UNIVERSITY OF CALICUT

SCHEME AND SYLLABI FOR

M-Tech

in

COMMUNICATION ENGINEERING AND SIGNAL PROCESSING

(2010 Admission onwards)
Scheme of M-Tech programme in Communication Engineering and Signal Processing

**SEMESTER I**

<table>
<thead>
<tr>
<th>Sl. no</th>
<th>Course code</th>
<th>Subject</th>
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L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

**ELECTIVE I**

ECS10 105 (A): Information Theory
ECS10 105 (B): Adaptive Signal Processing
ECS10 105 (C): Radio Frequency Integrated Circuits and Systems
ECS10 105 (D): Digital Image Processing

**Note:** 6 hours/week is meant for departmental assistance by students.
# SEMESTER II

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L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

**ELECTIVE II**

ECS10 204 (A): Multirate Signal Processing and Filter Banks

ECS10 204 (B): Spectral Analysis of Signals

ECS10 204 (C): Spread Spectrum and CDMA Systems

ECS10 204 (D): Markov Modeling and Queuing Theory

**ELECTIVE III**

ECS10 205 (A): Communication Switching Theory

ECS10 205 (B): Wavelets

ECS10 205 (C): Communication Networks

ECS10 205 (D): System design Using Embedded Processors

**Note:** 6 hours/week is meant for departmental assistance by students.
## SEMESTER III

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L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

### ELECTIVE IV

ECS10 301 (A): Signal Compression – Theory and Methods
ECS10 301 (B): Speech and Audio Processing
ECS10 301(C): Biomedical Signal Processing
ECS10 301 (D): DSP Algorithms and Architectures

### ELECTIVE V

ECS10 302 (A): Linear Systems Theory
ECS10 302 (B): Linear and Nonlinear Optimization
ECS10 302 (C): Transform Theory
ECS10 302 (D): Information Hiding and Data Encryption

Note: The student has to undertake the departmental work assigned by HOD
### SEMESTER IV

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L-Lecture; T-Tutorial; P-Practical; ICA-Internal Continuous Assessment; ESE-End Semester Examination

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

### GRAND TOTAL FOR ALL SEMESTERS

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Objective: This course is intended to provide the necessary Mathematical foundation needed for the subjects to be dealt with in the program. After the completion of the course, the student should have a thorough understanding of Linear Algebra, Random Processes and their applications.

Module I (14 hours)
Linear Algebra: Vector spaces, subspaces, Linear dependence, Basis and Dimension, Inner product spaces, Gram-Schmidt Orthogonalization Procedure, Linear transformations, Kernels and Images, Matrix representation of linear transformation, Change of basis, Eigen values and Eigen vectors of linear operator, Quadratic form.

Module II (14 hours)

Module III (13 hours)
Continuous Time Markov Chains: General pure Birth processes and Poisson processes, Birth and death processes, Finite state continuous time Markov chains

Module IV (13 hours)
References:


Examination pattern

The question paper shall contain 7 questions, choosing at least one from each module but not exceeding two from any one of the modules. 5 full questions out of 7 questions are to be answered

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module 1</th>
<th>Module 2</th>
<th>Module 3</th>
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</table>
Objectives: This course provides a thorough understanding of the principles of Digital Communication. It addresses the issues related the recent developments in the area of Modern Communication.

Module I (12 hours)
Random Process: Review of Random Process: 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 (14 hours)
Communication over Additive Gaussian Noise Channels, Characterization of Communication Signals and Systems: Signal space representation-Overview, Signal detection in Gaussian channels.
Optimum 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.

Module III (14 hours)
Digital Communication over Fading Channels: Characterization of Fading Multipath Channels: Statistical Models for Fading Channels, Time Varying Channel Impulse response, Narrow band Fading Models, Wideband Fading Models, Channel Correlation Functions, Key Multi path parameters, Rayleigh and Rician Fading Channels. Optimum non-coherent receiver in random amplitude, random phase channels: Performance of non-coherent receiver in random amplitude, random phase channels, Performance in Rayleigh and Rician channels, Performance of digital Modulation schemes such as BPSK, QPSK, FSK, DPSK etc over wireless Channels.

Module IV (14 hours)
References:


Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks

Question pattern:

Answer any 5 questions by choosing at least one question from each module.

<table>
<thead>
<tr>
<th>Module 1</th>
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Objectives: This is an extension of the principles of Digital Signal Processing, introduced in the undergraduate level. Upon completion of the course, the student must be able to design and implement various systems like filter banks, implement different means of spectral estimation and apply Digital Signal Processing principles to process speech and Radar signals.

Module I (14 hours)

Module II (14 hours)
Multirate system fundamentals: Basic multirate operations – up-sampling and down sampling, Time domain and frequency domain analysis– Identities of multirate operations– Interpolator and decimator design– Rate conversion– Polyphase representation. Multirate filter banks.

Module III (14 hours)
Parametric and non-parametric spectral estimation: Estimation of the Autocorrelation and power spectrum of random signals: periodogram- DFT in power spectrum estimation
Non-parametric spectral estimation: Barlett method, Welch method, Blackman and Tukey Method-Performance characteristics-Computational requirements.

Module IV (12 hours)
Application of DSP to Speech and Radar signal processing : Fourier analysis of non-stationary signals-speech and radar signals. Fourier analysis of stationary signals using Periodogram.
References:


Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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**Objectives:** Upon completion of this course, the student will be able to design systems using the popular Digital Signal Processor Family TMS 320 C64X.

**Module I (14 Hours)**
Introduction to a popular DSP from Texas Instruments, CPU Architecture, CPU Data Paths and Control, Timers, Interrupts, Internal Data/Program Memory, External Memory Interface, pipelining

**Module II (14 Hours)**
Programming: Instruction Set and Addressing Modes, TMS 320C64X CPU Simple programming examples using C and assembly.
Typical DSP development system, support tools and files, compiler, assembler, Code composer studio, CODECs

**Module III (13 Hours)**

**Module IV (13 Hours)**
DSP Application examples in CODEC: PLL, Image processing, FSK modems, Voice detection and reverse playback, Multirate filters, PID controllers.
Current Trends in Digital Signal Processors, DSP Controllers

**References:**
1. Digital Signal Processing and Application with C6713 and C6416 DSK, Rulph Chassaing, Worcester Polytechnic Institute, A Wiley-Interscience Publication
2. Digital Signal Processing Implementation using the TMS320C6000 DSP Platform, 1st Edition; Naim Dahnoun
6. DSP Applications using 'C' and the TMS320C6X DSK, 1st Edition; Rulph Chassaing

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
**Question pattern:**
Answer any 5 questions by choosing at least one question from each module.

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## ELECTIVE I

**ECS10 105(A) INFORMATION THEORY**  
*Hours/Week: Lecture – 3 hours Tutorial – 1 hour*  
*Credits – 4*

**Objectives:** Gives a detailed concepts in Information Theory. Upon completion of this course, the student will have a deep understanding of

- Information and its measurement
- Various source coding schemes
- Concept of Channel capacity for both discrete and continuous channels and Shannon’s theorems
- Rate distortion theory and its applications

### Module I (13 hours)


### Module II (13 hours)


### Module III (14 hours)

Channel Capacity: Properties-Data transmission over Discrete Memoryless Channels-Capacity of Binary symmetric and Binary Erasure channels-Computing channel capacity- Arimoto-Blahut algorithm- Fano’s inequality- Shannon’s Channel Coding Theorem

### Module IV (14 hours)

Continuous Sources and Channels: Information measure for Continuous sources and channels-Differential Entropy- Joint, relative and conditional differential entropy- Mutual information- Waveform channels- Gaussian channels- Mutual information and Capacity calculation for Band limited Gaussian channels- Shannon limit.

Rate Distortion Theory: Rate Distortion Function - Properties – Calculation of Rate Distortion Function for binary source Gaussian
References:

1. T. Cover and Thomas, “Elements of Information Theory”, John Wiley & Sons
4. T. Bergu, “Rate Distortion Theory a Mathematical Basis for Data Compression” PH Inc.

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks

Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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Objectives: This course is intended to impart to the students the principles of

- Adaptive signal processing,
- different algorithms used for design of Adaptive Filters,
- Performance evaluation of systems
- Modelling systems like multipath communication channel
- Synthesis of filters.

Module I  (14 Hours):

Module II  (14 Hours):

Module III  (13 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  (13 Hours):
Applications-adaptive modelling and system identification-adaptive modelling for multipath communication channel, geophysical exploration, FIR digital filter synthesis, inverse adaptive modelling, equalization, and deconvolution-adaptive equalization of telephone channels-adapting poles and zeros for IIR digital filter synthesis

References:
2. Simon Haykin, Adaptive Filter Theory, Pearson Education.

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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Objectives: Provides a detailed theory of the VLSI implementation of circuits used in Signal processing. Upon completion of the course, the student will have a thorough understanding of

- Modelling a MOS transistor at low and high frequencies
- Analysis and design of CMOS amplifiers, Opamps and switches
- Theory, application and implementation of switched capacitor circuits.

Module I  (12 Hours)
Analog, Digital and Sampled analog signals and systems, Transformation methods, Design of Sampled data filters from Continuous time models. The MOS transistor, small signal equivalent, short channel effects, Low frequency and High frequency models.

Module II  (14 Hours)

Module III  (14 Hours)

Module IV  (14 Hours)
Switched Capacitor Circuits: Switched Capacitor Filters, Integrated Filters, Switched Capacitor Integrators, Stray insensitive integrators, Second order sections; cascade filter design, Switched capacitor filter design, Switched Capacitor Amplifiers and Integrators. Application of Switched Capacitor circuits in Data modems/ Digital voice transmission systems.

References :
2. CMOS Analog Circuit Design; Phillip E. Allen, Douglas R. Holberg; Oxford Univesity Press
3. Analysis and Design of Analog Integrated Circuits; Gray, Hurst, Lewis and Meyer; Wiley, India.
Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks

Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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Objectives: Upon completion of this course, the student will have an understanding of various Monochrome and Colour Image processing methods, Image enhancement, Image segmentation, and image compression methods. The students are exposed to popular image compression standards like JPEG and JPEG 2000.

Module I  (14 Hours)
Fundamental steps in digital image processing, Components of an image processing system, Image sampling and quantization, Some basic relationships between pixels, Linear and nonlinear operations, 2D convolution- 2D FFT, 2D-wavelet, contourlet transforms.

Module II  (14 Hours)

Module III  (13 Hours)
Colour image processing: colour models, pseudo-colour processing, image compression: image compression models, loss-less and lossy compression, JPEG and JPEG 2000 - morphological image processing: dilation and erosion, opening and closing, some basic morphological algorithms.

Module IV  (13 Hours)
Image segmentation: Detection of discontinuities, Edge linking and boundary detection, Thresholding, Region based segmentation, applications of digital image processing in medical, recent developments, Image fusion, pseudo colouring.

References:
Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks

Question pattern:
Answer any 5 questions by choosing at least one question from each module.

<table>
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Objectives: This course enables the students to explore the concepts of designing and implementing various systems using DSP kits, Simulate and study various systems using MATLAB.

Tools:
- Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool, DSP Kits.

1. Generation of waveforms and observation of the output using the graphical display utility of integrated Development Environment (IDE)
2. Generation of a sine function and sampling of generated sine waveform. Observation of the spectrum and windowing effect.
3. Implementation of linear convolution on 1D and 2D signals
4. Implementation of circular convolution on 1D and 2D signal
5. Implementation of FIR filter (Filter coefficients may be obtained from MATLAB)
6. Implementation of FIR filter (Filter coefficients may be obtained from MATLAB)
7. Verification of FIR and IIR filters by inputting a signal from the signal generator (configure the codec in the DSP development board)
8. Implementation of simple algorithms in audio and image processing
9. Real time data exchange between MATLAB and IDE to transfer the data from computer to Development kit.
10. Assembly language programming
   i) Implementation of linear convolution
   ii) Implementation of circular convolution
11. Mini Project- Related to the area of advanced communication /signal processing using the development kit.

Internal continuous assessment: 100 marks

Regularity – 30%
Record – 20%
Test and Viva – 50%
Objectives: This course is intended for
- Increasing the breadth of knowledge
- Enhancing the ability of self study
- Improving presentation and communication skills
- Augmenting the skill of Technical Report Writing.

Each student is required to choose a topic of their interest from Communication / Signal Processing or related topics from outside the syllabus and present a topic for about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks
CORE SUBJECTS

| ECS10 201 | ESTIMATION AND DETECTION  
Hours/Week: Lecture – 3 hours Tutorial – 1 hour | Credits – 4 |
|-----------|---------------------------------|------------|

Objectives: Upon completion of this course, the students will have an understanding of the different criteria and methods used in detection theory, Methods and measures of estimation, Properties and characteristics of estimators and principles of state estimation.

**Module I (13 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 (13 hours)**
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, E_ciency, 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:**


Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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ECS10 202 | WIRELESS COMMUNICATION  
*Hours/Week: Lecture – 3 hours Tutorial – 1 hour*  
| Credits – 4  

Objectives: This course gives a thorough treatment of the principles of Wireless Mobile communication. Upon completion of the course, the student will have knowledge about:
- Different types of fading in wireless channels and their mitigation
- Diversity schemes
- MIMO channels
- Cellular communication systems – GSM and CDMA
- Cellular communication standards

**Module I (13 hours)**

**Module II (13 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.

**Module III (13 hours)**

**Module IV (15 hours)**
Cellular Wireless Communication Standards
Second generation cellular systems: Brief discussion specifications on GSM, CDMA, Wideband CDMA, Wi-Fi, Wi-max
Introduction to multicarrier Communication: OFDM, MCCDMA

References:


Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
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Objectives: Provides a thorough understanding of the theory and design of Channel codes for error control. The course begins with an introduction to the basic Mathematical concepts and develops systematically through Linear block codes to the Convolutional Codes.

Module I (13 hours)

Introduction to algebra: Groups- Rings- Fields- Binary Field arithmetic-Arithmetic of Galois Field- Integer Ring- Finite Field based on Integer Ring- Polynomial Rings- Finite Field based on Polynomial Rings-Primitive elements- Construction and basic properties of Finite Fields- Computations using Galois Field arithmetic- Vector spaces- Vector subspaces- Linear independence.

Module II (13 hours)

Linear Block Codes Matrix description of Linear Block codes- Minimum Distance of a Block code-- Error detecting and correcting capabilities of a Block code- Standard Array and Syndrome decoding- Hamming codes- Perfect and Quasi-perfect codes- Extended codes- Hadamard codes.

Module III (13 hours)

Cyclic Codes: Polynomial description-Minimal polynomial and conjugates- Generator and parity-Check matrices of cyclic codes- Encoding of cyclic codes- Syndrome computation- Error detection - decoding of cyclic codes- Cyclic Hamming codes- Binary Golay codes- BCH codes-Performance- Decoding of BCH codes, Reed Solomon codes-Encoding and Decoding

Module IV (15 hours)

References:

2. R.E. Blahut, “Theory and Practice of Error Control Coding”, MGH.

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
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ELECTIVE II

MULTIRATE SIGNAL PROCESSING AND FILTER BANKS

ECS10 204(A)  

Credits – 4

Objectives: Upon completion this course, the student will have deep understanding of the theory, design and applications of

- QMF banks
- Perfect Reconstruction filters
- Cosine modulated Filter banks.

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

Module II  (14 Hours)
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  (13 Hours)
Perfect reconstruction (PR) filter banks: Para-unitary 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  (13 Hours)

References:
1. P.P. Vaidyanathan. “Multirate systems and filter banks.” Prentice Hall. PTR.
Hill.
and Applications”, 3rd Edn. Prentice Hall India.

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments,
seminars or a combination of these. There will be a minimum of two tests in each
subject.

**End semester Examination: 100 marks**
**Question pattern:**
Answer any 5 questions by choosing at least one question from each module.

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Objectives: This course deals with the different methods for Power Spectrum Estimation. Upon completion of this course, students will be well versed with

- Power and Energy spectral density of signals
- Parametric and non parametric methods of estimation of PSD
- Filter bank methods of spectral analysis.

Module I (14 Hours)
Power Spectral Density: Energy spectral density of deterministic signals, Power spectral density of random signals, Properties of PSD.

Module II (14 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 (13 Hours)

Module IV (13 Hours)
Filterbank methods: Filterbank interpolation of periodogram, Slepia base-band filters, refined filterbank 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
3 Marple, Introduction to Spectral Analysis, Prentice Hall
Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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Objectives: Upon completion of this course, students will have deep insight on spread spectrum communication systems. The course imparts knowledge about principle of spread spectrum and use of orthogonal codes, performance of CDMA systems under AWGN and fading channels, use of CDMA systems in cellular communication and important CDMA standards.

Module I  (14 Hours)
Introduction to spread spectrum communication, pulse noise jamming, low probability of detection, direct sequence spread spectrum, frequency-hopping and time-hopping spread spectrum systems, correlation functions, spreading sequences- maximal-length sequences, gold codes, Walsh orthogonal codes- properties and generation of sequences. Synchronization and Tracking: delay lock and tau-dither loops, coarse synchronization- principles of serial search and match filter techniques.

Module II  (14 Hours)
Performance of spread spectrum system under AWGN, multi-user Interference, jamming and narrow band interferences Low probability of intercept methods, optimum intercept receiver for direct sequence spread spectrum, Error probability of DS-CDMA system under AWGN and fading channels, RAKE receiver

Module III  (14 Hours)
Basics of spread spectrum multiple access in cellular environments, reverse Link power control, multiple cell pilot tracking, soft and hard handoffs, cell coverage issues with hard and soft handoff, spread spectrum multiple access outage, outage with imperfect power control, Erlang capacity of forward and reverse links. Multi-user Detection -MF detector, decorrelating detector, MMSE detector. Interference Cancellation: successive, Parallel Interference Cancellation, performance analysis of multiuser detectors and interference cancellers.

Module IV  (14 Hours)
General aspects of CDMA cellular systems, IS-95 standard, Downlink and uplink, Evolution to Third Generation systems, WCDMA and CDMA-2000 standards, Principles of Multicarrier communication, MCCDMA and MC-DS-CDMA.

References:

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**

Answer any 5 questions by choosing at least one question from each module.

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Objectives: This course is a thorough treatment of Markov chains and Markov models of systems. It also deals with the essential queuing theory and application of Markov models in the analysis of queuing networks.

Module I  (14 Hours)
Stochastic Processes: Renewal Processes - Reward and Cost Models, Poisson Process; Point Processes; Regenerative Processes; Renewal Theorems.

Module II  (14 Hours)

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:
   Academic press.

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

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

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ELECTIVE III

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<tr>
<th>ECS10 205(A)</th>
<th>COMMUNICATION SWITCHING THEORY</th>
<th>Credits – 4</th>
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<td>Hours/Week: Lecture – 3 hours Tutorial – 1 hour</td>
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Objectives: Upon completion of this course, the students will have a deep knowledge about the Communication switching methods, blocking in switching networks, traffic analysis and multiplexing systems.

Module I (14 Hours)

Module II (14 Hours)

Module III (13 Hours)

Module IV (13 Hours)
Statistical multiplexing: blocking analysis in circuit multiplexed networks, with single rate or Multirate traffic- Models for performance analysis of integrated packet networks; deterministic models, worst case analysis; stochastic models, large deviations analysis. The effective Bandwidth approach for Admission control - Models for traffic flow in packet networks, long range dependence and self similar processes.

References:
1. A. Kumar, D. Manjunath, J. Kuri, Communication Networking: An Analytical

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
**Question pattern:**
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Objectives: This course provides the students with a thorough foundation of Wavelet theory, construction of wavelets and their applications in signal analysis.

Module I  (14 Hours)

Module II  (14 Hours)
Wavelets: The basic functions, Specifications, Admissibility conditions, Continuous wavelet transform (CWT), Discrete wavelet transform (DWT). The multiresolution analysis, MRA axioms, Construction of an MRA from scaling functions - The dilation equation and the wavelet equation, Compactly supported orthonormal wavelet bases - Necessary and sufficient conditions for orthonormality. Regularity and selection of wavelets: Smoothness and approximation order - Analysis in Soboleve space, Criteria for wavelet selection with examples.

Module III  (13 Hours)
Splines, Cardinal B-spline MRA, Subband filtering schemes, Compactly supported orthonormal wavelet bases. Wavelet decomposition and reconstruction of functions in $L^2(\mathbb{R})$. Fast wavelet transform algorithms - Relation to filter banks, Wavelet packets – Representation of functions, Selection of basis.

Module IV  (13 Hours)
Biorthogonality and biorthogonal basis, Biorthogonal system of wavelets - construction, The Lifting scheme.

References:
11. Ingrid Daubechies, “Ten lectures on wavelets” SIAM.

**Internal continuous assessment: 100 marks**

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**
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Objectives: This course provides a deep knowledge on Internet architecture, Quality of service issues in broadband networks, and Statistical multiplexing of communication networks.

Module I  (14 Hours)

Module II  (14 Hours)

Module III  (13 Hours)
Introduction to Queuing theory: Markov chain- Discrete time and continuous time Markov chains- Poisson process- Queuing models for Data gram networks- Little’s theorem- M/M/1 queuing systems- M/M/m/m queuing models- M/G/1 queue- Mean value analysis.

Module IV  (13 Hours)
Statistical Multiplexing in Communication Networks: Multiplexing; Network performance and source characterization; Stream sessions in packet networks - deterministic analysis, stochastic analysis, circuit multiplexed networks.

References:
Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
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Objectives: Upon completion of this course, the students will be able to program and interface PIC microcontroller, design and implement systems using PIC microcontrollers, development of embedded systems, gain knowledge about real time operating systems.

Module I (14 hours)
Microcontroller: Brief history of the PIC microcontroller - PIC18 features and block diagram-PIC18 Architecture and assembly language Programming, SFRs, RISC architecture in the PIC, Branch, Call, Time delay loop, PIC I/O Port programming, addressing modes, look-up table and table processing, Bank switching in the PIC18, Data types and time delays in C, I/O Port programming in C, Bit-addressable I/O programming, logic operations in C, Data conversion programs in C.

Module II (14 hours)
PIC Peripherals and Interfacing: PIC18 timer programming in assembly and C, Serial Port programming in assembly and C, Interrupt programming in assembly and C, ADC and DAC interfacing, CCP and ECCP programming, DC Motor interfacing and PWM.

Module III (13 hours)
Introduction to Embedded Systems: Characteristics of Embedded systems, Software embedded into a system- Device Drivers and Interrupt Servicing mechanisms.
Inter-process Communication and Synchronisation of Processes, Tasks and Threads: Multiple Processes in an Application - Data sharing by multiple tasks and routines-Inter Process Communication

Module IV (13 hours)
Real Time Operating Systems:
Operating System Services, I/O Subsystems - Network Operating Systems - Real Time and Embedded System Operating systems
Interrupt routines in RTOS Environments - RTOS Task Scheduling models, Interrupt Latency and response Times - Standardization of RTOS - Ideas of Embedded Linux. Case study using ARM processor/PIC microcontroller

References:
1. PIC Microcontroller and Embedded Systems using assembly and C for PIC18 – Muhammad Ali Mazidi, Roinid D. Mckinay, Danny Causey; Pearson Education.
2. Design with PIC microcontroller – John Peatman; Printice Hall
4. Real-time Systems - Jane Liu, PH 2000
6. Embedded Software Primer - Simon, David E.
7. Tornado API Programmers guide

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
**Question pattern:**
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**ECS10 206(P)** | **ADVANCED COMMUNICATION LAB** | **Credits – 2**
---|---|---
**Hours/Week: Practical** | **2 hours**

**Objectives:** Upon completion, the students will
- Be able to design enlisted experiments and implement using hardware
- Acquire sufficient expertise in simulating these systems using MATLAB
- Be able to design and implement self standing systems of their choice with sufficient complexity.

**Tools:**
Numerical Computing Environments – GNU Octave or MATLAB or any other equivalent tool

**Lab:**
1. Implementation of digital modulation schemes – BASK, BFSK, BPSK. Plot BER vs $E_b / N_0$ in AWGN channels.
2. Performance comparison of QPSK, DPSK, MSK & GMSK.
4. Comparison of diversity combining techniques – SC, EGC & MRC.
5. Simulation of CDMA systems.
8. Carrier recovery and bit synchronization.
9. Implementation of multicarrier communication.
11. Constellation diagram of various digital modulation schemes.

**Miniproject:**
12. Miniproject in the area of advanced communication/signal processing

**Internal continuous assessment: 100 marks**
- Regularity – 30%
- Lab Record – 10%
- Test and Viva – 25%
- Miniproject Report – 10%
- Demonstration and presentation – 25%
Objectives: This course is intended for
- Increasing the breadth of knowledge
- Enhancing the ability of self study
- Improving presentation and communication skills
- Augmenting the skill of Technical Report Writing.

Each student is required to choose a topic of their interest from Communication / Signal Processing or related topics from outside the syllabus and present a topic for about 45 minutes. A committee consisting of at least three faculty members shall assess the presentation. Internal continuous assessment marks are awarded based on the relevance of the topic, presentation skill, quality of the report and participation.

Internal continuous assessment: 100 marks
Objectives: Upon completion of this course, the students will get a deep understanding about the various source coding techniques used for signal compression. The course also provides knowledge about important data, audio, image and video compression standards.

Module I  (14 Hours)

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  (14 Hours)
References:
5. Toby Berger, Rate Distortion Theory: A Mathematical Basis for Data Compression, Prentice Hall, Inc.

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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Objectives: This course imparts a detailed knowledge of modelling of speech signals, subband coding of speech, vocoders, Homomorphic speech processing, Voice morphing, speaker identification and speaker recognition systems, and processing of music.

Module I (13 Hours)

Module II (14 Hours)

Module III (13 Hours)

Module IV (14 Hours)
References:

Internal continuous assessment: 100 marks

Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks

Question pattern:
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Objectives: Upon completion of this course, students will have thorough understanding of the various biomedical signals, their processing using standard signal processing tools, cardio vascular and neurological applications of signal processing, modeling of EEG, EEG segmentation and Medical image formats.

<table>
<thead>
<tr>
<th>Module I  (14 Hours)</th>
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<tbody>
<tr>
<td>Introduction to Biomedical Signals - Examples of Biomedical signals - ECG, EEG, EMG - 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 &amp; Stochastic signals - spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments</td>
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<tr>
<th>Module II  (13 Hours)</th>
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<th>Module III  (13 Hours)</th>
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<tr>
<th>Module IV  (14 Hours)</th>
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<tbody>
<tr>
<td>Neurological Applications : The electroencephalogram - EEG rhythms &amp; 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 &amp; their characteristics and processing - Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis - correlation analysis of EEG channels - coherence analysis of EEG channels. Medical Image format - DICOM, HL-7, PACS</td>
<td></td>
</tr>
</tbody>
</table>
References:
4. Semmlow, Marcel Dekker “Biosignal and Biomedical Image Processing”, 2004
5. Enderle, “Introduction to Biomedical Engineering,” 2/e, Elsevier, 2005

Internal continuous assessment: 100 marks
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

End semester Examination: 100 marks
Question pattern:
Answer any 5 questions by choosing at least one question from each module.

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Objectives: Upon completion of this course, the students will have detailed knowledge of design of DSP algorithms, simulation of DSP systems in C and modeling using VHDL, VLSI implementation of algorithms, synthesis of DSP modules and modeling the synthesis in VHDL.

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, nonrecursive and lattice), algorithmic simulations of DSP systems in C, behavioral modeling in HDL.

System modeling and performance measures.

Module II  (14 Hours)
Circuits and DSP Architecture Design: Fast filtering algorithms (Winograd's, FFT, short-length FIR), retiming and pipelining, block processing, folding, distributed arithmetic architectures, VLSI performance measures (area, power, and speed), structural modeling in VHDL, Analog signal processing for fast operation, Impact of nonideal characteristics of analog functional blocks on the system performance.

Module III  (13 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  (13 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:
3. Digital Signal Processing with Field Programmable Gate Array, Uwe Meyer-Baese, Springer-Verlag
7. Computer Arithmetic: Algorithms and Hardware Designs, Parhami, Behrooz, Oxford University Press,

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End semester Examination: 100 marks
Question pattern:
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ELECTIVE V

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<tr>
<th>ECS10 302(A)</th>
<th>LINEAR SYSTEMS THEORY</th>
<th>Credits – 4</th>
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<td>Hours/Week: Lecture – 3 hours Tutorial – 1 hour</td>
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Objectives: Upon completion of this course, the students will have deep knowledge and insight on vector space representation of signals, bases, orthonormal bases, analysis of linear systems, eigen values and eigen vectors, infinite dimensional vector spaces and Hilbert spaces.

Module I  (14 Hours)

Module II  (13 Hours)

Module III  (13 Hours)

Module IV  (14 Hours)

References:
1. Sheldon Axler, Linear Algebra Done Right, Springer
3. Paul R. Halmos, Finite-Dimensional Vector Spaces, Springer
5. Arch W. Naylor and George R. Sell, Linear Operator Theory in Engineering and Science, Springer

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**

**Question pattern:**
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Objectives: The objective of this course is to provide thorough Mathematical foundation for linear and non-linear optimization techniques. Upon completion of this course, the student will have deep understanding of Vector spaces, linear transformation, linear optimization algorithms, sensitivity analysis, constrained and unconstrained optimization and Engineering applications of these methods.

Module I (14 Hours)

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 (13 Hours)
Module IV  (13 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.

Internal continuous assessment: 100 marks
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End semester Examination: 100 marks
Question pattern:
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**Objectives:** The primary objective is to provide deep understanding of the various transforms used in signal analysis. Upon completion of this course, the student will have sound knowledge in the methods of Laplace transform, Z-transform, the Fourier transforms, Wavelet transform, DCT and other transforms, their applications in various fields like image compression. The course also introduces new transforms like CTT and WBCT.

**Module I** (14 Hours)
Introduction and Review: Introduction on the integral and discrete transforms and their applications- Need of reversibility- basis – Requirements of transforms- (Linear algebraic approach) - Review of Laplace Transform, Z transform, Continuous Fourier Transform, Discrete Time Fourier transform, Discrete transform-Relations between the transforms

**Module II** (14 Hours)

**Module III** (13 Hours)
Discrete Transforms and Applications: Discrete Cosine transform and applications in JPEG - Discrete STFT (DSTFT) – Application of DSTFT in audio signal processing.- Discrete Wavelet Transform (DWT) - lifting applied to DWT – Applications of DWT in audio signal processing - image compression (JPEG 2000) - At least one application of each transform in one dimensional, two-dimensional or three dimensional signals or multimedia signal processing (Example : compression, information security, watermarking , steganography, denoising, signal separation, signal classification).

**Module IV** (13 Hours)
New Transforms and Applications: Limitations of DWT in image processing - Contourlet transform (CTT) – Applications of CTT in image processing - Ridgelet and Curvelet transforms - New developments in DWT and CTT such as wavelet Based Contourlet Transform(WBCT)

**References:**
2. Integral and Discrete transforms with applications and error analysis, Abdul Jerri, Marcel Dekker Inc.
3. Integral Transforms and Their Applications  Lokenath Debnath, Dambaru Bhatta, Taylor & Francis Inc

**Internal continuous assessment: 100 marks**
Internal continuous assessment is in the form of periodical tests, assignments, seminars or a combination of these. There will be a minimum of two tests in each subject.

**End semester Examination: 100 marks**
**Question pattern:**
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Objectives: This course deals with the principles and implementation of secure communication. It extensively covers cryptography, steganography, their methods and applications.

Module I (14 Hours)

Module II (14 Hours)
Watermarking in spatial domain - Additive methods, spread spectrum based methods- Steganography in spatial domain - Information theoretic approach for watermarking - Watermarking and steganography in frequency domain – Based on Discrete cosine transform, Discrete Wavelet transform and Contourlet transform - different methods - Comparison between frequency domain and spatial domain methods

Module III (13 Hours)

Module IV (13 Hours)
Difference between steganography and cryptography - Encryption and decryption for Watermarks - Embedding and Extraction Procedures – Image hashing - Watermarking with Visual Cryptography - Analysis of different methods
References:

3. Fabien Petitcolas Stefan Katzenbeisser Information Hiding Techniques for Steganography and Digital Watermarking, Artech publishers

Internal continuous assessment: 100 marks
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End semester Examination: 100 marks

Question pattern:
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Objectives: Upon completion of Industrial Training,

- the student gains awareness of issues related to designing and maintaining sophisticated equipments, their management and adopting to new standards as when they are formed
- the student learns issues related to managing people in industries

The students have to undergo an industrial training of minimum two weeks in an industry dealing with communication/signal processing, during the semester break between semester II and semester III, and complete within 15 calendar days from the start of semester III. The students are required to submit a report of the training undergone and present the contents of the report before the evaluation committee. Evaluation committee will award the marks based on training quality, contents of the report and presentation.

Internal Continuous assessment: 50 Marks
Objectives: The main objective of the Master Research Project is to identify current issues in the area of Communication Engineering and Signal Processing. The ability of the student to address contemporary issues and to find practical solutions to the issues increases. Also, continued and self learning skill of the student is enhanced.

The project work can be a design project/experimental project and/or computer simulation project on any of the topics in communication/signal processing area. 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 master research project phase I during the 3rd semester and Phase II in the 4th semester. Phase I consists of preliminary thesis work, two reviews of the work and the submission of a preliminary report. First review would highlight the topic, objectives, methodology and expected results. Second review assesses the progress of the work, preliminary report and future plan of the work to be completed in the 4th semester. 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.
**Internal Continuous assessment:**

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<th>Guide</th>
<th>Evaluation Committee</th>
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<td>First Review</td>
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<td>Second Review</td>
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<td>Total</td>
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</table>
Master Research project phase II is a continuation of project phase I started in the 3rd semester. There would be two reviews in the 4th semester, first in the middle of the semester and the second at the end of the semester. First review is to evaluate the progress of the work. Second review would be a pre-submission presentation before the evaluation committee to assess the quality and quantum of the work done. This would be a pre-qualifying exercise for the students for getting approval by the Departmental committee 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:**

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