, Oxford University Press, New York, 1995.
2. John L Semmlow ,Signals and Systems for Bioengineers, Second Edition: A MATLAB-Based Introduction, Academic Press, 2011
3. John L Semmlow, Biosignal and Biomedical Image Processing MATLAB-Based Applications-Second Edition, Marcel Dekker, Inc, 2008
4. Eugene N. Bruce, Biomedical Signal Processing and Signal Modelling, John Wiley & Sons,2000
5. Rangaraj M. Rangayyan, Biomedical Signal Analysis A case study approach, John Wiley & Sons, 2002
6. Rangaraj M. Rangayyan, Biomedical Image Analysis, , CRC Press, 2005

Biomedical Signal Processing

Laboratory Assignments/Experiments:

1. A brief survey of biomedical transducers available commercially, exploring the detailed characteristics (can use internet search engines for acquiring literature)
2. Design and simulation of instrumentation amplifier, analog filter (LPF,HPF,BPF and notch topologies) (use of Multisim/ ORCAD PSpice/ Proteus or any SPICE based simulation program)
3. Study of digitized ECG signal (readily available at http://physionet.org), expected to observe spectrum, and time domain characteristics like peak amplitudes, identify fiducial points (P,Q,R,S,T,U) (usage of MATLAB expected)
4. Implement digital filter for ECG signal contaminated with some additive noise.
5. Basic image processing of biomedical images (usage of MATLAB expected)

Course Outcomes:

1. The students will be acquainted to various bio signals and methods of capturing them.
2. They will be able to model the biomedical systems and will be able to analyze ECG signals captured under different conditions.
3. The student will be able to implement the compression techniques of bio medical signals for storage and data transfer purpose and different classification techniques.
4. The student will be able to implement various image processing algorithms and techniques for MRI and FMRI images.
5. The student will be able to understand various sources of distortions in biomedical signals and its remedial techniques.

504410	Computer Vision	
ELECTIVE-II		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Introduction- Purpose, state of the art
Image Formation –CMOS CCD image sensors, projection, color image camera

Module II

Camera calibration- camera parameters, camera calibration.
Stereo imaging- Epipolar geometry, rectification, correspondence, triangulation, RANSAC algorithm, dynamic programming .

Module III

Feature detection and tracking- corner detector, , Scale Invariant Feature Transform , optical flow, mean shift tracking, Kalman filter, condensation, Object Tracking , condensation.

Module IV

Non-visible-light Imagery- infrared and thermal imaging, applications, **Applications of computer vision** - Tomography, Surveillance, Industrial robot vision, 3D reconstruction.

References

1. Forsyth and Ponce, Computer Vision: A Modern Approach, Prentice Hall
2. Richard Szeliski, Computer vision algorithms and applications, springer
3. Mubarak Shah, Fundamentals of Computer Vision, Online book
4. Linda Shapiro and George Stockman: Computer Vision, Prentice Hall
5. Emanuele Trucco, Alessandro Verri, "Introductory Techniques for 3-D Computer Vision", Prentice Hall, 1998
6. Ballard and Brown. "Computer Vision." Prentice Hall.

Computer Vision

Laboratory Assignments/Experiments:

(MATLAB/ JAVA platform)

1. Implementation of basic transformations like translation, rotation and scaling in 2-D. This should be implemented using matrix transformation in MATLAB and not with direct functions. Optional: Other affine transformation like shearing etc
2. Study of the camera calibration toolbox and calibration of your own camera from the toolbox

3. Depth map estimation in stereo vision using block matching/ sub pixel estimation and dynamic programming
4. Face recognition using Eigen faces. A case study

Course Outcomes:

1. Graduates will have understanding of image formation and working of camera as image sensor
2. Graduates will have knowledge of need and procedure of camera calibration
3. Graduates will have knowledge of stereo imaging, its applications and challenges
4. Graduates will have conceptual understanding of computer vision algorithms for motion tracking
5. Graduates will have conceptual understanding of infrared imaging

504410	RF and high speed circuits	
ELECTIVE-II		
Teaching Scheme: **Lectures 4Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Fundamentals of RF circuits: Importance of RF design, RF behavior of resistors, capacitors and inductors. Equivalent circuit representation of transmission line, Two wire lines, Coaxial line, Micro-strip Line. Parameters for terminated lossless transmission line, short circuit, open circuit and quarter wave transmission line. Input impedance matching, return and insertion loss calculations.

Module II

RF Design concepts: Single and multiport networks and parameters, Signal flow chart modeling, S, Z and T parameters and conversions. Low pass, high pass, band pass and band stop filters, calculations of Quality factors of filters. Butterworth and Chebyshev filters. Micro-strip filter design.

Module III

RF circuits and networks: Impedance matching using discrete components, design of micro-strip line matching networks, Broadband, high power and multistage amplifier designs. Basic oscillator models, High frequency Oscillator configuration, Basic characteristics of Mixers, single ended and single balanced mixer design.

Module IV

High Speed circuit design: High speed properties of logic gates- power, speed and packaging. Cross talk in solid ground and slotted ground planes, Near end and Far end cross talk. End terminators and cross talk in terminators, Vias and its characteristics. Stable voltage references, Connectors and crosstalk due to connectors. Clock Jitter and signal integrity mechanisms for high speed link. Clock and power distribution related problems.

References

1. "RF Circuit Design Theory and Applications" – by Reinhold Ludwig and Pavel Bretchko, Pearson education.
2. "High Speed digital Design, A Handbook of Black Magic" – by Howard Johnson and Martin Graham, Pearson Education.

3. "Jitter, Noise and Signal Integrity at High Speed" – by Mike Peng Li, Prentice Hall.
4. "Microwave Filters, Impedance Matching Networks and Coupling Structures" – by G. L. Matthaei, E. M. T Jones, L. Young, McGraw-Hill New York.

RF and high speed circuits

Laboratory Assignments/Experiments:

1. Write Matlab code for designing an impedance matching network using Pi-type.
2. Write Matlab code for designing an impedance matching network using T- type matching sections.
3. Append a code to find the S-parameters of Pi-type and T-type matching sections

Course Outcomes:

1. Would be able to identify challenges in RF circuit designs.
2. Would be able to parameterize the Quality factors in RF circuits.
3. Would be able to identify the challenges in board level designs for High Frequency applications.
4. Would be able to apply techniques to reduce the crosstalk, current loops etc on board level designs and connectors.

504410	Acoustic Signal Processing	
ELECTIVE-II		
Teaching Scheme: Lectures 4Hrs/ Week		**Examination Scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

Basic of Acoustic Engineering: - Echo and Reverberation, Acoustic wave, Transmission radiation and reflection, Room Acoustics, Room Transfer Function, Environmental Acoustics, Architectural acoustics, Transduction. Transfer function of acoustic pipe.

Module II

Auditory System and Hearing: - Anatomy, Physiology and Function of the Auditory System, Physiological Measures of Auditory Function, Auditory Processing Models, Speech Intelligibility and Signal Processing in Hearing Aids.

Module III

Acoustic Echo and Noise Control.:- Human Perception of Echoes, The Network Echo Problem, The Acoustic Echo Problem, Adaptive Filters for Echo Cancellation, The LMS and NLMS Algorithms, Least Squares and Recursive Least Squares Algorithms, Noise Reduction. Affine Projection algorithm, Fast Affine Projection Algorithm (FAP). Sub band Acoustic Echo Cancellation using FAP. Single Channel and Multichannel.

Module IV

Applications: Acoustics Echo Noise Cancellation, Adaptive Beam Forming for acoustic noise cancellation, Materials and Architectures of acoustics Underwater and Oceanographic Acoustics: - Propagation and Signal Modeling, inverse Problems in Underwater Acoustics, Active and passive sonar.

References

1. Fundamental of Acoustic, Lawrance E Kinseler, Wiley 4th Edition.
2. Topics in Acoustic Echo and Noise Control, E Hansler and G Schmidt, Springer
3. Acoustic Signal Processing for Telecommunication, Steven L. Gay, Jacob Benesty. Springer; 2000 edition.
4. Handbook of Signal Processing in Acoustics**,** Havelock, David; Kuwano, Sonoko; Vorländer, Michael (Eds.) Springer 2008.

Acoustic Signal Processing

Laboratory Assignments/Experiments:

1. Using Matlab S/W Generate echoes and reverberations of speech signals for various environments, examples room, auditorium, bathroom, mountain etc
2. Modeling of room impulse response.
3. Acoustic echo cancellation using LMS, NLMS or RLS algorithms.
4. Acoustic echo cancellation using Adaptive Beam forming.

Course Outcomes:

1. The student will be able to understand the challenges in Acoustic Echo Cancellations.
2. The student can analyze Psychology of Hearing, Acoustic Engineering and Room Transfer function.
   The student can analyze and develop Acoustic echo cancellation algorithms

504410	Satellite Communication and Signal Processing	
ELECTIVE-II		
Teaching Scheme: **Lectures 4Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Introduction to Satellite Communication: Satellite Communication concepts, Frequency Allocations for Satellite Services, Intelsat, Look angle calculation for geostationary satellites.
Polarization: Antenna polarization, polarization of satellite signals, crosspolar discrimination and its prediction, ionospheric depolarization, rain depolarization, Faraday Rotation, fading due to Multipath.

Module II

Propagation considerations in satellite communications: Free space loss, Atmospheric losses, ionospheric effects, ionospheric scintillation, rain attenuation, **Signals related to Satellite communications**: Digital baseband signals, PCM, TDM, Bandwidth requirements, Digital carrier systems : BPSK, QPSK, transmission rate and bandwidth for PSK modulation, BER for PSK modulation.

Module III

Satellite Multiple Access: Single access, Preassigned FDMA, Demand Assigned FDMA, Spade System, FDMA downlink analysis, SCPC, TDMA, reference burst, frame efficiency and channel capacity, preassigned TDMA, Demand Assigned TDMA, Downlink analysis for digital transmission, comparison of uplink power requirements for FDMA and TDMA, on board signal processing for FDMA/TDM operation, CDMA, Direct sequence spread spectrum, the code signal c(t), autocorrelation function for c(t), acquisition and tracking, spread spectrum and dispreading, CDMA throughput, SDMA.

Module IV

Satellite Link Design for Geostationary Satellites: Satellite transmission theory, system noise temperature and G/T ratio, design of downlink and uplink for C-band and ku band, Design for specified C/N ratio, combining C/N and C/I values in satellite links, S**atellite Interference**: Introduction, interference between satellite circuits.

References

Text Books:-

1. Timothy Pratt & Charles Bostian: Satellite Communications – John Wiley and Sons, 2003 Edition.
2. Dennis Roddy : Satellite Communications – McGraw Hill, 3rd Edition.

***Reference*:-**

1. Donald M. Jansky & M.C.Jeruchim: Communication Satellites in the Geostationary Orbit – Artech House Inc., 1987.
2. Walter L. Morgan, Gary D. Gordan: Communications Satellite Handbook – Wiley India Pvt. Ltd.
3. Anil K. Maini & Varsha Agrawal: Satellite Technology – Principles and Applications, John Wiley and Sons Ltd., 2007 edition.

Satellite Communication and Signal Processing

Laboratory Assignments/Experiments:

1. To set up an active satellite link and demonstrate link fail operation.
2. To communicate voice signal through satellite link.
3. To transmit and receive three separate signals (audio,video, tone) simultaneously through satellite link
4. To transmit and receive pc data through satellite link.
5. Analysis of Modulation Techniques for LEO Satellite Downlink Communications.
6. Analysis of a Direct Sequence Spread Spectrum (DSSS) and Frequency Hopping Spread Spectrum (FHSS) Technique.
7. Evaluation of SNR in Satellite Links
8. Analysis of Link Budget Equation.

Course Outcomes:

1. The student would be able to analyze the various aspects of establishing a geo-stationary satellite communication link.
2. The student would be able to design & engineer a geo-stationary satellite communication link taking into account the inter satellite interference aspects, frequency, Bandwidth, power & polarization considerations.

504410	***Software Tools**	
ELECTIVE-II		
Teaching Scheme: **Theory 1 Hrs/ Week**		**Examination Scheme:** **Credits :1**
Introduction to software tools such as Octave, MATLAB, LAB VIEW, RTLinux, VxWorks, µCOS-II, Tiny OS, ANDROID, Xilinx, Microwind, Tanner, TCAD Tools, NS-II, NS-III, OMNET++, OPNET, AWR Microwave office, CAD Feko, IE-3D.		
*For each Subject under Elective II the student Shall study open source/evaluation versions of at least two software tools mentioned above and should present term paper.		

504111	Lab Practice II	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Lab Practice II: The laboratory work will be based on completion of minimum two assignments/experiments confined to the courses of that semester.		

504112	Seminar I	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Seminar I : Shall be on state of the art topic of student‟s own choice approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.		

SEMESTER-III

604401	Statistical Signal Processing	
Teaching Scheme: **Lectures :04 Hrs/week**		**Examination scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Signal Modeling using Least Squares Methods: Introduction, Least Square methods for signal modeling and its disadvantages. AR(p),MA(q) and ARMA(p,q) . Pade‟, Prony‟s and Shank‟s Methods for signal Modeling.

Module II

Linear Prediction, Forward and Backward Predictions, Yule-walker and Wiener Hoff Equation Linear Prediction of Signals, Normal Equations. autocorrelation method, Levinson Durbin Algorithm, Lattice filter realization, lattice methods- Burg metod, selection of order of the predictor, Line spectral pair frequencies.

Module III

Parameter Estimation Theories: Introduction to Estimation theory, Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Maximum likelihood estimation. Spectral estimation, method of periodogram, Bartlett method, Welch method, Blckman-Tukey method, Power spectrum estimation using AR model, bi-spectrum estimation.

Module IV

LMS algorithm, convergence, application using LMS algorithms, Normalize LMS.

RLS algorithm, tracking performance of LMS and RLS Algorithms in non- stationary environment.

References

1. Statistical Digital Signal Processing and Modeling by Monson H. Hayes, Wiley, 1996.
2. “Advanced Digital Signal Processing” Dr. Shaila Apte, Wiley India 2013.
3. Statistical and Adaptive Signal Processing, by Dimitris G. Manolakis, Vinay K. Ingle, Stephen M. Kogon, McGraw-Hill.
4. Advance Digital Signal Processing by Proakis, Rader, Ling, and Nikias.
5. *Fundamentals of Statistical Signal Processing: Estimation Theory*, by S. M. Kay, Prentice Hall, 1993.
6. *Modern Spectral Estimation: Theory and Application*, by S. M. Kay, Prentice Hall, 1988.

Statistical Signal Processing

Laboratory Assignments/Experiments:

1. Modelling of low pass filter, high pass and band pass filter using pade‟, pronys and shank‟s method and compare the errors performance for above methods.
2. Develop FIR or IIR wiener filter for noise cancellation. Compare results for different filter orders.
3. Power spectral estimation of speech signal using non parametric method Peridogram, Bartlett and Welch method compare the estimated PSD using above method with reference to figure of merit, frequency resolution, etc
4. Power spectral estimation of speech signal using parametric i.e. Yule-walker and Burg Methods.

Course Outcomes:

1. The student will be able to understand various Statistical base algorithms .
2. The student can analyze and develop algorithms / Methods which are extensively used in speech and image processing.
3. The student can implement suitable algorithms for specific applications and will be equipped to pursue research work.

604402	Still image and Moving picture	

	Compression Standards	
Teaching Scheme: **Lectures :04 Hrs/week**		**Examination scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**
Module I		
Still Picture Compression standard, JPEG 2000- Preprocessor, Core encoder, Post processing, ROI encoding, scalability .		
Module II		
Video compression basics- Analog and digital video, Temporal Redundancy, Motion estimation.		
Module III		
Video and audio compression standards MPEG1-Video structure, Group of Pictures, Picture slice, Macro- block and block, Motion estimation, Coding of I, P, B and D type pictures, Video Buffer, MPEG2- Difference between MPEG1 and MPEG2, scalability feature, applications.		
Module IV		
Advanced compression techniques- MPEG4- Video object plane, shape coding H.263- Video coding for low bit rates, motion vector coding, coefficient coding, protection against error.		
References 1. Mohammed Ghanbari , Standard Codecs**:** Image Compression to Advanced Video Coding", IEE publication. 2. V. Bhaskaran and K. Konstantinides, "Image video compression standards: algorithms and architecture," Kluwer Academic Publishers 3. Joan Mitchell "MPEG and Video compression standard" Springer 4. **Iain E. G. Richardson** "H.264 and MPEG-4 Video Compression" Wiley publication		

Still image and Moving picture Compression Standards

Laboratory Assignments/Experiments:(MATLAB/ JAVA platform)

1. Implementation of encoding and decoding scheme of JPEG 2000. This consists of pre-processing, DWT and quantization. The coding of embedded block coding is optional
2. Implementation of block based motion compensation and estimation for video coding. This should include plotting of motion vectors
3. Implementation of the spatial scalability with layered approach mode supported by MPEG.

Course Outcomes:

1. Graduates will have overview compression standards JPEG 2000, MPEG1, MPEG2
2. Graduates will have knowledge of features of various compression standards
3. Graduates will have ability to choose compression standard for the given application
4. Graduates will have knowledge of compressed file formats
5. Graduates will have knowledge of techniques used in data compression.

ELECTIVE-III

Select one subjects from Group-I, and one subject from Group-II from the following list as Elective-III.

Group		Subject	Credit
I	1	Value Education, Human Rights and Legislative Procedures	3
	2	Environmental Studies	3
	3	Energy Studies	3
	4	Disaster Management	3
	5	Knowledge Management	3
	6	Foreign Language	3
	7	Economics for Engineers	3
	8	Engineering Risk – Benefit Analysis	3
II	1	Technology Play	2
	2	Optimization Techniques	2
	3	Fuzzy Mathematics	2
	4	Design and Analysis of Algorithms	2
	5	CUDA	2

604103	Value Education, Human Rights and Legislative Procedures	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory :** **50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 3**

Module I

Values and Self Development-Social values and individual attitudes, Work ethics, Indian vision of humanism, Moral and non moral valuation, Standards and principles, Value judgments. Importance of cultivation of values, Sense of duty, Devotion, Self reliance, Confidence, Concentration, Truthfulness, Cleanliness, Honesty, Humanity, Power of faith, National unity, Patriotism, Love for nature, Discipline.

Module II

Personality and Behavior Development- Soul and scientific attitude, God and scientific attitude, Positive thinking, Integrity and discipline, Punctuality, Love and kindness, Avoiding fault finding, Free from anger, Dignity of labor, Universal brotherhood and religious tolerance, True friendship, Happiness vs. suffering love for truth, Aware of self destructive habits, Association and cooperation, Doing best, Saving nature.

Module III

Human Rights- Jurisprudence of human rights nature and definition, Universal protection of human rights, Regional protection of human rights, National level protection of human rights, Human rights and vulnerable groups.

Legislative Procedures- Indian constitution, Philosophy, fundamental rights and duties, Legislature, Executive and Judiciary, Constitution and function of parliament, Composition of council of states and house of people, Speaker, Passing of bills, Vigilance, Lokpal and functionaries

References:

1. Chakraborty, S.K., Values and Ethics for Organizations Theory and Practice, Oxford University Press, New Delhi, 2001.
2. Kapoor, S.K., Human rights under International Law and Indian Law, Prentice Hall of India, New Delhi, 2002.
3. Basu, D.D., Indian Constitution, Oxford University Press, New Delhi, 2002.
4. Frankena, W.K., Ethics, Prentice Hall of India, New Delhi, 1990.
5. Meron Theodor, Human Rights and International Law Legal Policy Issues, Vol. 1 and 2, Ox ford University Press, New Delhi, 2000.

604103	Environmental Studies	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory:50 Marks (In Semester)** **50 Marks (End Semester)** **Credits 3**

Module I:

Introduction and Natural Resources: Multidisciplinary nature and public awareness, Renewable and nonrenewal resources and associated problems, Forest resources, Water resources, Mineral resources, Food resources, Energy resources, Land resources, Conservation of natural resources and human role.
Ecosystems: Concept, Structure and function, Producers composers and decomposers, Energy flow, Ecological succession, Food chains webs and ecological pyramids, Characteristics structures and functions of ecosystems such as Forest, Grassland, Desert, Aquatic ecosystems.

Module II

Environmental Pollution- Definition, Causes, effects and control of air pollution, water pollution, soil pollution, marine pollution, noise pollution, thermal pollution, nuclear hazards, human role in prevention of pollution, Solid waste management, Disaster management, floods, earthquake, cyclone and landslides.

Module III:

Social issues and Environment- Unsustainable to sustainable development, Urban problems related to energy, Water conservation and watershed management, Resettlement and re-habitation, Ethics, Climate change, Global warming, Acid rain, Ozone layer depletion, Nuclear accidents, holocaust, Waste land reclamation, Consumerism and waste products, Environment protection act, Wildlife protection act, Forest conservation act, Environmental issues in legislation, population explosion and family welfare program, Environment and human health, HIV, Women and child welfare, Role of information technology in environment and human health.

References:

1. Agarwal, K.C., Environmental Biology, Nidi Publication Ltd., Bikaner, 2001.
2. Bharucha Erach, Biodiversity of India, Mapin Publishing Pvt. Ltd., Ahmadabad, 2002.
3.Bukhootsow, B., Energy Policy and Planning, Prentice Hall of India, New Delhi, 2003.
4.Cunningham, W.P., et al. , Environmental Encyclopedia, Jaico Publishing House, Mumbai, 2003.

604103	Energy Studies	Group I

ELECTIVE- III

Teaching Scheme: Lectures 3 Hrs/ Week		Examination Scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 3

Module I:

Energy Sources : Fossil fuels, Nuclear fuels, hydel, solar, wind and bio fuels in India, Energy conservation, Nuclear energy through fission and fusion processes.

Module II:

Energy Conservation: Energy conversion from source to utility, Solar, Nuclear, Geothermal, Tide and Wind Energies.

Global Energy Scenario: Role of energy in economic development and social transformation, Overall energy demand, availability and consumption, Depletion of energy resources and its impact on economy, Non proliferation of nuclear energy. International energy policies of G-8, G-20, OPEC and European union countries.

Module III:

Indian Energy Scenario- Commercial and noncommercial forms of energy, Utilization pattern in the past, present and also future prediction, Sector wise energy consumption.

Energy Policy: Energy policy issues at global level, national level and state level, Energy conservation act 2001, Electricity act 2003, Energy pricing and its impact on global variations

References:

1. Jose Goldenberg, Thomas Johanson, and Reddy, A.K.N., Energy for Sustainable World, WileyEastern ,2005.
2. Charles E. Brown, World Energy Resources, Springer Publication, New York, 2002.
3. Culp, A.W., Principles of Energy Conversion, McGraw Hill New York, 2004.
4. Bukhootsow, B., Energy Policy and Planning, Prentice Hall of India, New Delhi, 2003.

604103	Disaster Management	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 3**

Module I

Introduction :Concepts and definitions: disaster, hazard, vulnerability, risk, capacity, impact, prevention, mitigation). Disasters classification; natural disasters (floods, draught, cyclones, volcanoes, earthquakes, tsunami, landslides, coastal erosion, soil erosion, forest fires etc.); manmade disasters (industrial pollution, artificial flooding in urban areas, nuclear radiation, chemical spills etc); hazard and vulnerability profile of India, mountain and coastal areas, ecological fragility

Module II

Disaster Impacts :Disaster impacts (environmental, physical, social, ecological, economical, political, etc.); health, psycho-social issues; demographic aspects (gender, age, special needs); hazard locations; global and national disaster trends; climate-change and urban disasters.

Module III

Disaster Risk Reduction (DRR) : Disaster management cycle – its phases; prevention, mitigation, preparedness, relief and recovery; structural and non-structural measures; risk analysis, vulnerability and capacity assessment; early warning systems, Post-disaster environmental response (water, sanitation, food safety, waste management, disease control); Roles and responsibilities of government, community, local institutions, NGOs and other stakeholders; Policies and legislation for disaster risk reduction, DRR programmes in India and the activities of National Disaster Management Authority.

References:

1. http://ndma.gov.in/ (Home page of National Disaster Management Authority).
2. http://www.ndmindia.nic.in/ (National Disaster management in India, Ministry of Home Affairs).
3. Pradeep Sahni, 2004, Disaster Risk Reduction in South Asia, Prentice Hall.
4. Singh B.K., 2008, Handbook of Disaster Management: techniques & Guidelines, Rajat Publication.
5. Ghosh G.K., 2006, Disaster Management ,APH Publishing Corporation.

604103	Knowledge Management	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 3**

Module I

Introduction: Definition, evolution, need, drivers, scope, approaches in Organizations, strategies in organizations, components and functions, understanding knowledge; Learning organization: five components of learning organization, knowledge sources, and documentation. Essentials of Knowledge Management; knowledge creation process, knowledge management techniques, systems and tools.

Module II

Organizational knowledge management; architecture and implementation strategies, building the knowledge corporation and implementing knowledge management in organization. Knowledge management system life cycle, managing knowledge workers, knowledge audit, and knowledge management practices in organizations, few case studies

Module III

Futuristic KM: Knowledge Engineering, Theory of Computation, Data Structure.

References:

1. Knowledge Management – a resource book – A Thohothathri Raman, Excel, 2004.
2. Knowledge Management- Elias M. Awad Hasan M. Ghazri, Pearson Education
3. The KM Toolkit – Orchestrating IT, Strategy & Knowledge Platforms, Amrit Tiwana, Pearson, PHI, II Edn.
4. The Fifth Discipline Field Book – Strategies & Tools For Building A learning oganization PeterSenge et al. Nicholas Brealey 1994
5. Knowledge Management – Sudhir Warier, Vikas publications
6. Leading with Knowledge, Madanmohan Rao, Tata Mc-Graw Hill.

604103	Foreign Language	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 3**
Module I:		
Pronunciation guidelines; Single vowels, Accentuated vowels, Vowels and consonants combinations, Consonants; Numbers 1-10 Articles and Genders; Gender in French, Plural articles, Some usual expressions. Pronouns and Verbs; The verb groups, The pronouns, Present tense, Some color Adjectives and Plural ; Adjectives, Some adjectives, Our first sentences, More Numbers.		
Module II:		
Sentences Structures; Some Prepositions, Normal Sentences, Negative Sentences, Interrogative Sentences, Exercises The Family; Vocabulary ,Conversation, Notes on Pronunciation, Notes on Vocabulary, Grammar, Liaisons Guideline. D'où viens-tu (Where do you come from); Vocabulary, Conversation, Notes on Vocabulary, Liaisons Guidelines . Comparer (Comparing); Vocabulary, Conversation, Notes on Vocabulary, Grammar Liaisons Guidelines, Ordinal Numbers		
Module III:		
Le temps (Time); Vocabulary, Grammar, Time on the clock Additional French Vocabulary; Vocabulary related to - The Family, Vocabulary related to - Where do you come from? French Expressions and Idioms; Day-to-day Life, At Work, The car, Sports, Specia Events Other French Flavours; Nos cousins d'Amérique - Québec et Accadie, Au pays de la bière et des frites, Mettez-vous à l'heure Suisse, Vé, peuchère, le français bien de chez nous		
Reference: http://www.jump-gate.com/languages/french/index.html		

604103	Engineering Economics	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 3**

Module I:

Introduction to the subject: Micro and Macro Economics, Relationship between Science, Engineering, Technology and Economic Development. Production Possibility Curve, Nature of Economic Law, **Time Value of Money:** concepts and application. Capital budgeting; Traditional and modern methods, Payback period method, IRR, ARR, NPV, PI (with the help of case studies)

Module II:

Meaning of Production and factors of production, Law of variable proportions and returns to scale. Internal and external economies and diseconomies of scale. Concepts of cost of production, different types of costs; accounting cost, sunk cost, marginal cost, Opportunity cost. Break even analysis, Make or Buy decision (case study). Relevance of Depreciation towards industry. Meaning of market, types of market, perfect competition, Monopoly, Monopolistic, Oligopoly. (Main features). Supply and law of supply, Role of demand and supply in price determination.

Module III:

Indian Economy, nature and characteristics. Basic concepts; fiscal and monetary policy, LPG, Inflation, Sensex, GATT, WTO and IMF. Difference between Central bank and Commercial banks

Text Books:

1. Jain T.R., Economics for Engineers, VK Publication
2. Singh Seema, Economics for Engineers, IK International

Reference Books:

1. Chopra P. N., Principle of Economics, Kalyani Publishers
2. Dewett K. K., Modern economic theory, S. Chand
3. H. L. Ahuja., Modern economic theory, S. Chand
4. Dutt Rudar & Sundhram K. P. M., Indian Economy
5. Mishra S. K., Modern Micro Economics, Pragati Publications
6. Pandey I.M., Financial Management; Vikas Publishing House
7. Gupta Shashi K., Management Accounting, Kalyani Publication

604103	Engineering Risk – Benefit Analysis	Group I
ELECTIVE- III		
Teaching Scheme: **Lectures 3 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 3**

Module I :

Introduction- Knowledge and Ignorance, Information Uncertainty in Engineering Systems, Introduction and overview of class; definition of Engineering risk; overview of Engineering risk analysis. Risk Methods: Risk Terminology, Risk Assessment, Risk Management and Control, Risk Acceptance, Risk Communication, Identifying and structuring the Engineering risk problem; developing a deterministic or parametric model System Definition and Structure: System Definition Models, Hierarchical Definitions of Systems, and System Complexity.

Module 2:

Reliability Assessment: Analytical Reliability Assessment, Empirical Reliability Analysis Using Life Data, Reliability Analysis of Systems

Module 3:

Reliability and probabilistic risk assessment (RPRA), decision analysis (DA), and cost-benefit analysis (CBA). All of these pertain to decision making in the presence of significant uncertainty. In ERBA, the issues of interest are: The risks associated with large engineering projects such as nuclear power reactors, the International Space Station, and critical infrastructures; the development of new products; the design of processes and operations with environmental externalities; and infrastructure renewal projects

Books:

1. Risk Analysis in Engineering and Economics, B. M. Ayyub, Chapman-Hall/CRC Press, 2003.
2. Hoyland, Arnljot, and Rausand, Marvin. *System Reliability Theory*. Hoboken, NJ: Wiley-Interscience, 1994. ISBN: 9780471471332.
3. Clemen, Robert, " Making Hard Decisions: An Introduction to Decision Analysis (Business Statistics) " PHI publications

604103	Optimization Techniques	Group II
ELECTIVE- III		
Teaching Scheme: **Lectures 2 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 2**

Module I :

First and second order conditions for local interior optima (concavity and uniqueness), Sufficient conditions for unique global optima; Constrained optimization with Lagrange multipliers; Sufficient conditions for optima with equality and inequality constraints;

Module 2:

Recognizing and solving convex optimization problems. Convex sets, functions, and optimization problems. Least-squares, linear, and quadratic optimization. Geometric and semidefinite programming. Vector optimization. Duality theory. Convex relaxations. Approximation, fitting, and statistical estimation. Geometric problems. Control and trajectory planning

Books:

1. Stephen Boyd and Lieven Vandenberghe, *Convex Optimization*, Cambridge University Press.
2. A. Ben-Tal, A. Nemirovski, *Lectures on Modern Convex Optimization: Analysis,Algorithms, and Engineering Applications*, SIAM.
3. D. P. Bertsekas, A. Nedic, A. E. Ozdaglar, *Convex Analysis and Optimization,*Athena Scientific.
4. D. P. Bertsekas, *Nonlinear Programming*, Athena Scientific.
5. Y. Nesterov, *Introductory Lectures on Convex Optimization: A Basic Course*, Springer.
6. J. Borwein and A. S. Lewis, *Convex Analysis and Nonlinear Optimization:Theory and Examples,* Springer**.**

604103	Fuzzy Mathematics	Group II
ELECTIVE- III		
Teaching Scheme: **Lectures 2 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 2**
Module I :		
Definition of a Fuzzy set; Elements of Fuzzy logic. Relations including, Operations, reflexivity, symmetry and transitivity; Pattern Classification based on fuzzy relations		
Module II:		
Fuzzy Models: Mamdani , Sugeno, Tsukamoto		
Books: 1. Neuro-Fuzzy and Soft Computing by S.R.Jung, Sun, Mizutani,		

604103	Design and Analysis of Algorithm	Group II
ELECTIVE- III		
Teaching Scheme: **Lectures 2 Hrs/ Week**		**Examination Scheme:** **Theory :** **50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 2**
Module I :		
Introduction- Fundamental characteristics of an algorithm. Basic algorithm analysis –Asymptotic analysis of complexity bounds– best, average and worst-case behaviour, standard notations for expressing algorithmic complexity. Empirical measurements of performance, time and space trade-offs in algorithms.		
Module II:		
Properties of big-Oh notation – Recurrence equations – Solving recurrence equations – Analysis of linear search. Divide and Conquer: General Method – Binary Search – Finding Maximum and Minimum – Merge Sort – Greedy Algorithms: General Method – Container Loading – Knapsack		
Books: Algorithm Design – Jon Kleinberg and Eva Tardos Introduction to Algorithms – T.H. Corman et. Al		

604103	CUDA	Group II
ELECTIVE- III		
Teaching Scheme: **Lectures 2 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 2**

Module I :

History of GPUs leading to their use and design for HPC- The Age of Parallel Processing, The Rise of GPU Computing ,CUDA, Applications of CUDA, Development Environment, Introduction to CUDA C, Kernel call, Passing Parameters, Querying Devices, Using Device Properties

Module II:

Parallel Programming in CUDA C - CUDA Parallel Programming, Splitting Parallel Blocks, Shared Memory and Synchronization, Constant Memory, Texture Memory, CUDA events, Measuring Performance with Events.

Books:

1. Programming Massively Parallel Processors: A Hands-on Approach –second edition by David B. Kirk, Wen-mei W. Hwu.
2. CUDA by Example - An Introduction to General-Purpose GPU Programming by Jason Sanders ,Edward Kandrot- Addison Wesley
3. GPU Computing Gems Emerald Edition -Applications of GPU Computing Series by Wen-mei, W. Hwu
4. CUDA Programming: A Developer's Guide to Parallel Computing with GPUs by shane cook

604404	Seminar II	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Seminar II : shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		

604405	Project Stage- I	
Teaching Scheme: **Practical 8 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :8**
Project Stage – I Project Stage – I is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/SRS/UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. As a part of the progress report of Project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic. The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		

SEMESTER-IV

604406	Seminar III	
Teaching Scheme: **Practical 5 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :5**
Seminar III: shall preferably an extension of **seminar II.** The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		

604407	Project Stage- II	
Teaching Scheme: **Practical 20 Hrs/ Week**		**Examination Scheme:** **Term Work : 150 Marks** **Oral/ Presentation: 50 Marks** **Credits :20**
Project Stage – II In Project Stage – II, the student shall complete the remaining part of the project which will consist of the fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		