### Syllabus for PhD Course work

#### Course Structure

<table>
<thead>
<tr>
<th>SL No.</th>
<th>Course category</th>
<th>Course Code</th>
<th>Course Name</th>
<th>L</th>
<th>T</th>
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<th>Contact Hours</th>
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<tbody>
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<td>1.</td>
<td>Compulsory</td>
<td>EL 721</td>
<td>Research Methodology</td>
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- A student must select two courses from the elective list over and above the compulsory course.
- Students should require to appear in a comprehension examination involving courses in Sl. No. 1, 2 and two from the courses listed in Sl. No. 3.
- Students clearing the written comprehension examination shall require to make a presentation in a seminar called State of Art Seminar (SOAS) where the proposed research proposal shall be presented and discussed.
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**Objectives**
- Learn to focus on a research problem using scientific methods
- Learn methods to devise and design an experimentation set-up
- Learn basic instrumentation and data collection methods
- Learn parameter estimation and related modeling methods

**Unit 1: Research Problem**
Meaning of research problem, Sources of research problem, Criteria / Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

**Unit 2: Basic instrumentation**
Instrumentation schemes, Static and dynamic characteristics of instruments used in experimental set up, Performance under flow or motion conditions, Data collection using a digital computer system, Linear scaling for receiver and fidelity of instrument, Role of DSP is collected data contains noise.

**Unit 3: Applied statistics**
Regression analysis, Parameter estimation, Multivariate statistics, Principal component analysis, Moments and response curve methods, State vector machines and uncertainty analysis.

**Unit 4: Modelling and prediction of performance**
Setting up a computing model to predict performance of experimental system, Multiscale modelling and verifying performance of process system, Nonlinear analysis of system and asymptotic analysis, Verifying if assumptions hold true for a given apparatus setup, Plotting family of performance curves to study trends and tendencies, Sensitivity theory and applications.

**Unit 5: Developing a Research Proposal**
Format of research proposal, Individual research proposal, Institutional proposal

**Suggested Reading**
1. 'Research Methodology: A Step by Step Guide for Beginners' by Ranjit Kumar, 2nd Edition
2. Research Methodology: Methods and Trends by Dr. C. R. Kothari
3. Operational Research by Dr. S.D. Sharma, Kedar Nath Ram Nath & co.
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**Course Objective**

- To provide basic familiarization with the foundations of mathematics
- To provide the basic knowhow to use mathematical techniques for problem definition and derive solutions.

**Unit 1: Linear Algebra**  
Matrix Algebra, Systems of linear equations, Eigen values and eigen vectors.

**Unit II: Calculus**  
Mean value theorems, Theorems of integral calculus, Evaluation of definite and improper integrals, Partial Derivatives, Maxima and minima, Multiple integrals, Fourier series.

**Unit III: Vector identities**  
Directional derivatives, Line, Surface and Volume integrals, Stokes, Gauss and Green's theorems.

**Unit IV: Differential equations**  
First order equation (linear and nonlinear), Higher order linear differential equation with constant coefficients, Method of variation of parameters, Cauchy's and Euler's equations, Initial and boundary value problems, Partial Differential Equations and variable separable method.

**Unit V: Complex variables**  
Analytic functions, Cauchy's integral theorem and integral formula, Taylor's and Laurent' series, Residue theorem, solution integrals.

**Unit VI: Probability and Statistics**  
Sampling theorems, Conditional probability, Mean, median, mode and standard deviation, Random variables, Discrete and continuous distributions, Poisson, Normal and Binomial distribution, Correlation and regression analysis.

**Unit VII: Numerical Methods**  
Solutions of non linear-algebraic equations, single and multistep methods for differential equations.

**Unit IX: Transform Theory**  
Fourier transform, Laplace transform, Z transform.

**Suggested Reading**

Advanced Engineering Mathematics - Erwin Kreyszig, John Wiley & Sons
**Unit 1:** Introduction to Wireless Mobile Communications

History and evolution of mobile radio systems; Types of mobile wireless services / systems- Cellular, WLL, Paging, Satellite systems, Standards, Future trends in personal wireless systems

**Unit 2:** Cellular Concept and System Design Fundamentals

Cellular concept and frequency reuse, Multiple Access Schemes, channel assignment and handoff, Interference and system capacity, Trunking and Erlang capacity calculations; cellular concept, spectral efficiency; design parameters at base station: antenna configurations, noise, power and field strength; design parameters at mobile unit: directional antennas and diversity schemes: frequency dependency; noise; antenna connections; field component diversity antennas; signaling and channel access: word-error-rate, channel assignment;

**Unit 3:** Mobile Radio Propagation

Radio wave propagation issues in personal wireless systems, Representation of a mobile radio signal; Propagation models, propagation path loss and fading- causes, types of fading and classification of channels; prediction of propagation loss: measurements, prediction over flat terrain, point-to-point prediction, microcell prediction model; calculation of fades- amplitude fades, random PM and random FM, selective fading, diversity schemes, combining techniques, bit error-rate and word-error-rate; Multipath fading and Base band impulse respond models, parameters of mobile multipath channels, Antenna systems in mobile radio;

**Unit 4:** Modulation and Signal Processing

Analog and digital modulation techniques, Performance of various modulation techniques- Spectral efficiency, mobile radio interference: co-channel and adjacent-channel interference, intermodulation, intersymbol and simulcast interference; frequency plans: channelized schemes and frequency reuse, FDM, TDM, spread spectrum and frequency hopping, Error-rate, Power Amplification, Equalizing Rake receiver concepts, Diversity and space-time processing, Speech coding and channel coding

**Unit 5:** System Examples and Design Issues

Multiple Access Techniques- frequency division multiple access, time division multiple access, code division multiple access, space division multiple access, operational systems, Wireless networking, design issues in personal wireless systems; Cellular CDMA: narrow band and wide band signal propagation, spread spectrum techniques, capacities of multiple access schemes; micro cell systems: conventional cellular system, micro cell system design, capacity analysis.

**Suggested reading**

1. Wireless digital communications- K.Feher, PHI,
2. Wireless Digital Communications Principles and Practice - T.S.Rappaport, Pearson Education
4. Mobile Communications- Schiller, Pearson Education
5. Wireless Communications and Networks -Stallings, Pearson Education
6. Wireless Communication Systems -Wang and Poor, Pearson Education
Course Name: Information Theory
Contact Hours: 8

Course objective
The course is an advanced treatment of different coding methods associated with information systems.

Module 1

Review of sampling theorem-Practical aspects of sampling-quantization of analog signals-Spectra of Quantization-wave from coding- PCM, ADPCM, Delta modulation- ADM-Bit rate and SNR-calculation-Mean and prediction coding; Base band shaping, binary Data formats, NRZ, RZ, Manchester formats- Baseband transmission-ISI- Effect of ISI, Synchronization-application. correlative coding Eye Pattern-Adaptive equalization for data transmission data reception matched filter, Optimum SNR. Introduction to Information Theory: Information and Sources Uniquely Decodable Codes; Instantaneous codes-. Construction of an Instantaneous code; Kraft's Inequality. Coding Information Sources--: The Average length of a code;

Module 2

Encoding for special Sources; Shannon's Theorems. Shannon's theorem for the Binary Symmetric channel, Entropy and Source coding, Lossless coding techniques including Huffman codes, Arithmetic codes, Lempel-Ziv coding, Lossy coding techniques, Shannon coding theorem, Channel codes including Linear block codes, Cyclic codes, BCH codes Convolutional codes. Finding Binary Compact Codes, Huffman's code, r-ary compact Codes, Code Efficiency and Redundancy.

Module 3

Channels and Mutual Information: Information Channels, Trellis Coded Modulation; Probability relations in a channel; Apriori and Aposteriori Entropies, Generalization of Shannon's first theorem, Mutual Information. Properties of Mutual Information, Noiseless and Deterministic channels,

Module 4

Cascaded channels, Channel Capacity, Conditional Mutual Information; Reliable Messages through Unreliable channels: Error probability and Decision rules, the Fano bound, Hamming distance, Random Coding; Ensemble performance analysis of block and convolution codes; Introduction linear block codes-cyclic codes-Burst error detecting and correcting codes-Decoding algorithms of convolution codes-ARQ codes performance of codes.

Suggested reading

Course Code | Course Name | L | T | P | C | Contact Hours
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EL 516 | Digital Communication | 3 | 1 | 2 | 6 | 8

**Course Objective**
The course provides basic foundation of different aspects of Digital Communication and its applications.

**Module 1**: Random Process:
Probability theory, random variable, statistical averages, transformation of random variables, random process, stationarity, mean, correlation and covariance, ergodicity, transmission of a random process through a linear filter, power spectral density, Gaussian process;

**Module 2**: Pulse modulation
Sampling theorem, pulse analog modulations (PAM), Shaping of the transmitted signals spectrum, Equalization, Pulse Width Modulation (PWM) and Pulse Position Modulation (PPM), Quantization; PCM- Limitations of PCM; Companding; DM, DPCM-preliminary idea; coding speech at low bit rate, APCM; CODEC;

**Module 3**: Digital Modulation techniques
Amplitude shift keying (ASK), Frequency Shift Keying (FSK), phase shift keying (PSK), Dual Phase Shift Keying (DPSK) schemes, Coherent binary PSK/ FSK; Coherent quadri- PSK; Coherent minimum shift keying; differential PSK Comparison of digital modulation schemes, M-array signaling scheme; QAM; Time Division Multiplexing (TDM) and Frequency Division Multiplexing (FDM).

**Module 4**: MODEM techniques:
Baseband transmission; modem principles & architecture;

**Module 5**: Spread Spectrum modulation
Definition; types-direct sequence & frequency hoping; pseudo-noise generation; Idealized model of a spread spectrum modulator; DS- & FH-spread spectrum modulation generation and detection; application; CDMA, GSM;

**List of experiments.**
1. Generation of ASK using kits/software/ ICs.
2. Generation of PSK using kits/software/ ICs.
4. Generation of BPSK using kits/software/ ICs.
5. Study of FDM using kits/ software.
7. Study of GSM using kits/ software.
8. Study of CDMA using kits/ software.

**Suggested reading**
1. Communication Systems- Simon Haykin, Wiley Eastern
2. Digital & Data Communication- Miller, Jaico.
3. Digital Communication- Simon Haykin, Willey Eastern
5. Digital Communication- Sklar, Pearson Education
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<td>EL 522</td>
<td>Statistical Signal Processing</td>
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**Unit 1:** Discrete Random Signal Processing


**Unit 2:** Spectrum Estimation


**Unit 3:** Linear Estimation And Prediction


**Unit 4:** Adpative Filters


**Unit 5:** Multirate Signal Processing

Decimation and Interpolation by a factor; Sampling rate conversion by a rational factor; filter design and implementation for sampling rate conversion; multistage implementation of sampling rate conversion; sampling rate conversion of bandpass signals; sampling rate conversion by an arbitrary factor; applications- phase shifter, interfacing of digital systems with different sampling rates, digital filter banks, subband coding of speech signals, Quadrature mirror filters, Transmultiplexers, Oversampling ADC and DAC;

**Suggested reading**

2. Digital Signal processing - Proakis, Pearson Education
3. Adaptive Filter Theory- Haykin, Pearson Education
4. Statistical Signal processing- Srinath, PHI
Course Objective
The course provides an exposure to the different principles of image processing using digital means, applications and insights into Computer Vision and Machine Learning.

Module 1: Introduction
Steps in Digital Image Processing, Components of an Image Processing system, Applications. Human Eye and Image Formation; Sampling and Quantization, Basic Relationship among pixels-neighbour, connectivity, regions, boundaries, distance measures.

Module 2: Image Enhancement
Spatial Domain-Gray Level transformations, Histogram, Arithmetic/Logical Operations, Spatial filtering, Smoothing & Sharpening Spatial Filters; Frequency Domain- 2-D Fourier transform, Smoothing and Sharpening Frequency Domain Filtering; Convolution and Correlation Theorems;

Module 3: Image Restoration
Inverse filtering, Wiener filtering; Wavelets- Discrete and Continuous Wavelet Transform, Wavelet Transform in 2-D;

Module 4: Image Compression
Redundancies- Coding, Interpixel, Psycho visual; Fidelity, Source and Channel Encoding, Elements of Information Theory; Loss Less and Lossy Compression; Run length coding, Differential encoding, DCT, Vector quantization, entropy coding, LZW coding; Image Compression Standards-JPEG, JPEG 2000, MPEG; Video compression;

Module 5: Image Segmentation
Discontinuities, Edge Linking and boundary detection, Thresholding, Region Based Segmentation, Watersheds; Introduction to morphological operations; binary morphology- erosion, dilation, opening and closing operations, applications; basic gray-scale morphology operations; Feature extraction; Classification; Object recognition;

Module 6: Colour Image Processing
Colour models, Different processing techniques; Colour image filtering;

Suggested Reading
4. Digital Image Processing and Analysis- Chanda and Mazumdar, PHI
5. Digital Image Processing- Annadurai and Shanmugalakshmi, Pearson Education
6. Digital Image Processing- Pratt, John Wiley
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<td>EL 611 D</td>
<td>Speech Processing</td>
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**Unit 1**: Introduction

Definition, basic concepts, Types- voiced and unvoiced; Production of speech- Biological Model, Signal Processing Model; Application areas and trends; Steps of human-human communication; Speech reception and Comprehension by the listener; Digital model of speech perception;

**Unit 2**: Speech Signal Processing

Spectral analysis- DTFT, STFT, DFT; Sinusoidal analysis; Cepstral Analysis; LP Analysis- LP and Inverse LP filters, LP-derived features;

**Unit 3**: Speech Coding

Definition, Importance, Requirements, Speech coding trends, Classification- PCM, ADPCM, Transform domain coding, Sub band coding, Multi Pulse Linear Predictive Coding, Code Excitation Linear Prediction Coding;

**Unit 4**: Speaker Recognition

Importance, Man-Machine interface, Automatic Speaker Recognition, Biometric speaker recognition, Speaker verification v/s Speaker Identification, Text- dependence and independence, Closed set and opened set, Speaker recognition using pattern Recognition Methods, Feature Extraction, Pattern Classification Techniques- Vector Quantization, Dynamic Time Warping, Hidden Markov Model, Neural Networks; Pattern Comparison;

**Unit 5**: Speech Enhancement

Definition, Requirements, Examples of degraded speech, Enhancement of single channel and multi channel speech; Time delay estimates;

**Suggested Reading**

1. Digital Processing of Speech- Rabiner and Schafer, Pearson Education;
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<td>EL 611 E</td>
<td>Soft Computing</td>
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**Unit 1:** Artificial Neural Networks

Basic-concepts-single layer perception-Multi layer perception-Supervised and un supervised learning back propagation networks, Application;

**Unit 2:** Fuzzy Systems

Fuzzy sets and Fuzzy reasoning-Fuzzy matrices-Fuzzy functions-decomposition-Fuzzy automata and languages- Fuzzy control methods-Fuzzy decision making, Adaptive Control, Applications;

**Unit 3:** Neuro-Fuzzy Modelling

Adaptive networks based Fuzzy interfaces-Classification and Representation trees- algorithms – Rule base structure identification-Neuro-Fuzzy controls;

**Unit 4:** Genetic Algorithm

Survival of the fittest-pictures computations-cross overmutation-reproduction-rank method-rank space method, Application;

**Unit 5:** Soft Computing And Conventional Ai

AI Search algorithm-Predicate calculu rules of interface - Semantic networks-frames-objects-Hybrid models; Applications;

**Suggested Reading**

2. Fuzzy Logic Engineering Applications- Timothy J.Ross; McGraw Hill;
3. Neural Networks- Simon Haykin, pearson Education
4. Fuzzy Sets and Fuzzy Logic- George J.Klir and Bo Yuan, Prentice Hall ;
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**Unit 1: Introduction**

Origins of Bioelectric signals, Electrocardiogram (ECG), Electromyogram (EMG); Recording Electrodes- Silver-silver Electrodes, Electrodes for ECG, EEG and EMG; Physiological Transducers- Pressure Transducers, Temperature sensors, Pulse sensors; Sources of bioelectric potential, resting potential, action potential, propagation of action potentials in nerves; rhythmic excitation of heart;

**Unit 2: ECG**

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

**Unit 3: EMG**

Wave pattern studies, biofeedback. application of signal processing techniques such as linear prediction, lattice - filtering & adaptive signal processing for extraction of physiological parameters;

**Unit 4: Introduction to wavelets & time frequency models**

Biomedical signal processing by Fourier analysis; Biomedical signal processing by wavelet; Multi resolution analysis; Fetal ECG & vesicular sound signals;

**Unit 5: Speech Signals**

Speech production model, inverse filtering techniques for extraction of vocal tract parameters, glottal inverse filtering; Electroglostographic signals; signal processing techniques for detection of pathologies in speech production system; speech synthesis and speech recognition in diagnostic and; therapeutic applications;

**Unit 6: Medical imaging techniques**

CT scan, ultrasound, NMR and PET; Experiments are based on acquisition of biomedical signals and implementation of algorithms covered in the course to characterize these signals.

**Suggested Reading**

1. Biomedical Signal Processing and Signal Modeling- E.N. Bruce, John Wiley and Sons,
3. Wavelets and Time frequency methods for Biomedical signal Processing- M. Akay, IEEE Press,
4. Digital Processing of speech signals- L. Rabinar, Pearson Education
5. Biomedical Instrumentation and Measurements-Cromwell, Weibell and Pfeiffer, PHI