File Ref.No.11704/GA - IV - E2/2013/CU

UNIVERSITY OF CALICUT

Abstract

Faculty of Engineering - M.Tech Course in Signal Processing - Scheme and Syllabus - Approved - Implemented- With effect from 2012 Admission - Orders issued.

UNIVERSITY OF CALICUT (G & A - IV - E)

U.O.No. 1348/2013/CU Dated, Calicut University.P.O, 24.04.2013

Read:-1. Letter No. C1/4651/2010 dated 16-11-2012 from the Principal, Government Engineering College, Kozhikode.

2. This office Letter No. 6738/GA - IV - E2/2012/CU dated 30-11-2012.

3. Letter dated 03-12-2012 from the Chairman, Board of Studies in Engineering(PG), University of Calicut.

4. U.O. No. 519/2012/CU dated 27-12-2012.

5. Item No. I(b) of the minutes of the meeting of the Board of Studies in Engineering(PG), held on 11-02-2013.

6. Orders of the Vice Chancellor at para No.29 of File No. 5291/GA - IV - 2013/CU on 01-04-2013.

ORDER

Vide paper read as I above, draft Scheme and draft Syllabus for the proposed M.Tech. Course in Signal Processing in the Department of Applied Electronics and Instrumentation was forwarded by the Principal, Government Engineering College, Kozhikode for approval.

Vide paper read as II above, the draft Scheme and draft Syllabus for the proposed M.Tech Course in Signal Processing was forwarded to the Chairman, Board of Studies in Engineering(PG) for remarks and to place the same in the meeting of the Board of Studies.

Vide paper read as III above, the Chairman, Board of Studies in Engineering (PG), recommended to form an Expert Committee for framing the Scheme and Syllabus for M.Tech. Course Signal Processing.

Vide paper read as IV above, an Expert Committee was constituted to frame Scheme and Syllabus of M.Tech course in Signal Processing.

The Convener of the Expert Committee submitted the Syllabus of M.Tech course in "Signal Processing" in the meeting of the Board of Studies in Engineering (PG) held on 11-02-2013 for approval.

Vide paper read as V above, The Board of Studies in Engineering (PG) held on 11-02-2013, unanimously decided to approve the Scheme and Syllabus of the M.Tech. Course in Signal Processing , incorporating a few minor changes regarding the Code Numbers of a few subjects in the Syllabus and to follow the Eligiblility Criteria for admission to the Course to be as per the Clause 2 of M.Tech. Degree Course Regulations-2010 and to recognise the following eligible B.Tech Degree courses for the admission to the M.Tech Course in Signal Processing.

1. B.Tech Degree in Electronics & Communication Engineering
2. Electrical and Electronics Engineering
3. Applied Electronics & Instrumentation Engineering.
4. Electronics & Instrumentation Engineering.
5. Electronics Engineering.
6. Electrical Communication Engineering.

Having Considered the matter in detail, vide paper read as VI above, Sanction has been accorded by the Vice Chancellor to implement the Scheme and Syllabus of the M.Tech. Course in Signal Processing with effect from 2012 admission, to fix the Clause 2 of M.Tech. Degree Course Regulations-2010 to be the eligibility criteria and to recognise the following B.Tech. Degree Courses for the admission to the Course, subject to ratification by the Academic Council.

1. B.Tech Degree in Electronics & Communication Engineering
2. Electrical and Electronics Engineering
3. Applied Electronics & Instrumentation Engineering.
4. Electronics & Instrumentation Engineering.
5. Electronics Engineering.
6. Electrical Communication Engineering.

Orders are issued accordingly.

Moideen Kutty C.E
Deputy Registrar

To

The Principal, Govt. Engineering College, Kozhikode.

Copy to:- PS to VC/PA to Reg./PA to CE/DR; AR, M.Tech Branch/CDC branch/Dean, Faculty of Engineering.

Forwarded / By Order

Section Officer

UNIVERSITY OF CALICUT

M.Tech. DEGREE COURSE
Signal Processing
(Applied Electronics and Instrumentation Engineering Department)

Curricula, Scheme of Examinations and Syllabi
(With effect from 2012 admissions)

M. Tech. Signal Processing

SCHEME OF EXAMINATIONS

Semester - I

Code	Subject	Hours per week			Marks		Total Marks	Sem-end exam duration - Hrs	Credits
		L	T	P/D	Intl.	Sem-end			
ESP 10 101	Linear Algebra for Signal Processing	3	1	-	100	100	200	3	4
ESP 10 102	DSP Algorithms and Architecture	3	1	-	100	100	200	3	4
ESP 10 103	Random Processes and Applications	3	1	-	100	100	200	3	4
ESP 10 104	Multirate Signal Processing	3	1	-	100	100	200	3	4
ESP 10 105	Elective-I	3	1	-	100	100	200	3	4
ESP 10 106(P)	*DSP Systems Lab / Mini Project*	-	-	2	100	-	100	3	2
ESP 10 107(P)	*Seminar*	-	-	2	100	-	100	-	2
TOTAL		15	5	4	700	500	1200		24

NB: The student has to undertake the departmental work assigned by HOD

Electives -I

1	ESP 10 105(A)	Digital Filter Design and Applications
2	ESP 10 105(B)	DSP System Design
3	ESP 10 105(C)	Image Processing
4	ESP 10 105(D)	Digital Communication Techniques

Semester - II

Code	Subject	Hours per week			Marks		Total Marks	Sem-end exam duration-Hrs	Credits
		L	T	P/D	Intl.	Sem - end			
ESP 10 201	Wavelet Transforms: Theory and Applications	3	1	-	100	100	200	3	4
ESP 10 202	Pattern Recognition and Analysis	3	1	-	100	100	200	3	4
ESP 10 203	Adaptive Signal Processing	3	1	-	100	100	200	3	4
ESP 10 204	Elective-II	3	1	-	100	100	200	3	4
ESP 10 205	Elective-III	3	1	-	100	100	200	3	4
ESP 10 206(P)	*Signal Processing Lab II/ Mini Project*	-	-	2	100	-	100	-	2
ESP 10 207(P)	*Seminar*	-	-	2	100	-	100	-	2
TOTAL		15	5	4	700	500	1200		24

NB: The student has to undertake the departmental work assigned by HOD

Electives -II

1	ESP 10 204 (A)	Signal Compression Techniques
2	ESP 10 204 (B)	Array Signal Processing
3	ESP 10 204 (C)	Digital Control Systems
4	ESP 10 204 (D)	Information Theory & Data Encryption

Electives -III

1	ESP 10 205 (A)	Personal Wireless Networks and Mobile Computing
2	ESP 10 205 (B)	Spectrum Analysis Techniques
3	ESP 10 205 (C)	Secure Communication
4	ESP 10 205 (D)	Wireless Communications

Semester - III

<table>
<tr><th rowspan="2">Code</th><th rowspan="2">Subject</th><th colspan="3">Hours per week</th><th colspan="3">Marks</th><th rowspan="2">Total Marks</th><th rowspan="2">Sem-end exam duration - Hrs</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>T</th><th>P/D</th><th colspan="2">Intl.</th><th>Sem-end</th></tr>
<tr><td>ESP 10 301</td><td>Elective-IV</td><td>3</td><td>1</td><td>-</td><td colspan="2">100</td><td>100</td><td>200</td><td>3</td><td>4</td></tr>
<tr><td>ESP 10 302</td><td>Elective-V</td><td>3</td><td>1</td><td>-</td><td colspan="2">100</td><td>100</td><td>200</td><td>3</td><td>4</td></tr>
<tr><td>ESP 10 303(P)</td><td>Industrial Training</td><td>-</td><td>-</td><td>-</td><td colspan="2">50</td><td>-</td><td>50</td><td>-</td><td>1</td></tr>
<tr><td rowspan="2">ESP 12 304(P)</td><td rowspan="2">Masters Research Project(Phase -I)</td><td rowspan="2">-</td><td rowspan="2">-</td><td rowspan="2">22</td><td>Guide</td><td>EC *</td><td rowspan="2">-</td><td rowspan="2">300</td><td rowspan="2">-</td><td rowspan="2">6</td></tr>
<tr><td>150</td><td>150</td></tr>
<tr><td colspan="2">TOTAL</td><td>6</td><td>2</td><td>22</td><td colspan="2">550</td><td></td><td>750</td><td></td><td>15</td></tr>
</table>

NB: The student has to undertake the departmental work assigned by HOD

*EC – Evaluation Committee

Electives –IV

1	ESP 10 301 (A)	Speech and Audio Processing
2	ESP 10 301 (B)	Biomedical Signal Processing
3	ESP 10 301 (C)	Theory of Error Control Coding
4	ESP 10 301 (D)	Graph Theory

Electives –V

1	ESP 10 302 (A)	VLSI Structure for DSP
2	ESP 10 302(B)	Estimation and Detection Theory
3	ESP 10 302 (C)	Optimization Techniques
4	ESP 10 302 (D)	Markov Modeling and Queuing Theory

Semester - IV

Code	Subject	Hours per week			Internal Marks		Sem-end exam.		Total Marks	Credits
		L	T	P/D	Guide	Evaluation committee	Extl. Guide	Viva-Voce		
ESP 10 401(P)	*Masters Research Project (Phase -II)*	-	-	30	150	150	150	150	600	12
TOTAL				30	150	150	150	150	600	12

NB: The student has to undertake the departmental work assigned by HOD

FIRST SEMESTER

ESP 10 101: LINEAR ALGEBRA FOR SIGNAL PROCESSING

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- *This course provides further studies on linear algebra which has wide areas of application. Also it gives a brief description of the concepts and results in matrices and power series that may be useful in engineering.*

Module I: (13 Hours)
Algebraic Structures: Sets - functions - operators- Group - homomorphism of groups - Ring - Field - Vector Space - Subspaces - direct sum - metric space - inner product space - Lp space - Banach Space - Hilbert Space.

Module II: (13 Hours)
Linear independence:- basis - dimension - orthonormal basis finite dimensional vector spaces - isomorphic vector spaces - Examples of finite and infinite dimensional vector spaces - RN, CN, signal space.

Module III: (13 Hours)
Linear Transformations :- Linear Transformations – four fundamental subspaces of linear transformation – inverse transformation - rank nullity theorem - Matrix representation of linear transformation – square matrices – unitary matrices - Inverse of a square matrix - Change of basis – coordinate transformation - system of liner equations – existence and uniqueness of solutions- projection – least square solution – pseudo inverse.

Module IV: (13 Hours)
Transforms:- Eigen values, Eigen vectors and spectrum - Diagonalizability – orthogonal diagonilization - Properties of Eigen values and Eigen vectors of Hermitian matrices - Diagonalization of LTI operator – Fourier basis - DFT as a linear transformation — Translation invariant linear transformation – wavelet basis – wavelet transforms.

References:

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

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 102: DSP ALGORITHMS AND ARCHITECTURE

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- *The evolving field of ASIC design enables the customized design of DSP algorithms on dedicated chips. This paper introduces systematic approaches for mapping algorithms to VLSI architectures. It deals with representation of DSP algorithms, various techniques to optimize these architectures for various parameters such as computation time, hardware, space and power consumption. It also introduces fast DSP algorithms for efficient hardware implementation.*

Module I: (14 hours)

DSP Algorithm Design
DSP representations (data-flow, control-flow, and signal-flow graphs, block diagrams),fixed-point DSP design (A/D precision, coefficient quantization, round-off and scaling), filter structures (recursive, non-recursive and lattice), algorithmic simulations of DSP systems in C, behavioral modeling in HDL. System modeling and performance measures.

Module II: (12 hours)

Circuits and DSP Architecture Design
Fast filtering algorithms (Winograd's, FFT, short- length FIR), re-timing and pipelining, block processing, folding, distributed arithmetic architectures, VLSI performance measures (area, power, and speed), structural modeling in VHDL. Analog signal processing for fast operation. Impact of non ideal characteristics of analog functional blocks on the system performance.

Module III: (14 hours)

DSP Module Synthesis
Distributed arithmetic (DA). Advantageous of using DA. Size reduction of look-up tables. Canonic signed digit arithmetic. Implementation of elementary functions Table-oriented methods. Polynomial approximation Random number generators. Linear feedback shift register. High performance arithmetic unit architectures (adders, multipliers, dividers), bit-parallel, bit-serial, digit-serial, carry-save architectures, redundant number system, modeling for synthesis in HDL, synthesis place-and-route.

Module IV: (12 hours)

Parallel algorithms and their dependence

Applications to some common DSP algorithms. System timing using the scheduling vector. Projection of the dependence graph using a projection direction. The delay operator and z-transform techniques for mapping DSP algorithms onto processor arrays. Algebraic technique for mapping algorithms. The computation domain. The dependence matrix of a variable. The scheduling and projection functions. Data broadcast and pipelining Applications using common DSP algorithms.

References:

1. Sen M.Kuo , Woon-Seng S. Gan, *Digal Signal Processors: Architectures, Implementations, and Applications* Prentice Hall 2004.
2. Keshab K. Parhi, *VLSI Signal Processing Systems, Design and Implementation*, John Wiley & Sons,1999.
3. Uwe Meyer-Baese, *Digital Signal Processing with Field Programmable Gate Array*, Springer- Verlag 2001
4. John G. Proakis , Dimitris Manolakis K, *DSP Principles, Algorithms and Applications*, Prentice Hall 1995
5. Pirsch, *Architectures for Digital Signal Processing*, John Wiley and Sons, 1998.
6. Lars Wanhammar, *DSP Integrated Circuits*, Academic Press, 1999
7. Parhami, Behrooz, *Computer Arithmetic: Algorithms and Hardware Designs*, Oxford University Press, 2000
8. Israel Koren, A. K. Peters, Natick, *Computer Arithmetic Algorithms*, MA, 2002

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 103: RANDOM PROCESSES AND APPLICATIONS

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- *To introduce the fundamentals of probability theory and random processes and illustrate these concepts with engineering applications. This course will present the basic principles of random variables and random processes needed in applications such as signal processing, digital communications, speech processing, data modeling, etc. MATLAB will be used as a software tool for bringing probability theory and real-world applications closer together.*

Module I: (13 hours)

Probability Theory & Random variables

Probability axioms, conditional probability, discrete and continuous random variables, cumulative distribution function (CDF), probability mass function (PMF), probability density function (PDF), conditional PMF/PDF, expected value, variance, functions of a random variable, expected value of the derived random variable, multiple random variables, joint CDF/PMF/PDF, functions of multiple random variables, multiple functions of multiple random variables, independent/uncorrelated random variables, sums of random variables, moment generating function, random sums of random variables. The sample mean, laws of large numbers, central limit theorem, convergence of sequence of random variables.

Module II: (13 hours)

Introduction to random processes: specification of random processes, *n*th order joint PDFs, independent increments, stationary increments, Markov property, Markov process and martingales, Gaussian process, Poisson process and Brownian motion, Mean and correlation of random processes, stationary, wide sense stationary, ergodic processes, Mean-square continuity, mean-square derivatives.

Module III: (14 hours)

Random processes as inputs to linear time invariant systems: power spectral density, Gaussian processes as inputs to LTI systems, white Gaussian noise. Discrete-time Markov chains: state and n -step transition probabilities, Chapman-Kolmogorov equations, first passage probabilities, classification of states, limiting state probabilities.

Module IV: (12 hours)

Series representation of random process: Fourier series, Karhunen-Loeve expansion, Mercer's theorem, sampled band-limited processes, filtering using series representation

Reference:

1. A. Papoulis and S. U. Pillai: *Probability, Random Variables and Stochastic Processes*, 4th edition, 2002, McGraw Hill.
2. Geoffrey Grimmett: *Probability and Random Processes*, 3rd edition, 2001, Oxford University Press
3. V. Krishnan: *Probability and Random Processes*, 2006, John Wiley & Sons
4. Albert Leon Garcia: *Probability and Random Processes for Electrical Engineering*, 1993, Prentice Hall

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 104: MULTIRATE SIGNAL PROCESSING

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- *The course focuses on multirate signal processing which is the basic to modern signal processing. Topics include multirate signal processing material such as decimation, interpolation, filter banks, polyphase filtering, advanced filtering structures and nonuniform sampling and the cosine modulated filter banks.*

Module I: (14 hours)
Fundamentals of Multirate Theory
The sampling theorem**:** sampling at subnyquist rate - Basic Formulations and schemes.
Basic Multirate operations**:** Decimation and Interpolation - Digital Filter Banks- DFT Filter Bank- Identities- Polyphase representation
Maximally decimated filter banks: Polyphase representation - Errors in the QMF bank- Perfect reconstruction (PR) QMF Bank - Design of an alias free QMF Bank

Module II: (12hours)
M-channel perfect reconstruction filter banks
Uniform band and non uniform filter bank - tree structured filter bank- Errors created by filter bank system- Polyphase representation- perfect reconstruction systems

Module III: (14 Hours)
Perfect reconstruction (PR) filter banks
Paraunitary PR Filter Banks- Filter Bank Properties induced by paraunitarity- Two channel FIR paraunitary QMF Bank- Linear phase PR Filter banks- Necessary conditions for Linear phase property- Quantization Effects: -Types of quantization effects in filter banks. - coefficient sensitivity effects, dynamic range and scaling.

Module IV: (12Hours)
Cosine Modulated filter banks
Cosine Modulated pseudo QMF Bank- Alas cancellation- phase - Phase distortion- Closed form expression- Polyphase structure- PR Systems

Text Books

1. P.P. Vaidyanathan. *Multirate systems and filter banks*, Prentice Hall. PTR. 1993.
2. N.J. Fliege. *Multirate digital signal processing*, John Wiley 1994.

Reference Books

1. Sanjit K. Mitra, *Digital Signal Processing: A computer based approach*, McGraw Hill. 1998.
2. R.E. Crochiere. L. R., *Multirate Digital Signal Processing*, Prentice Hall. Inc.1983.
3. J.G. Proakis. D.G. Manolakis, *Digital Signal Processing: Principles. Algorithms and Applications*, 3rd Edn. Prentice Hall India, 1999.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 105(A): DIGITAL FILTER DESIGN & APPLICATIONS

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- *This course includes an in depth treatment of the topic digital filter design. It will strengthen the student's understanding of the foundations of DSP, filter design aspects in view of major application areas. It also covers the implementation issues such as finite word length effects which is a very important aspect of digital processing. It also covers the adaptive filter design concepts and spectral estimation methods which are used extensively in today's engineering applications.*

Module I :(12 hours)

LTI Systems & Transform
LTI systems as frequency selective filters. Inevitability of LTI systems. Minimum phase, maximum phase and mixed phase systems. All-pass filters. Design of digital filters by placement of poles and zeros. DFT as a linear transformation. Linear filtering methods based on DFT. Frequency analysis of signals using DFT. Discrete cosine transform.

Module II :(14 hours)

Design of FIR filters
Introduction-Specifications-Coefficient calculation methods-Window, Optimal and Frequency sampling methods-Comparison of different methods-Realization structures-Finite word length effects-Implementation techniques-Application examples. FIR filter design with Matlab or Octave. Implementation of FIR filtering in general purpose digital signal processors.

Module III :(14 hours)

Design of IIR filter: Introduction-Specifications. Coefficient calculation methods-Pole zero placement, Impulse invariant, Matched Z transform and Bilinear Z transform(BZT) .Design using BZT and classical analog filters. IIR filter coefficients by mapping S plane poles and zeros. Realization structures-Finite word length effects-Implementation techniques. Application examples. IIR filter design with Matlab or Octave. Implementation of IIR filtering in general purpose digital signal processors.

Module IV :(12hours)

Adaptive Digital Filters: Concepts -Wiener filter, LMS adaptive algorithm, Recursive least squares algorithm, Lattice Ladder filters. Application of Adaptive filters.
Power Spectrum Estimation: Estimation of spectra from finite-duration signals. Non-parametric and Parametric methods for Power Spectrum Estimation.

Reference:

1. Emmanuel C Ifeachor, Barrie W.Jervis, *Digital Signal Processing, A practical Approach,* 2/e, Pearson Education.
2. Proakis, Manolakis, *Digital Signal Processing: Principles, Algorithms, and Applications,* 4/e, Pearson Education.
3. Johnny R. Johnson, *Introduction to Digital Signal Processing,*PHI,1992
4. Ashok Ambardar, *Digital Signal Processing: A Modern Introduction,* Thomson,IE,2007.

Reading:

1. Douglas F. Elliott, *Handbook of Digital Signal Processing- Engineering Application ,* Academic Press.
2. Robert J.Schilling, Sandra L.Harris, *Fundamentals of Digital Signal Processing using MATLAB,*Thomson,2005
3. Ingle, Proakis, *Digital Signal Processing Using MATLAB,* Thomson, 1/e
4. Jones D. *Digital Filter Design* [Connexions Web site]. June 9, 2005. Available at: http://cnx.rice.edu/content/col10285/1.1/

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 105(B): DSP SYSTEM DESIGN

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:4**

Objective:

- *The aim of the paper is to introduce to the students the architectural features as well as the programming aspects of the latest DSPs available in the market. The students at the end of the course should be able to choose the appropriate processor for a given application environment and should be in a position to design stand alone systems based on DSPs, given a set of specifications.*

Module I:(14 hours) : **Introduction to a popular DSP from Texas Instruments:** CPU Architecture - CPU Data Paths and Control - Timers - Internal Data/Program Memory - External Memory Interface - Programming - Instructions Set and Addressing Modes - Code Composer Studio - Code Generation Tools - Code Composer Studio Debug tools – Simulator

Module II: (16 hours) : **Sharc Digital Signal Processor:** A popular DSP from Analog Devices - Sharc/ Tiger Sharc/ Blackfin (one of them) - Architecture - IOP Registers - Peripherals - Synchronous Serial Port - Interrupts - Internal/External/Multiprocessor Memory Space - Multiprocessing - Host Interface - Link Ports.

Module III: (16 hours) Digital Signal Processing Applications: FIR and IIR Digital Filter Design, Filter Design Programs using MATLAB - Fourier Transform: DFT, FFT programs using MATLAB - Real Time Implementation : Implementation of Real Time Digital Filters using DSP - Implementation of FFT Applications using DSP - DTMF Tone Generation and Detection

Module IV: (6 hours)
Current trends: Current trend in Digital Signal Processor or DSP Controller- Architecture and their applications.

Text Books:

1. Naim Dahnoun, *Digital Signal Processing Implementation using the TMS320C6000 DSP Platform*, 1st Edition.
2. T.J. Terrel and Lik-Kwan Shark, Digital *Signal Processing - A Student Guide*,1st Edition; Macmillan Press Ltd.
3. David J Defatta J, Lucas Joseph G & Hodkiss William S, *Digital Signal Processing: A System Design Approach*, 1st Edition, John Wiley
4. Rulf Chassaing, *Digital Signal Processing and Application with C6713 and C6416 DSK*, Wiley-Interscience Publication
5. Steven K Smith, Newnes, *Digital Signal Processing-A Practical Guide for Engineers and Scientists*, Elsevier Science.

References:

1. Rulph Chassaing, DSP *Applications using 'C' and the TMS320C6X DSK*, 1st Edition;
2. Andrew Bateman, Warren Yates, *Digital Signal Processing Design*, 1st Edition
3. John G Proakis, Dimitris G Manolakis, *Introduction to Digital Signal Processing*, 2^{nd} Ed.
4. Kreig Marven & Gillian Ewers, *A Simple approach to Digital Signal processing*, 1st Edition, Wiely Interscience
5. JAMES H. McClellan, Ronald, Schaffer and Mark A. Yoder*, DSP FIRST - A Multimedia Approach*, 1st Edition, Prentice Hall
6. Oppenheim A.V and Schafer R.W, *Digital Signal Processing*, 2nd Edition, Pearson Edn.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 105(C): IMAGE PROCESSING

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits: 4**

Objective:

- *Visual information plays an important role in almost all areas of our life. This course introduces the fundamentals of digital image processing. It emphasizes general principles of image processing, rather than specific applications. It cover topics such as image representation, color representations, sampling and quantization, point operations, linear image filtering and correlation, transforms and subband decompositions, and nonlinear filtering, contrast and color enhancement, dithering, and image restoration and compression. It also introduces the basic concepts of video processing.*

Module I: (14 hours)
Image Representation: Gray scale and colour Images, image sampling and quantization. Two dimensional orthogonal transforms: DFT, WHT, Haar transform, KLT, DCT. Image enhancement - filters in spatial and frequency domains, histogram-based processing, homomorphic filtering. Edge detection - non parametric and model based approaches, LOG filters, localisation problem.

Module II: (14 hours)
Image Restoration: Degradation Models, PSF, circulant and block - circulant matrices, deconvolution, restoration using inverse filtering, Wiener filtering and maximum entropy-based methods Image Segmentation: Pixel classification, Bi-level thresholding, Multi-level thresholding, P-tile method, Adaptive thresholding, Spectral & spatial classification, Edge detection, Hough transform, Region growing.

Module III: (14 hours)
Fundamental Concepts of Image Compression: Compression models - Information theoretic perspective - Fundamental coding theorem - Lossless Compression: Huffman Coding- Arithmetic coding - Bit plane coding - Run length coding - Lossy compression: Transform coding - Image compression standards.

Module IV: (10 hours)
Video Processing: Representation of Digital Video, Spatio-temporal sampling; Motion Estimation; Video Filtering; Video Compression, Video coding standards.

Texts/References

1. A. K. Jain, *Fundamentals of digital image processing*, Prentice Hall of India, 1989.
2. R. C. Gonzalez, R. E. Woods*, Digital Image Processing,* Pearson Education. II Ed., 2002
3. W. K. Pratt, *Digital image processing*, Prentice Hall, 1989
4. A. Rosenfold and A. C. Kak, *Digital Image Processing*, Vols. 1 and 2, Prentice Hall, 1986.
5. H. C. Andrew and B. R. Hunt, *Digital Image Restoration*, Prentice Hall, 1977
6. R. Jain, R. Kasturi and B.G. Schunck, *Machine Vision*, McGraw-Hill International Edition, 1995
7. A. M. Tekalp, *Digital Video Processing* , Prentice-Hall, 1995
8. A. Bovik, *Handbook of Image & Video Processing*, Academic Press, 2000

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 105(D): DIGITAL COMMUNICATION TECHNIQUES

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objective:

- *This course introduces the theoretical background needed to understand digital communication techniques. The main emphasis is on digital transmission via additive white Gaussian noise channels, synchronization aspects of communication systems and communication over band limited channels.*

Module I: (12 hours)
Random Variables and Processes: Review of Random variable: Moment generating function, Chernoff bound, Markov,s inequality, Chebyshev’s inequality, Central Limit Theorem, Chi square, Rayleigh and Rician distributions, Correlation, Covariance matrix - Stationary processes, wide sense stationary processes, ergodic process, cross correlation and autocorrelation functions-Gaussian process

Module II: (16 hours)
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- Probability of error for envelope detection of M-ary Orthogonal signals**.** Optimum waveform receiver for coloured Gaussian noise channels-Karhunen Loeve expansion approach, whitening.

Module III: (14 hours)
Synchronization in Communication Systems
Carrier Recovery and Symbol Synchronization in Signal Demodulation- Carrier Phase Estimation- Effect of additive noise on the phase estimate- Maximum Likelihood phase estimation- Symbol Timing Estimation- Maximum Likelihood timing estimation- Receiver structure with phase and timing recovery-Joint Estimation of Carrier phase and Symbol Timing- Frequency offset estimation and tracking.

Module IV: (10 hours)
Communication over Band limited Channels
Communication over band limited Channels- Optimum pulse shaping- Nyquist criterion for zero ISI, partial response signaling- Equalization Techniques- Zero forcing linear Equalization- Decision feedback equalization- Adaptive Equalization..

Text Book:

1. John G. Proakis, *Digital Communication*, McGraw Hill, 4TH edition, 1995.

Reference Books:

Edward. A. Lee and David. G. Messerschmitt, *Digital Communication*, Allied Publishers (second edition).
1. J Marvin.K.Simon, Sami. M. Hinedi and William. C. Lindsey, *Digital Communication Techniques*, PHI.
2. William Feller, *An introduction to Probability Theory and its applications*, Vol 11, Wiley 2000.
3. Sheldon.M.Ross, *Introduction to Probability Models*, Academic Press, 7th edition.

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 106(P): DSP SYSTEMS LAB / MINI PROJECT

Hours per week*: 2 hours practical* **Credits:** 2

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

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

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

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

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

Mini Project (Compulsory)
Student has to do a mini project on a topic approved by a 3 member committee and submit two copies of project report and an assessment will be conducted by the committee.

Reference

1. Jones D. DSP Laboratory with TI TMS320C54x [Connexions Web site]. January 22, 2004. Available at: http://cnx.rice.edu/content/col10078/1.2/
2. The manuals of the IDE and Processor being used.

Internal continuous assessment: 100 marks

Internal continuous assessment will be as follows.

Continuous Evaluation (Assessment of individual Experiments): 30
Mini Project (Demonstration, Report & Viva): 30
End Semester Exam (Practical Test & Viva): 40

ESP 10 107(P): SEMINAR

Hours per week: *2 hours practical* **Credits:** 2

Objective:

- *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his/her ideas and thus creating self esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest preferably from outside the M.Tech syllabus and give a seminar on that topic about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of the seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal Continuous Assessment ***(Maximum Marks-100)***

Presentation +Discussion	: 60
Relevance + Literature	: 10
Report	: 20
Participation	: 10
Total marks	: 100

SECOND SEMESTER

ESP 10 201: WAVELET TRANSFORMS: THEORY AND APPLICATIONS

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objective:

- *To impart the importance of wavelets*
- *To understand the fundamentals of wavelet theory*
- *To familiarize with the most commonly used wavelets*
- *Selection procedure of wavelets*
- *To familiarize with the construction of different types of wavelets*

Module I: (10 hours)

Continuous Wavelet Transform: Continuous time frequency representation of signals, The Windowed Fourier Transform, Uncertainty Principle and time frequency tiling, Wavelets, specifications, admissibility conditions, Continuous wavelet transform, CWT as a correlation, CWT as an operator, Inverse CWT.

Module II: (13 hours)

Discrete wavelet Transform: Approximations of vectors in nested linear vector spaces, Example of an MRA, Formal definition of MRA, Construction of genera orthonormal MRA, a Wavelet basis for MRA, Digital filtering interpretations- Decomposition and Reconstruction filters, examples of orthogonal basis generating wavelets, interpreting orthonormal MRA for Discrete time signals, Mallat algorithm Filter bank implementation of DWT

Module III: (16 hours)

Alternative wavelet representations- Biorthogonal Wavelets: Biorthogonality in vector space, biorthogonal wavelet bases, signal representation using biorthogonal wavelet system, advantages of biorthogonal wavelets, biorthogonal analysis and synthesis, Filter bank implementation, Two dimensional Wavelets, filter bank implementation of two dimensional wavelet transform. Lifting scheme: Wavelet Transform using polyphase matrix factorization, Geometrical foundations of the lifting scheme, lifting scheme in the z- domain, mathematical preliminaries for polyphase factorization, Dealing with Signal Boundary.

Module IV: (13 hours)

Applications: Image Compression: EZW Coding, SPIHT, Wavelet Difference Reduction Compression Algorithm, Denoising, speckle removal, edge detection and object isolation, audio compression, communication applications – scaling functions as signaling pulses, Discrete Wavelet Multi-tone Modulation.

Text books:

1. Stephen G. Mallat, “A wavelet tour of signal processing” 2nd Edition Academic Press, 2000.
2. M. Vetterli, J. Kovacevic, “Wavelets and subband coding” Prentice Hall Inc, 1995

Reference books:

1. Gilbert Strang and Truong Q. Nguyen, “Wavelets and filter banks” 2nd Edition Wellesley-Cambridge Press, 1998.
2. Gerald Kaiser, “A friendly guide to wavelets” Birkhauser/Springer International Edition, 1994, Indian reprint 2005.
3. L. Prasad and S. S. Iyengar, “Wavelet analysis with applications to image processing” CRC Press, 1997.
4. J. C. Goswami and A. K. Chan, “Fundamentals of wavelets: Theory, Algorithms and Applications” Wiley-Interscience Publication, John Wiley & Sons Inc., 1999.
5. Mark A. Pinsky, “Introduction to Fourier Analysis andWavelets” Brooks/Cole Series in Advanced Mathematics, 2002
6. Christian Blatter, “Wavelets: A primer” A. K. Peters, Massachusetts,1998.
7. M. Holschneider, “Wavelets: An analysis tool” Oxford Science Publications, 1998.
8. R. M. Rao and A. Bopardikar, “Wavelet transforms: Introduction to theory and applications” Addison-Wesley, 1998.
9. Ingrid Daubechies, “Ten lectures on wavelets”, SIAM, 1990.
10. H. L. Resnikoff and R. O. Wells, Jr., “Wavelet analysis: The scalable structure of information”, Springer, 1998.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 202: PATTERN RECOGNITION AND ANALYSIS

Teaching scheme *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objectives:

- *To impart a basic knowledge on pattern recognition and to give a sound idea on the topics of parameter estimation and supervised learning, linear discriminant functions and syntactic approach to Pattern recognition*
- *To provide a strong foundation to students to understand and design pattern recognition systems.*

Module I: (14 hrs)
Introduction - features, feature vectors and classifiers, Supervised versus unsupervised pattern recognition. Classifiers based on Bayes Decision theory- introduction, discriminant functions and decision surfaces, Bayesian classification for normal distributions, Estimation of unknown probability density functions, the nearest neighbour rule. Linear classifiers,- Linear discriminant functions and decision hyper planes, The perceptron algorithm, MSE estimation, Logistic determination, Support Vector machines.

Module II: (12 hrs)
Non-Linear classifiers- Two layer and three layer perceptrons, Back propagation algorithm, Networks with Weight sharing, Polynomial classifiers, Radial Basis function networks, Support Vector machines-nonlinear case, Decision trees, combining classifiers, Feature selection, Receiver Operating Characteristics (ROC) curve, Class separability measures, Optimal feature generation, The Bayesian information criterion.

Module III: (13 hrs)
Feature Generation 1- Linear transforms- KLT, SVD, ICA, DFT, DCT, DST, Hadamard Transform, Wavelet Transform, Wavelet Packets etc- Two dimensional generalizations - Applications. Feature Generation 2- regional features, features for shape and characterization, Fractals, typical features for speech and audio classification, Template Matching, Context dependent classification-Bayes classification, Markov chain models, HMM, Viterbi Algorithm. System evaluation - Error counting approach, Exploiting the finite size of the data.

Module IV: (13 hrs)
Clustering - Cluster analysis, Proximity measures, Clustering Algorithms - Sequential algorithms, Neural Network implementation. Hierarchical algorithms - Agglomerative algorithms, Divisive algorithms. Schemes - based on function optimization - Fuzzy clustering algorithms, Probabilistic clustering, K - means algorithm. Clustering algorithms based on graph theory - Competitive learning algorithms, Binary Morphology Clustering Algorithms Boundary detection methods, Valley seeking clustering, Kernel clustering methods. Clustering validity.

Text Books

1. Rochard O. Duda and Hart P.E, and David G Stork, Pattern classification , 2nd Edn., John Wiley & Sons Inc., 2001
2. Simon Haykin , Neural Networks and Learning Machines, 3rd edition, Pearson Education Inc., 2009
3. Sergios Theodoridis, Konstantinos Koutroumbas, “Pattern Recognition”, Academic Press, 2006.

Reference Books

4. Earl Gose, Richard Johnsonbaugh, and Steve Jost; Pattern Recognition and Image Analysis, PHI Pvte. Ltd., NewDelhi-1, 1999.
5. Fu K.S., Syntactic Pattern recognition and applications, Prentice Hall, Eaglewood cliffs, N.J., 1982
6. Duda and Hart P.E, Pattern classification and scene analysis, John Wiley and sons, NY, 1973.
7. Andrew R. Webb, “ Statistical Pattern Recognition”, John Wiley & Sons, 2002

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 203: ADAPTIVE SIGNAL PROCESSING

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objective:

- To introduce adaptive systems
- To understand the filter design related to adaptive signal processing
- To introduce different algorithms to implement adaptive signal processing
- Application of adaptive signal processing

Module I: (13 hours)

Adaptive systems - definitions and characteristics - applications - properties-examples - adaptive linear combiner-input signal and weight vectors - performance function-gradient and minimum mean square error - introduction to filtering-smoothing and prediction - linear optimum filtering-orthogonality - Wiener – Hopf equation-performance surface

Module II: (13 hours)

Searching performance surface-stability and rate of convergence - learning curve-gradient search - Newton's method - method of steepest descent - comparison - gradient estimation - performance penalty - variance - excess MSE and time constants – mis adjustments

Module III: (12 hours)

LMS algorithm convergence of weight vector- LMS/Newton algorithm - properties - sequential regression algorithm - adaptive recursive filters - random-search algorithms - lattice structure - adaptive filters with orthogonal signals

Module IV: (14 hours)

Applications-adaptive modeling and system identification-adaptive modeling for multipath communication channel, geophysical exploration, FIR digital filter synthesis, inverse adaptive modeling, equalization, and deconvolution-adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis

References:

1. Bernard Widrow and Samuel D. Stearns, “Adaptive Signal Processing”, Person Education, 2005.
2. Simon Haykin, “ Adaptive Filter Theory”, Pearson Education, 2003.
3. John R. Treichler, C. Richard Johnson, Michael G. Larimore, “Theory and Design of Adaptive Filters”, Prentice-Hall of India, 2002
4. S. Thomas Alexander, “ Adaptive Signal Processing - Theory and Application”, Springer-Verlag.
5. D. G. Manolokis, V. K. Ingle and S. M. Kogar, “Statistical and Adaptive Signal Processing”, Mc Graw Hill International Edition, 2000.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 204(A): SIGNAL COMPRESSION TECHNIQUES

Common with DSP 10 204 (A)

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objective:

- To familiarize with different coding techniques.
- To introduce the concept of rate distortion theory.
- To introduce different types of transforms
- To familiarize with different data compression standards

Module I: (13 hours)

Review of Information Theory: The discrete memoryless information source - Kraft inequality; optimal codes Source coding theorem. Compression Techniques - Lossless and Lossy Compression - Mathematical Preliminaries for Lossless Compression -Huffman Coding - Optimality of Huffman codes - Extended Huffman Coding – Adaptive Huffman Coding - Arithmetic Coding - Adaptive Arithmetic coding, Run Length Coding, Dictionary Techniques - Lempel-Ziv coding, Applications - Predictive Coding - Prediction with Partial Match – Burrows Wheeler Transform, Dynamic Markov Compression.

Module II: (13 hours)

Rate distortion theory: Rate distortion function R(D),Properties of R(D); Calculation of R(D) for the binary source and the Gaussian source, Rate distortion theorem, Converse of the Rate distortion theorem, Quantization - Uniform

& Non-uniform - optimal and adaptive quantization, vector quantization and structures for VQ, Optimality conditions for VQ, Predictive Coding - Differential Encoding Schemes

Module III: (13 hours)

Mathematical Preliminaries for Transforms, Karhunen Loeve Transform, Discrete Cosine and Sine Transforms, Discrete Walsh Hadamard Transform, Lapped transforms - Transform coding - Subband coding - Wavelet Based Compression - Analysis/Synthesis Schemes

Module IV: (13 hours)

Data Compression standards: Zip and Gzip, Speech Compression Standards: PCM-G.711, ADPCM G.726, SBC G.722, LD-CELP G.728, CS-ACELP (-A) G.729, MPC-MLQ , G.723.1, GSM HR VSELP, IS-54 VSELP, IS-96 QCELP, Immarsat - B APC, MELP, FS 1015, LPC10, FS1016, CELP, G721. Audio Compression standards: MPEG, Philips PASC, Sony ATRAC, Dolby AC-3, Image Compression standards: JBIG, GIF, JPEG & JPEG derived industry standards, CALIC, SPIHT, EZW, JPEG 2000. Video Compression Standards: MPEG, H.261, H.263 & H264.

Text books

1. Khalid Sayood, “Introduction to Data Compression”, Morgan Kaufmann Publishers., Second Edn, 2005.
2. David Salomon, “Data Compression: The Complete Reference”, Springer Publications, 4th Edn., 2006.
3. Thomas M. Cover, Joy A. Thomas, “Elements of Information Theory," John Wiley & Sons, Inc., 1991.

Reference books

1. Toby Berger, “Rate Distortion Theory: A Mathematical Basis for Data Compression”, Prentice Hall, Inc., 1971.
2. K.R.Rao, P.C.Yip, “The Transform and Data Compression Handbook”, CRC Press., 2001.
3. R.G.Gallager, “Information Theory and Reliable Communication”, John Wiley & Sons, Inc., 1968.
4. Ali N. Akansu, Richard A. Haddad, “Multiresolution Signal Decomposition: Transforms, Subbands and Wavelets”, Academic Press., 1992
5. Martin Vetterli, Jelena Kovacevic, “Wavelets and Subband Coding”, Prentice Hall Inc., 1995.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 204(B): ARRAY SIGNAL PROCESSING

Common with DSP 10 204 (B)

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objective:

- To familiarize with spatial signals.
- To introduce the concept behind sensor arrays
- To familiarize with spatial frequency
- To introduce the different methods for direction of arrival estimation

Module I: (13 hours)

Spatial Signals: Signals in space and time. Spatial frequency, Direction vs. frequency. Wave fields. Far field and Near field signals.

Module II: (13 hours)

Sensor Arrays: Spatial sampling, Nyquist criterion. Sensor arrays. Uniform linear arrays, planar and random arrays. Array transfer (steering) vector. Array steering vector for ULA. Broadband arrays.

Module III: (13 hours)

Spatial Frequency: Aliasing in spatial frequency domain. Spatial Frequency Transform, Spatial spectrum. Spatial Domain Filtering. Beam Forming. Spatially white signal.

Module IV: (13 hours)

Direction of Arrival Estimation: Non parametric methods - Beam forming and Capon methods. Resolution of Beam forming method. Subspace methods - MUSIC, Minimum Norm and ESPRIT techniques. Spatial Smoothing.

Reference

1. Dan E. Dugeon and Don H. Johnson. (1993). Array Signal Processing: Concepts and Techniques. Prentice Hall.
2. Petre Stoica and Randolph L. Moses. (2005, 1997) Spectral Analysis of Signals. Prentice Hall.
3. Bass J, McPheeters C, Finnigan J, Rodriguez E. Array Signal Processing [Connexions Web site]. February 8, 2005. Available at: http://cnx.rice.edu/content/col10255/1.3/

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 204 (C) DIGITAL CONTROL SYSTEMS

Teaching scheme: *3 hours lecture & 1 hour tutorial per week* **Credits:** 4

Objective:

- To introduce basic concepts of digital control systems.
- To introduce the concept of stability of systems and analysis of stability.
- To impart knowledge in the design of digital control systems.

Module I: (12 hours)

Sampling process: Sampling process- continuous and sampled signal, uniform impulse sampling- time domain and frequency domain analysis, aliasing, sampling theorem, data reconstruction, zero order hold, first order hold.

Module II: (13 hours)

Z -Transform methods: Z transform definition- theorem, inverse Z Transform, mapping s plane to Z- plane, linear constant coefficient difference equation, solution by recursion and Z transform method, principles of discretization.

Module III: (15 hours)

Design of digital control systems: Digital Control systems, pulse transfer function, Z Transform analysis of closed loop and open loop systems, steady state accuracy, characteristic equation, stability, tests for stability, frequency domain analysis, Bode diagrams- gain margin, phase margin, root locus techniques Cascade and feedback compensation using continuous data controllers, digital controller- design using bilinear transformation, root locus based design, digital PID controllers, Dead beat control design.

Module IV: (13 hours)

State variable methods: State variable techniques for digital control systems, state space models algebraic transformation-canonical forms, interrelations between Z Transform models and state variable models, controllability, observability, stability, response between sampling instants using state variable approach, state feedback, pole placement using state feedback, dynamic output feedback, SISO systems, effect of finite word length on controllability and closed loop placement, case study examples using MATLAB/clones.

Text Books:

1.Digital Control systems, Benjamin C Kuo, Saunders College publishing, 1997.
2.Digital control and state variable methods, M. Gopal, Tata McGraw Hill publishers, 1997.

Reference books:

3.Discrete time control systems, Katsuhito Ogata, Prentice Hall
4.Digital Control systems, Constantine H Houpis and Gary B Lamont, McGraw Hill

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 204(D): INFORMATION THEORY & DATA ENCRYPTION

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- To introduce the different techniques in cryptography
- To impart knowledge in the field of information hiding. Introduced the different techniques and their applications
- To introduce the concept of hiding in 1D signals, 2D signals and in video signals.
- To introduce the concept of steganalysis .

Module I: (12 hours)

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

Module II: (14 hours)

Information Hiding: Watermarking, Steganography. Objectives, difference, requirements, types (Fragile and robust). Parameters and metrics (BER, PSNR, WPSNR, Correlation coefficient, MSE, Bit per pixel). LSB, additive, spread spectrum methods. Applications: Authentication, annotation, tamper detection and Digital rights management. Hiding text and image data, mathematical formulations, Adaptive steganography, Costa's approach, hiding in noisy channels, Information theoretic approach for capacity evaluation

Module III: (14 hours)

Hiding in 1D signals: Time and transform techniques-hiding in Audio, biomedical signals, HAS Adaptive techniques.

Hiding in 2D signals: Spatial and transform techniques-hiding in images, ROI images, HVS Adaptive techniques.

Hiding in video: Temporal and transform domain techniques, Bandwidth requirements.

Module IV: (12 hours)

Steganalysis: Statistical Methods, HVS based methods, SVM method, Detection theoretic approach.

Quality evaluation: Benchmarks, Stirmark, Certimark, Checkmark, standard graphs for evaluation.

Reference

1. Neal Koblitz, *A Course in Number Theory and Cryptography*, 2nd Edition, Springer

2. Stefan Katzenbeisser, Fabien A. P. Petitcolas, *Information Hiding Techniques for Steganography and Digital Watermarking,* Artech House Publishers, 2000.

3. Neil F Johnson et al Kluwer, *Information hiding: steganography and watermarking attacks and countermeasures* Academic Publishers London.

4. Ingmar J Cox eta al *Digital Watermarking,* Morgan Kaufman Series, Multimedia information and system.

Reading

1. Ira S Moskowits, *Proceedings, 4th international workshop,* IH 2001, Pitts burg, USA April 2001 Eds:

2. AVISPA package homepage ,http:/ www.avispaproject.org/

3. Handbook of Applied Cryptography, AJ Menezes etc al, CRC Press

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 205(A) PERSONAL WIRELESS NETWORKS AND MOBILE COMPUTING

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- To introduce the various aspects of Bluetooth, WLAN, Infrared technologies and Home RF.
- To understand standards (802.15) Wireless PAN, which shall have interoperability between a broad range of consumer devices and allow global use of Personal Area Networks.
- To study the fundamentals of wireless networking and mobile computing.

Module I : (15 hours)

Over view of all technologies, IEEE 802.15 WPAN,Home RF, Blue tooth, interface between blue tooth and WLAN, standards, major telecommunications standards organizations, the radio frequency spectrum, interoperability issues. Infrared Standards-Differences between the OSI communications model and the IEEE 802 of a radio system, infrared WLAN Bluetooth Technology- Bluetooth protocol architecture, Link management, Logical Link control, Blue tooth profiles and Blue tooth security

Module II: (13 hours)
Wireless LANS: infrastructure Vs Ad hoc Networks, IEEE 802.11: Architecture. MAC layer- Synchronization, power management, roaming-IEEE 802.11b, 802.11a, new developments. Mobile IP Overview, network elements, packet delivery agent discovery, registration - Tunneling and encapsulation optimization, IPv6, IP micro mobility support, DHCP and mobile IP, mobile transport layer - Traditional TCP and implications on mobility, indirect and snooping TCP - TCP over 2.5G/3G networks- Performance enhancing process.

Module III: (12 hours)
Mobile Computing Challenges of mobile computing -File systems and WWW architectures for mobile computing – WAP- Architecture, protocols wireless applications, environment WML, push architecture, push/pull services, WAP 1.72 stacks, I-mode, WAP 2.0 - J2ME- BREW.

Module IV: (13 hours)
Wireless Security Public key infrastructure and certification authorities- wireless public key infrastructure- Characteristics of SIM - Security protocols- Authentication.

Text Books:

1. Mobile Communication, John Schiller, Addison Wesley-2003.
2. Principles of Wireless Networks - A Unified Approach ,K. Pahlvanand P. Krishnamurthy",
Pearson Education , 2004.

Reference books:

3. Wireless Network Evolution: 2G to 3G",V.K.Garg - Prentice Hall , 2002 ..
4. "Mobile IP Design-Principles and practice",C.E.Perkins - Addison Wesley ,1998.
5. "Wireless Personal Communication Systems", DJ.Goodman-Addisson Wesley, 1997.
6. Kaven pahlavan and others, "Principles of Wireless networks", Pearson ed. 2002.
7. Nathan J Muller, "Blue tooth Demystified" TMH, Third reprint 2007.
8. William Stallings, "Wireless communications and Networks", 2nd ed. PHI 2007.
9. John R Barry, "Wireless infrared communications" ISBN 0792394763
10. Asoke Talukder, Yavagal, "Mobile Computing", TataMcGraw Hill, 2005
Dee M Bakker and others, "Blue tooth end to end" ISBN 978-0-7645-4887-1

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 205(B): SPECTRUM ANALYSIS TECHNIQUES

Common with DSP 10 205 (B)

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- To introduce Power spectral density
- To impart knowledge in different methods of PSD estimation both in Non-parametric & parametric methods
- To introduce the filter bank methods

Module I: (10 hours)

Power Spectral Density: Energy spectral density of deterministic signals, Power spectral density of random signals, Properties of PSD

Module II: (13 hours)

PSD Estimation - Non-parametric methods: Estimation of PSD from finite data, Non-parametric methods : Periodogram properties, bias and variance analysis, Blackman-Tuckey method, Window design considerations, time-bandwidth product and resolution - variance trade-offs in window design, Refined periodogram methods : Bartlet method, Welch method.

Module III: (17 hours)

PSD Estimation - Parametric methods: Parametric method for rational spectra**:-** Covariance structure of ARMA process, AR signals, Yule-Walker method, Least square method, Levinson-Durbin Algorithm, MA signals, Modified Yule-Walker method, Two stage least square method, Burg method for AR parameter estimation.

Parametric method for line spectra: Models of sinusoidal signals in noise, Non-linear least squares method, Higher order Yule-Walker method, MUSIC and Pisayenko methods, Min-norm method, ESPIRIT method

.

Module IV: (12 hours)

Filter bank methods: Filter bank interpretation of periodogram, Slepia base-band filters, refined filter bank method for higher resolution spectral analysis, Capon method, Introduction to higher order spectra.

References

1. Introduction to Spectral Analysis, Stoica , R.L. Moses, Prentice Hall
2. Modern Spectral Estimation Theory & Applications, Kay SM, Prentice Hall

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 205(C): SECURE COMMUNICATION
Common with DSP 10 205 (C)

Teaching scheme: **Credits:** 4
3 hours lecture & 1 hour tutorial per week

Objective:
- To introduce the basic concept encryption techniques
- To familiarize with the concept of private key and public key crypto systems.
- To introduce the concept of Elliptic curves

Module I: (12 hours)
Rings and fields - Homomorphism- Euclidean domains - Principal Ideal Domains - Unique Factorization Domains -- Field extensions- Splitting fields - Divisibility- Euler theorem - Chinese Remainder Theorem –Primality

Module II: (13 hours)
Basic encryption techniques - Concept of cryptanalysis - Shannon's theory - Perfect secrecy - Block ciphers - Cryptographic algorithms - Features of DES - Stream ciphers - Pseudo random sequence generators – linear complexity - Non-linear combination of LFSRs - Boolean functions

Module IIi: (14 hours)
Private key and Public key crypto systems - One way functions - Discrete log problem - Factorization problem - RSA encryption - Diffie Hellmann key exchange - Message authentication and hash functions –Digital signatures - Secret sharing - features of visual cryptography - other applications of cryptography

Module IV: (13 hours)
Elliptic curves - Basic theory - Weirstrass equation - Group law - Point at Infinity -Elliptic curves over finite fields - Discrete logarithm problem on EC - Elliptic curve cryptography - Diffie Hellmann key exchange over EC - Elgamal encryption over EC – ECDSA

Text Books
1. Douglas A. Stinson, “Cryptography, Theory and Practice”, 2nd edition, Chapman & Hall, CRC Press Company, Washington
2. William Stallings, “ Cryptography and Network Security”, 3rd edition, Pearson Education

Reference Books
1. Lawrence C. Washington, “ Elliptic Curves”, Chapman & Hall, CRC Press Company, Washington.
2. David S. Dummit, Richard M. Foote, “ Abstract Algebra”, John Wiley & Sons
3. Evangelos Kranakis, “ Primality and Cryptography”, John Wiley & Sons
4. Rainer A. Ruppel, “ Analysis and Design of Stream Ciphers”, Springer Verlag

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 205(D): WIRELESS COMMUNICATIONS

Teaching scheme: **Credits:** 4
3 hours lecture & 1 hour tutorial per week

Objective:

- To familiarize with different channel models
- To impart knowledge in the concept of fading and diversity.
- To familiarize with different techniques in cellular communication
- To introduce the concept of spread spectrum and CDMA
- To impart knowledge in fading channel capacity in different systems

Module I: (13 hours)
Fading and Diversity: Wireless Channel Models- path loss and shadowing models- statistical fading models- Narrow band and wideband Fading models- Review of performance of digital modulation schemes over wireless channels- Diversity- Repetition coding and Time Diversity- Frequency and Space Diversity- Receive Diversity - Concept of diversity branches and signal paths- Combining methods- Selective diversity combining - Switched combining- maximal ratio combining- Equal gain combining- performance analysis for Rayleigh fading channels.

Module II: (10 hours)
Cellular Communication: Cellular Networks- Multiple Access: FDM/TDM/FDMA/TDMA- Spatial reuse- Co-channel interference Analysis- Hand over Analysis- Erlang Capacity Analysis- Spectral efficiency and Grade of Service - Improving capacity - Cell splitting and sectorization.

Module III: (14 hours)
Spread spectrum and CDMA: Motivation- Direct sequence spread spectrum- Frequency Hopping systems- Time Hopping.- Anti-jamming - Pseudo Random (PN) sequence- Maximal length sequences- Gold sequences- Generation of PN sequences - Diversity in DS-SS systems- Rake Receiver- Performance analysis. Spread Spectrum Multiple Access - CDMA Systems- Interference Analysis for Broadcast and Multiple Access Channels- Capacity of cellular CDMA networks- Reverse link power control- Hard and Soft hand off strategies.

Module IV: (15 hours)
Fading Channel Capacity: Capacity of Wireless Channels- Capacity of flat and frequency selective fading channels- Multiple Input Multiple output (MIMO) systems- Narrow band multiple antenna system model- Parallel Decomposition of MIMO Channels- Capacity of MIMO Channels. Cellular Wireless Communication Standards -

Second generation cellular systems: GSM specifications and Air Interface - specifications, IS 95 CDMA - 3G systems: UMTS & CDMA 2000 standards and specifications

Text Books

1. Andrea Goldsmith, "Wireless Communications", Cambridge University press.
2. Simon Haykin and Michael Moher, " Modern Wireless Communications", Person Education.

Reference Books

1. T.S. Rappaport, "Wireless Communication, principles & practice", PHI, 2001.
2. G.L Stuber, "Principles of Mobile Communications", 2nd edition, Kluwer Academic Publishers.
3. Kamilo Feher, 'Wireless digital communication', PHI, 1995.
4. R.L Peterson, R.E. Ziemer and David E. Borth, "Introduction to Spread Spectrum Communication", Pearson Education
5. A.J.Viterbi, "CDMA- Principles of Spread Spectrum", Addison Wesley, 1995.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 206(P): SIGNAL PROCESSING LAB II /MINI PROJECT

Hours per week: Practical 2 hours **Credits: 2**

OBJECTIVE:

- To experiment the concepts introduced in the courses Adaptive Signal Processing and Pattern Recognition and Analysis

Tools :

1. Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool.
2. DSP Kits – TMS320C6X or AD or equivalent

Suggested Experiments:

1. ***Numerical Computing Environments*** – Weiner Filtering, LMS filters, System Identification, Adaptive Equalization, Deconvolution
2. ***DSP Kits*** – LMS filtering, Lattice structures, Adaptive Equalization.
3. **Classification** – Bayesian, Perceptron, MLFFN, RBF and SVM based classifiers
4. **Clustering**- K-means and probabilistic clustering

Internal Continuous Assessment *(Maximum Marks-100):*

Regularity	- 30 marks
Record	- 20 marks
Tests, Viva	- 50 marks

ESP 10 207(P): SEMINAR

Hours per week: *2 hours practical* **Credits:** 2

Objective:

- *To assess the debating capability of the student to present a technical topic. Also to impart training to a student to face audience and present his/her ideas and thus creating self esteem and courage that are essential for an engineer.*

Individual students are required to choose a topic of their interest preferably from outside the M.Tech syllabus and give a seminar on that topic about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation of the seminar and award marks to the students based on merits of topic of presentation. Each student shall submit two copies of a write up of the seminar topic. One copy shall be returned to the student after duly certifying it by the chairman of the assessing committee and the other will be kept in the departmental library. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal Continuous Assessment ***(Maximum Marks-100)***

Presentation +Discussion	: 60
Relevance + Literature	: 10
Report	: 20
Participation	: 10
Total marks	: 100

THIRD SEMESTER

The student has to credit 2 theory subjects from the two groups of electives listed. The student has to undergo an industrial training of duration one month during the semester break after the semester II and complete that within 15 calendar days from the start of semester III.

ESP 10 301A: SPEECH AND AUDIO PROCESSING

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

- *To study the mechanisms of speech production and various models used for speech processing*
- *To provide a knowledge of different coding methods used in speech and audio processing*

Module I (13 hrs)

Digital models for the speech signal - mechanism of speech production - acoustic theory - lossless tube models - digital models - linear prediction of speech - auto correlation - formulation of LPC equation - solution of LPC equations - Levinson Durbin algorithm - Levinson recursion - Schur algorithm - lattice formulations and solutions - PARCOR coefficients - Spectral analysis of speech - Short Time Fourier analysis - filter bank design. Auditory Perception: Psychoacoustics - Frequency Analysis and Critical Bands – Masking properties of human ear

Module II: (14 hrs)

Speech coding -subband coding of speech - transform coding - channel vocoder - formant vocoder – cepstral vocoder - vector quantizer coder- Linear predictive Coder. Speech synthesis - pitch extraction algorithms - gold rabiner pitch trackers - autocorrelation pitch trackers - voice/unvoiced detection - homomorphic speech processing - homomorphic systems for convolution - complex cepstrums - pitch extraction using homomorphic speech processing. Sound Mixtures and Separation - CASA, ICA & Model based separation.

Module III: (13 hrs)

Speech Transformations - Time Scale Modification - Voice Morphing. Automatic speech recognition systems - isolated word recognition - connected word recognition – large vocabulary word recognition systems - pattern classification - DTW, HMM - speaker recognition systems - speaker verification systems – speaker identification Systems.

Module IV:(12 hrs)

Audio Processing: Non speech and Music Signals - Modeling - Differential transform and subband coding of audio signals & standards - High Quality Audio coding using Psychoacoustic models - MPEG Audio coding standard. Music Production - sequence of steps in a bowed string instrument - Frequency response measurement of the bridge of a violin. Audio Data bases and applications - Content based retrieval.

Reference books:

1. Rabiner L.R. & Schafer R.W., “Digital Processing of Speech Signals”, Prentice Hall Inc.
2. O'Shaughnessy, D. “Speech Communication, Human and Machine”. Addison - Wesley.

3. Thomas F. Quatieri , "Discrete-time Speech Signal Processing: Principles and Practice" Prentice . Hall, Signal Processing Series
4. Deller, J., J. Proakis, and J. Hansen. "Discrete-Time Processing of Speech Signals." Macmillan.
5. Ben Gold & Nelson Morgan , " Speech and Audio Signal Processing", John Wiley & Sons, Inc.
6. Owens F.J., "Signal Processing of Speech", Macmillan New Electronics
7. Saito S. & Nakata K., "Fundamentals of Speech Signal Processing", Academic Press, Inc.
8. Papamichalis P.E., "Practical Approaches to Speech Coding", Texas Instruments, Prentice Hall
9. Rabiner L.R. & Gold, "Theory and Applications of Digital Signal Processing", Prentice Hall of India
10. Jayant, N. S. and P. Noll. "Digital Coding of Waveforms: Principles and Applications to Speech and Video. Signal Processing Series", Englewood Cliffs: Prentice-Hall
11. Thomas Parsons, "Voice and Speech Processing", McGraw Hill Series
12. Chris Rowden, "Speech Processing", McGraw-Hill International Limited
13. Moore. B, "An Introduction to Psychology of hearing"Academic Press, London, 1997
14. E. Zwicker and L. Fastl, "Psychoacoustics-facts and models", Springer-Verlag., 1990

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 301B: BIOMEDICAL SIGNAL PROCESSING

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

- *To impart knowledge about the principle of different types of bio-medical signals*
- *To give ideas about the interpretation of various signals in biomedical applications*

Module I: (12 hrs)

Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG etc - Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio-potentials - Review of linear systems - Fourier Transform and Time Frequency Analysis - (Wavelet) of biomedical signals- Processing of Random & Stochastic signals - spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments

Module II:(12 hrs)

Concurrent, coupled and correlated processes - illustration with case studies - Adaptive and optimal filtering - Modeling of Biomedical signals - Detection of biomedical signals in noise - removal of artifacts of one signal embedded in another -Maternal-Fetal ECG – Muscle -contraction interference. Event detection - case studies with ECG & EEG - Independent component Analysis - Cocktail party problem applied to EEG signals - Classification of biomedical signals.

Module III: (14 hrs)

Cardio vascular applications : Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multiscale analysis for ECG parameters estimation - Noise & Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection - Arrhythmia analysis - Data Compression: Lossless & Lossy- Heart Rate Variability – Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals.

Module IV: (14 hrs)

Neurological Applications: The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modeling EEG- linear, stochastic models - Non linear modeling of EEG - artifacts in EEG & their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels.

Reference Books:

1. Bruce, “Biomedical Signal Processing & Signal Modeling,” Wiley, 2001
2. Sörnmo, “Bioelectrical Signal Processing in Cardiac & Neurological Applications”, Elsevier
3. Rangayyan, “Biomedical Signal Analysis”, Wiley 2002.
4. Semmlow, Marcel Dekker “Biosignal and Biomedical Image Processing”, 2004
5. Enderle, “Introduction to Biomedical Engineering,” 2/e, Elsevier, 2005
6. D.C.Reddy , “ Biomedical Signal Processing: Principles and techniques”, Tata McGraw Hill, New Delhi, 2005

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 301C: THEORY OF ERROR CONTROL CODING

Teaching scheme **Credits:** 4
3 hours lecture & 1 hour tutorial per week

Objectives:
- *To give the basic ideas of error control coding*
- *To impart knowledge about different types of codes used in communication*

Module I: (13 hours)
Finite Field Arithmetic: Introduction, Groups- Rings- Fields- Arithmetic of Galois Field- Integer Ring- Polynomial Rings- Polynomials and Euclidean algorithm, primitive elements, Construction and basic properties of Finite Fields- Computations using Galois Field arithmetic- sub fields- Minimal polynomial and conjugates - Vector space - Vector Subspace- Linear independence.

Module II: (13 hours)
Linear Block Codes: Linear Block codes- Properties- Minimum Distance- Error detection and correction- Standard Array and Syndrome decoding- Hamming codes- Perfect and Quasi-perfect codes - Extended codes- Hadamard codes.

Module III: (12 hours)
Cyclic Codes: Basic theory of Cyclic codes- Generator and Parity check matrices - Cyclic encoders- Error detection & correction- decoding of cyclic codes- Cyclic Hamming codes- Binary Golay codes- BCH codes- Decoding of BCH codes-The Berlekamp- Massey decoding algorithm. Reed Solomon codes- Generalized Reed Solomon codes- MDS codes.

Module IV: (14 hours)
Convolutional Codes: Generator matrices and encoding- state, tree and trellis diagram - Transfer function - Maximum Likelihood decoding Hard versus Soft decision decoding - The Viterbi Algorithm- Free distance- Catastrophic encoders.
Soft Decision and Iterative Decoding: Soft decision Viterbi algorithm- Two way APP decoding- Low density parity check codes- Turbo codes - Turbo decoding

Text Books
1. R.E. Blahut, "Theory and Practice of Error Control Coding", MGH 1983.
2. W.C. Huffman and Vera Pless, "Fundamentals of Error correcting codes", Cambridge University Press, 2003.
3. Shu Lin and Daniel. J. Costello Jr., "Error Control Coding: Fundamentals and applications", Prentice Hall Inc, 1983.
4. Rolf Johannesson, Kamil Sh. Zigangirov, "Fundamentals of Convolutional Coding", Universities Press(India) Ltd. 2001.
5. Sklar, ' Digital Communication', Pearson Education.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 301(D): GRAPH THEORY

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- To introduce different concepts in graph theory

Module I: (13 hours)

Introduction to graphs, definitions, subgraphs, paths and cycles, isomorphism, cut vertex, bridge, block, bipartite graph, complement of a graph, vertex and edge connectivity, degree sequence, metric , eccentricity, centre , median.

Module II: (13 hours)

Trees, definitions and properties, rooted trees, trees and sorting, weighted trees and prefix codes, Matrix representation of graphs, Adjacency, Incidence and Distance matrices, Matrix tree theorem, biconnected components and articulation points.

Module III: (12 hours)

Planar graphs, Euler formula, platonic bodies. Hamiltonian graphs, graph colouring and chromatic polynomials, Network flows and max-flow min-cut theorem.

Module IV: (14 hours)

Digraphs, connectivity, acyclic digraphs, tournaments, Algorithms and complexity, Polynomial algorithms and NP completeness, BFS, DFS, Kruskal's, Prim's, Dijkstra's & Floyd's algorithms.

References:

1. Gary Chartrand, Ping Zhang, ‘ Introduction to Graph Theory, McGraw Hill International Edition, 2005.
2. J Clark and D. A Holton. ‘A First Look at Graph Theory’. Allied Publishers (World Scientific). New Delhi, 1991.
3. R. P. Grimaldi, ‘Discrete and Combinatorial Mathematics: An Applied Introduction’. Addison Wesley, 1994.
4. T. H. Cormen, C. E. Leiserson and R. L. Rivest, ‘Introduction to Algorithms’ PHI 1990.
5. C. R. Foulds, ‘ Graph Theory Applications’, Narosa Publishing House, 1994
6. Harary. F, ‘ Graph Theory’, Addison Wesley, 1972.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 302(A): VLSI STRUCTURE FOR DSP

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

- *To study the different VLSI structures used for DSP*
- *To introduce the DSP processors used for different applications*
- *To introduce the various steps in IC fabrication , starting from the raw material to*

The finished product as well as physical principles involved in these processes

Module I: (13 hours)

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: (13 hours)

Parallel FIR filters – discrete time cosine transform – implementation of DCT based on algorithm – architecture transformations – parallel architectures for rank order filters.

Module III: (13 hours)

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 IV: (13 hours)

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

References:

1. Keshab K. Parhi, VLSI Digital signal processing Systems: Design and Implementation, John Wiley & Sons, 1999.

2. Uwe meyer-Baes, DSP with Field programmable gate arrays, Springer, 2001

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 302(B): ESTIMATION AND DETECTION THEORY

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- To introduce Detection theory and impart knowledge in both single observation and multiple observations.
- To introduce the need of Estimation theory and different methods for estimation
- To understand the different properties of estimators
- To introduce state estimation

Module I: (12 hours)

Detection theory : Binary decisions - Single observation

Maximum likelihood decision criterion; Neymann-Pearson criterion; Probability of error criterion; Bayes risk criterion; Minimax criterion; Robust detection; Receiver operating characteristics.

Module II: (12 hours)

Detection theory: Binary decisions - Multiple observations

Vector observations; The general Gaussian problem; Waveform observation in additive Gaussian noise; The integrating optimum receiver; Matched filter receiver.

Module III: (14 hours)

Estimation theory

a) Methods: Maximum likelihood estimation; Bayes cost method Bayes estimation criterion -
Mean square error criterion; Uniform cost function; absolute value cost function; Linear minimum variance - Least squares method; Estimation in the presence of Gaussian noise - Linear observation; Non-linear estimation.
b) Properties of estimators : Bias, Efficiency, Cramer Rao bound Asymptotic properties;
Sensitivity and error analysis

Module IV: (14 hours)

a) State estimation: Prediction; Kalman filter.

b) Sufficient statistics and statistical estimation of parameters: Concept of sufficient statistics; Exponential families of distributions; Exponential families and Maximum likelihood estimation; Uniformly minimum variance unbiased estimation.

References:

1. James L. Melsa and David L. Cohn, "Decision and Estimation Theory," McGraw Hill, 1978
2 . Dimitri Kazakos, P. Papantoni Kazakos, "Detection and Estimation," Computer Science Press, 1990
3 Steven M. Kay, "Statistical Signal Processing: Vol. 1: Estimation Theory, Vol. 2: Detection Theory," Prentice Hall Inc., 1998.
4. Harry L. Van Trees, "Detection, Estimation and Modulation Theory, Part 1," John Wiley & Sons Inc.1968.

5. Jerry M. Mendel, "Lessons in Estimation Theory for Signal Processing, Communication
6. Sophocles J. Orfanidis, "Optimum Signal Processing," 2 nd edn., McGraw Hill, 1988.
and Control," Prentice Hall Inc., 1995
7. Monson H. Hayes, "Statistical Digital Signal Processing and Modelling," John Wiley & . Sons Inc., 1996

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 302(C): OPTIMISATION TECHNIQUES

Teaching scheme: **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objective:

- *The aim of this course is to expose students to various deterministic optimization tools and techniques. The course generally covers topics such as: an overview of mathematical modeling, linear and non linear programming and various constrained & unconstrained optimization techniques which will be useful for engineering applications.*

Module I: (12Hours)

Mathematical Background: Sequences and Subsequences- Mapping and functions- Continuous functions- Infimum and Supremum of functions- Minima and maxima of functions- Differentiable functions. Vectors and vector spaces- Matrices- Linear transformation- Quadratic forms- Definite quadratic forms- Gradient and Hessian- Linear equations- Solution of a set of linear equations-Basic solution and degeneracy. Convex sets and Convex cones- Introduction and preliminary definition- Convex sets and properties- Convex Hulls- Extreme point- Separation and support of convex sets- Convex Polytopes and Polyhedra- Convex cones- Convex and concave functions- Basic properties- Differentiable convex functions- Generalization of convex functions.

Module II: (14 hours)

Linear Programming: Introduction -Optimization model, formulation and applications -Classical optimization techniques: Single and multi variable problems-Types of constraints. Linear optimization algorithms: The simplex method -Basic solution and extreme point -Degeneracy-The primal simplex method -Dual linear programs - Primal, dual, and duality theory - The dual simplex method -The primal-dual algorithm-Duality applications. Post optimization problems: Sensitivity analysis and parametric programming

Module III: (14 hours)

Nonlinear Programming: Minimization and maximization of convex functions- Local & Global optimum - Convergence-Speed of convergence. Unconstrained optimization: One dimensional minimization - Elimination methods: Fibonacci & Golden section search - Gradient methods - Steepest descent method. Constrained optimization: Constrained optimization with equality and inequality constraints. Kelley's convex cutting plane algorithm - Gradient projection method - Penalty Function methods.

Module IV: (12 Hours)

Constrained optimization: Lagrangian method - Sufficiency conditions - Kuhn-Tucker optimality conditions- Rate of convergence - Engineering applications Quadratic programming problems-Convex programming problems.

References:

1. David G Luenberger, *Linear and Non Linear Programming*, 2nd Ed, Addison-Wesley.
2. S.S.Rao, *Engineering Optimization.; Theory and Practice*; Revised 3rd Edition, New Age International Publishers, New Delhi
3. S.M. Sinha, *Mathematical programming: Theory and Methods*, Elsevier, 2006.
4. Hillier and Lieberman *Introduction to Operations Research*, McGraw-Hill, 8th edition, 2005.
5. Saul I Gass, *Linear programming*, McGraw-Hill, 5th edition, 2005.
6. Bazarra M.S., Sherali H.D. & Shetty C.M., *Nonlinear Programming Theory and Algorithms*, John Wiley, New York, 1979.
7. Kalyanmoy Deb, *Optimization for Engineering: Design-Algorithms and Examples*, Prentice Hall (India), 1998.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 302(D): MARKOV MODELING AND QUEUING THEORY

Teaching scheme **Credits:** 4

3 hours lecture & 1 hour tutorial per week

Objectives:

- *To give an idea of different models used in queuing theory*
-

Module I: (13 hours)

Stochastic Processes: Renewal Processes - Reward and Cost Models, Poisson Process; Point Processes; Regenerative Processes; Renewal Theorems.

Module II: (13 hours)

Markov Models: Discrete Time Markov Chain - Transition Probabilities, Communication Classes, Irreducible - Chains; Continuous Time Markov Chain - Pure-Jump Continuous-Time Chains, Regular Chains, Birth and Death Process, Semi-Markov Processes.

Module III: (13 hours)

Single Class & Multi-class Queuing Networks: Simple Markovian queues; M/G/1 queue; G/G/1 queue; Open queuing networks; Closed queuing networks; Mean value analysis; Multi-class traffic model; Service time distributions; BCMP networks; Priority systems.

Module IV: (13 hours)

Time Delays and Blocking in Queuing Networks: Time delays in single server queue; Time delays in networks of queues; Types of Blocking; Two finite queues in a closed network; Aggregating Markovian states.

References:

1. Ronald W. Wolff, Stochastic Modeling and The Theory of Queues, Prentice-Hall International, Inc, 1989.
2. Peter G. Harrison and Naresh M. Patel, Performance Modeling of Communication Networks and Computer Architectures, Addison-Wesley, 1992.
3. Gary N. Higginbottom, Performance Evaluation of Communication Networks, Artech House, 1998
4 Anurag Kumar, D. Manjunath, and Joy Kuri, Communication Networking: An Analytical Approach, Morgan Kaufman Publ. 2004.
1. D. Bertsekas and R. Gallager, Data Networks, Prentice Hall of India, 2001.
2. Ross, K.W., Multiservice Loss Models for Broadband Telecommunication Networks, Springer-Verlag, 1995.
3. Walrand, J., An Introduction to Queueing Networks, Prentice Hall, 1988.
4. Cinlar, E., Introduction to Stochastic processes, Prentice Hall, 1975.
5. Karlin, S. and Taylor, H., A First course in Stochastic Processes, 2nd edition Academic press, 1975.

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of all whichever suits best. There will be minimum of two tests per subject. The assessment details are to be announced right at the beginning of the semester by the teacher.

End semester Examination: 100 marks

Question pattern: Answer *ANY* 5 questions by choosing at least *ONE* question from each module.

Module I	Module II	Module III	Module IV
Question 1: 20 marks Question 2: 20 marks	Question 3: 20 marks Question 4: 20 marks	Question 5: 20 marks Question 6: 20 marks	Question 7: 20 marks Question 8: 20 marks

ESP 10 303: INDUSTRIAL TRAINING

Teaching scheme: 1 hour per week **Credits:** 1

The students have to undergo an industrial training of minimum two weeks in a Chemical industry during the semester break after second semester and complete within 15 calendar days from the start of third semester. The students have to submit a report of the training undergone and present the contents of the report before the evaluation committee constituted by the department. An internal evaluation will be conducted for examining the quality and authenticity of contents of the report and award the marks at the end of the semester.

Internal continuous assessment: Marks 50

ESP 10 304(P): MASTERS RESEARCH PROJECT (PHASE – I)

Teaching scheme: 22 hours per week **Credits:** 6

Objective:

- *To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.*

The project work can be a design project / experimental project and or computer simulation project on chemical engineering or any of the topics related with chemical engineering stream. The project work is allotted individually on different topics. The students shall be encouraged to do their project work in the parent institute itself. If found essential, they may be permitted to continue their project outside the parent institute subject to the conditions in clause 10 of M.Tech regulations. Department will constitute an Evaluation Committee to review the project work. The Evaluation committee consists of at least three faculty members of which internal guide and another expert in the specified area of the project shall be two essential members.

The student is required to undertake the masters research project phase-I during the third semester and the same is continued in the 4th semester.(Phase-II). Phase-I consists of preliminary thesis work, two reviews of the work and the submission of preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review evaluates the progress of the work, preliminary report and scope of the work which is to be completed in the 4th semester.

Internal Continuous assessment:

First Review:

Guide	50 marks
Evaluation Committee	50 marks

Second review:

Guide	100 marks
Evaluation Committee	100 marks
Total	**300 marks**

FOURTH SEMESTER

ESP 10 401(P): MASTERS RESEARCH PROJECT (PHASE - 2)

Teaching scheme: 30 hours per week **Credits:** 12

Objectives:

To improve the professional competency and research aptitude by touching the areas which otherwise not covered by theory or laboratory classes. The project work aims to develop the work practice in students to apply theoretical and practical tools/techniques to solve real life problems related to industry and current research.

Masters Research project phase-II is a continuation of project phase-I started in the third semester. Before the end of the fourth semester, there will be two reviews, one at middle of the fourth semester and other towards the end. In the first review, progress of the project work done is to be assessed. In the second review, the complete assessment (quality, quantum and authenticity) of the Thesis is to be evaluated. Both the reviews should be conducted by guide and Evaluation committee. This would be a pre qualifying exercise for the students for getting approval for the submission of the thesis. At least one technical paper is to be prepared for possible publication in journal or conferences. The technical paper is to be submitted along with the thesis. The final evaluation of the project will be external evaluation.

Internal Continuous assessment:

First review:

Guide	50 marks
Evaluation committee	50 marks

Second review:

Guide	100 marks
Evaluation committee	100 marks