M. Tech – ECE (Communication)

i

1st semester

Theory:							
Code	**Subject**	**Contacts periods per week**				**Full marks**	**Credit**
		L	**T**	**P**	**Total**		
MCE 101	Advanced Engg. Math.	3	1	0	4	100	4
MCE102	**Compulsory:** Advanced digital communication	4	0	0	4	100	4
MCE103	**Compulsory:** Advanced digital signal processing	4	0	0	4	100	4
MCE104	**Compulsory:** Advanced microwave communication engineering	4	0	0	4	100	4
MCE105	**Elect I:** A. Computer communication & networking B. Telecommunication engineering C. Statistical communication D. Microwave applications E. Remote sensing techniques & applications.	4	0	0	4	100	4
	Total of theory				**20**	**500**	**20**
Practical							
MCE191	**Lab I:** Advanced communication Lab	0	0	3	3	100	2
MVE193	**Lab II:** Design and Simulation Lab	0	0	3	3	100	2
	Total of practical				**6**	**200**	**4**
Sessional							
MCE183	Seminar I	0	2	0	2	100	1
	Total credit of 1st semester:				**28**	**800**	**25**

M. Tech – ECE (Communication)

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2nd semester

Theory:							
Code	**Subject**	**Contacts periods per week**				**Full marks**	**Credit**
		L	**T**	**P**	**Total**		
MCE 201	**Compulsory:** Photonics and Optical Communication	4	0	0	4	100	4
MCE 202	**Compulsory:** Error control coding	4	0	0	4	100	4
MCE 203	**Compulsory:** Mobile communication	4	0	0	4	100	4
MCE 204	**Elect II:** A. Cryptography & network security B. Artificial intelligence & soft computing C. Integratable circuits & Design D. Microwave measurement Techniques	4	0	0	4	100	4
MCE 205	**Elect III:** A. Satellite communication B. Image processing & pattern recognition C. Multimedia communication D. Advanced antenna and wave propagation	4	0	0	4	100	4
	Total of theory				**20**	**500**	**20**
Practical							
MCE 291	**Lab III:** Communication systems Lab	0	0	3	3	100	2
Sessional							
MCE 281	Term paper leading to thesis	0	2	0	2	100	1
MCE 282	Comprehensive Viva-Voce					100	4
	Total credit of 2nd semester:				**26**	**800**	**27**

M. Tech – ECE (Communication)

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3rd semester

Theory:							
Code	**Subject**	**Contacts periods per week**				**Full marks**	**Credit**
		L	**T**	**P**	**Total**		
MCE 301	**Compulsory:** Management	4	0	0	4	100	4
MCE 302	**Elect IV:** A. EMI/EMC B. Ad-hoc networking C. Optical signal processing D. Convergence in communication technology	4	0	0	4	100	4
Sessional							
MCE 381	Dissertation (Part-I)				24	100	4
MCE 382	Defense of dissertation (Part-I)					100	8
	Total credit of 3rd semester:				**32**	**400**	**20**

4TH semester

Sessional:							
Code	**Subject**	**Contacts periods per week**				**Full marks**	**Credit**
		L	**T**	**P**	**Total**		
Sessional							
MCE 481	Dissertation (Completion)				24	100	6
MCE 482	Post-submission defense of dissertation					100	18
	Total credit of 4th semester:				**24**	**200**	**24**
	Grand Total of credits:						**96**

Detail Syllabus

First Semester

Advanced Engineering Mathematics
Code: MCE 101
Contacts: 3-1-0
Credits: 4

Complex Variables: Elements of set theory, Set notations, Applications of set theory, Open & Closed Sets. Review of Complex variables, Conformal mapping and transformations, Functions of complex variables, Integration with respect to complex argument, Residues and basic theorems on residues.
Numerical Analysis: Introduction, Interpolation formulae, Difference equations, Roots of equations, Solutions of simultaneous linear and non-linear equations, Solution techniques for ODE and PDE, Introduction to stability, Matrix eigen value and eigen vector problems.
Optimization Technique: Calculus of several variables, Implicit function theorem, Nature of singular points, Necessary and sufficient conditions for optimization, Elements of calculus of variation, Constrained Optimization, Lagrange multipliers, Gradient method, Dynamic programming.
Probability and Statistics: Definition and postulates of probability, Field of probability, Mutually exclusive events, Bayes' Theorem, Independence, Bernoulli trial, Discrete Distributions, Continuous distributions, Probable errors, Linear regression, Introduction to non-linear regression, Correlation, Analysis of variance.

Reference Books:

1. Sen, M. K. and Malik, D. F.-Fundamental of Abstract Algebra, Mc. Graw Hill
2. Khanna, V. K. and Ghamdri, S. K.- Course of Abstract Algebra, Vikash Pub.
3. Halmos, T. R.-Naïve Set Theory, Van Nostrand
4. Scarborough, J. B.-Numerical Mathematical Analysis, Oxford University Press
5. Cone, S. D.-Elementary Numerical Analysis, Mc. Graw Hill.
6. Mukhopadhyay ,P.-Mathematical Statistics ,New Central Book Agency
7. Kapoor, V. K and Gupta, S.C.-Fundamental of Mathematical Statistics, Sultan Chand and Sons.
8. Uspensky, J. V.-Introduction to Mathematical Probability, Tata Mc. Graw Hill
9. Dreyfus, S. E.-The Art and Theory of Dynamic Programming –Theory and Applications, Academic Press.
10. Rao, S. S.-Optimisation Theory and Application, Wiley Eastern Ltd., New Delhi

Advanced digital communication
Code: MCE 102
Contacts: 4-0-0
Credits: 4

- *Perquisites*:
    - Fourier Expansion, Fourier transform, Normalized power spectrum, Power spectral density, Effect of transfer function on output power spectral density, Perseval's theorem.
    - Autocorrelation & cross correlation between periodic signals, cross correlation power.
    - Relation between power spectral density of a signal, its autocorrelation function and its spectrum.
    - Distinction between a random variable and a random process.
    - Probability, sample space, Venn diagramme, joint probability, bay's theorem, cumulative probability distribution function, probability density function, joint cumulative probability distribution function, joint probability density function.
    - Mean/average/expectation of a random variable and of sum of random variables.
    - Standard deviation, variance, moments of random variables, - explanation with reference to common signals.
    - Tchebycheff's inequality.
    - Gaussian probability density function – error function & Q function
    - Central limit theorem.

- Spectral analysis of signals:
    - Orthogonal & orthonormal signals. Gram-Schmidt procedure to represent a set of arbitrary signals by a set of orthonormal components; - numerical examples.

- The concept of signal-space coordinate system, representing a signal vector by its orthonormal components, measure of distinguishability of signals.

- Characteristics of random variables and random processes:
  - Common probability density functions, - Gaussian, Rayleigh, Poisson, binomial, Rice, Laplacian, log-normal, etc.
  - Probability of error in Gaussian Binary symmetric channel.
  - Random processes – time average, ensemble average, covariance, autocorrelation, cross correlation, stationary process, ergodic process, wide sense stationary process.
  - Power spectral density and autocorrelation, power spectral density of a random binary signal.
  - Linear mean square estimation methods.

- *Revision* of source coding: Sampling theorem, instantaneous/ flat top/ natural sampling, band width of PAM signal, quantization, quantization noise, principle of pulse code modulation, delta modulation & adaptive delta modulation.

- Parametric coding/ hybrid coding/ sub band coding: APC, LPC, Pitch predictive, ADPCM, voice excited vocoder, vocal synthesizer.

- Line codes:
  - UPNRZ, PNRZ, UPRZ, PRZ, AMI, Manchester etc.
  - Calculation of their power spectral densities.
  - Bandwidths and probabilities of error P_e for different line codes.

- *Revision* of digital modulation: Principle, transmitter, receiver, signal vectors, their distinguish ability (d) and signal band width for BPSK, QPSK, M-ARY PSK, QASK, MSK, BFSK, M-ARY FSK.

- Spread spectrum modulation:
  - Principle of DSSS, processing gain, jamming margin, single tone interference, principle of CDMA, MAI and limit of number of simultaneous users.
  - Digital cellular CDMA system: model of forward link, reverse link, error rate performance of decoder using m-sequence chip codes.
  - Properties of m-sequences, their generation by LFSR, their PSDs, limitations of m-sequences.
  - Gold sequence, Kasami sequence – generating the sequences, their characteristic mean, cross correlation and variance of cross correlation, their merits and limitations as chip codes in CDMA.

- Multiplexing & multiple access:
  - TDM/TDMA, FDM/FDMA, Space DMA, Polarization DMA, OFDM, ALOHA, Slotted ALOHA, Reservation ALOHA, CSMA-CD, CSMA-CA – basic techniques and comparative performances e.g. signal bandwidth, delay, probability of error etc.

- Noise:
  - Representation of noise in frequency domain.
  - Effect of filtering on the power spectral density of noise – Low pass filter, band pass filter, differentiating filter, integrating filter.
  - Quadrature components of noise, their power spectral densities and probability density functions.
  - Representation of noise in orthogonal components.

- Characteristics of different types of channels:
  - Gaussian, Poisson etc.

- Band limited channel:
  - Characteristics of band limited channel, inter symbol interference (ISI) - it's mathematical expression.
  - Niquist's theorem for signal design for no ISI in ideal band limited channel, Niquist's criteria, raised cosine pulse signals.
  - Signal design for controlled ISI in ideal band limited channel, partial response signals, duobinary & partial duobinary signals - their methods of generation and detection of data.
  - Concept of maximum likelihood detection, log likely hood ratio.
  - Detection of data with controlled ISI by linear transverse filters.
  - Performance of minimum mean square estimation (MMSE) detection in channels with ISI.

- Base band signal receiver and probabilities of bit error:
    - Peak signal to RMS noise output ration, probability of error.
    - Optimum filter, it's transfer function.
    - Matched filter, it's probability of error.
    - Probability of error in PSK, effect of imperfect phase synchronization or imperfect bit synchronization.
    - Probability of error in FSK, QPSK.
    - Signal space vector approach to calculate probability of error in BPSK, BFSK, QPSK.
    - Relation between bit error rate and symbol error rate.
    - Comparison of various digital modulation techniques vis-à-vis band width requirement and probabilities of bit error.

Text Books:

1. Digital communication, 4th ed. - J. G. Proakis, MGH International edition.
2. Principle of Communication Systems – Taub, Schilling, TMH
3. Digital and Analog Communication Systems, 7th ed. – Leon W. Couch, PHI.
4. Principles of Digital Communication – Haykin
5. Digital Communication – Zeimer, Tranter.
6. Principle of Digital communication - J. Das, S. K. Mallick, P. K Chakraborty, New Age Int.
7. Communication Systems, 4th ed. – A. Bruce Carlson, Paul B. Crilly, Janet C. Rutledge, MGH International edition.
8. Digital Communications, 2nd ed. – Bernard Sklar, Pearson Education.
9. Electronic Communications, 4th ed. – Dennis Roddy, John Coolen, PHI

Advanced digital signal processing
Code: MCE 103
Contacts: 4-0-0
Credits: 4

Prerequisite: The student must be conversant with frequency domain analysis of discrete time signals and systems. They will be familiar with the various kind of adaptive filter design technique. Multirate Signal Processing fundamentals and applications of Wavelet Transforms will be covered.

Frequency Domain Analysis of Discrete Time Domain Signals and Systems: 6L
The concept of frequency in continuous time and discrete time signals. Fourier series for discrete periodic signals, Fourier Transform of discrete aperiodic signals, Power spectral densities of discrete aperiodic signals, Relationship between Fourier Transform and Z-Transform. Properties of Fourier Transform in discrete time domain; Time reversal, convolution, correlation, Wiener-Khintchine theorem, frequency shifting, modulation, windowing theorem, differentiation in digital frequency domain. Symmetry property for various types of signals.

Frequency Domain Characteristics of LTI Systems 6L
Response to complex exponential signals, steady state and transient response to sinusoidal signals, steady state response to periodic signals, response to aperiodic signals. Relation between system function H (z) and frequency response function h (w). Input-output correlation function and spectra, correlation functions and power spectra for random input signals. Invertibility of LTI systems, minimum/maximum/mixed phase systems, homomorphic systems and homomorphic deconvolution.

DFT & FFT 2L
Computation of DFT and it's properties, computation of DFT via FFT, chirp z-transform.

Design of Digital Filters 6**L**
Design of FIR filters, Effect of various windows, Effect of finite register length, frequency sampling, Optimization Algorithm. Adaptive Filters design, State-Space Kalman Filter, Extended Kalman Filter, Unscented Kalman Filter Sample-Adaptive Filters, Recursive Least Square (RLS) Adaptive Filters, The Steepest-Descent Method, LMS Filter.

Power Spectrum 6L
Estimation of Power Spectrum and Correlation, Non-parametric and Parametric methods, Minimum Variation Estimation methods, Eigen Analysis algorithm, Power Spectrum analysis using DFT, Maximum Entropy Spectral Estimation, Model-Based Power Spectral Estimation.

Multirate Signal Processing 6L

Sampling Rate Conversion; Decimation and Interpolation; Time and Frequency Domain Characterization; Filters in Sampling Rate Alteration Systems; Multi-rate Design of Decimator and Interpolator; Poly-phase Techniques; Poly-phase Down-sampler and Interpolator; Poly-phase Filter Design; Two-channel QMF Banks. Alias free FIR and IIR QMF Banks; Perfect Reconstruction Two-channel FIR Filter Banks; M-Channel Filter Banks Design; Cosine-Modulated M-channel Filter Banks Design;

Wavelet Transforms **6L**

Fourier Transform and its limitations, Short Time Fourier Transform, Continuous Wavelet Transform, Discretization of the Continuous Wavelet Transform, Multiresolution Approximations; Wavelet and Scaling Function Coefficients, Orthonormality of Compactly Supported Wavelets, Bi-orthogonal Decomposition, Harr Wavelets, The Daubechies Wavelets Construction, Fast Wavelet Transform and Image Compression, Denoising using Wavelets, Perfect Reconstruction Filter bank design using Wavelets.

References:

1. Discrete – Time Signal Processing by A.V. Oppenheim and R. W. Schafer, with J. R. Buck (Prentice- Hall, 1998)
2. Digital Signal Processing Using MATLAB by V. K. Ingle and J. G. Prokis (Books/Cole,2000)
3. Digital Signal Processing: A Computer Based Approach by S.K. Mitra (Second edition , McGraw-Hill, 2001)
4. Digital Signal Processing: Principles, Algorithms and Applications by J. G. Proakis and D. G. Manolakis.
5. C.K.Chui, "Wavelets: A tutorial in Theory and Applications" (Academic Press).
6. R. E. Crochiere and L. R. Rabiner, *Multirate digital signal processing,* Prentice-Hall, 1983. A classic on multirate signal processing, although a bit outdated.
7. M. Vetterli and J. Kovacevic, *Wavelets and Subband Coding,* Prentice-Hall, 1995. Graduate level textbook with a unified view on wavelets and subband coding.
8. G. Strang and T. Nguyen, *Wavelets and Filter Banks,* Wellesley Cambridge Press, 1996. Nice exposition of wavelets and filter bank theory from a joint math-engineering perspective.
9. C. S. Burrus, R. A. Gopinath, and H. Guo, *Introduction to Wavelets and Wavelets Transforms,* Prentice Hall, 1997. An excellent graduate-level introduction to wavelets.

Advanced microwave communication engineering
Code: MCE 104
Contacts: 4-0-0
Credits: 4

Prerequisites:

- One semester course in electromagnetic engineering, microwave and antenna fundamentals.

Microwave and millimeter wave devices:

- Overview of microwave and millimeter wave vacuum tube devices, limitations of microwave vacuum tubes, gyratron vacuum tube devices.
- Advances in microwave and millimeter wave solid state devices, Gunn devices, oscillator using Gunn diode, and injection locked oscillators, IMPATT devices, and microwave and mm wave performance of IMPATT.
- Other solid state devices like Tunnel diode, BARITT and TRAPAT.

Microwave and mm wave circuits:

- Review of scattering matrix concept in the light of vector network analyzer, impedance matching network, couplers, power dividers, resonators and filters.
- Detectors, mixers, attenuators, phase shifters, amplifier and oscillator
- Ferrite based circuits.

Antennas:

- Hertzian dipole, loop antenna, helical antenna, frequency independent antenna: Du0Hamel principle, log spiral and log periodic dipole antenna array.
- Babinet principle, waveguide slot antenna, microstrip antenna, horn antenna, parabolic reflector.
- Antenna arrays and phased array antenna.

Antenna measurement.

Microwave and mm wave propagation.

- Overview of basic radio wave propagation mechanisms, Friis transmission formula, plane earth propagation model, troposcatter systems, ionosphere propagation, duct propagation, microwave radio link and calculation of link budget.
- Effect on radio wave propagation due to rain, fog, snow, ice, atmospheric gases, Earth's magnetic field.

Books

- P Bhartia & I J Bahl, *Millimeter wave engineering and Applications*, John Wiley & Sons
- David M Pozar, *Microwave Engineering*, John Wiley & Sons
- R E Collin, *Antenna & Radio wave Propagation*, McGraw Hill Book Co.
- Jordan & Balman, *Electromagnetic waves & Radiating System*
- R E Collin, *Microwave Engineering*, McGraw Hill CO.

Computer communication & networking
Code: MCE 105A
Contacts: 4-0-0
Credits: 4

Introduction - Motivation, goals, applications and classification of computer networks, common networks and standard organizations

Network Structure and Architecture- Network structure-concept of subnet, backbone and local access, Channel sharing techniques- FDM, TDM. Circuit and packet switching. Topological Design of a network.

Network architecture layering concept, OSI Reference Model, OSI Services and protocols
Physical layer - bit communication between DTE and DCE, RS232, transmission media, modems.
Data link layer - error detection and correction, retransmission strategies, stop and wait protocol, sliding window protocols, pure Aloha protocols, slotted Aloha protocol, CSMA protocols, CSMA / CD and CSMA / CA protocol, HDLC.

LANs and their Interconnection - Basic concepts and IEEE standards, Architecture, protocol, management and performance of Ethernet, token ring and token bus LANs, WLAN, Bluetooth, LAN interconnection - repeaters and bridges, Transparent and source routing bridges and their relative advantages and disadvantages.

Network layer - basic design issues, network layer services, connection oriented and connection less services, routing – static, dynamic, stochastic, flow based routing, optimal routing, Quality of service, congestion control, Leaky Bucket Algorithm
Transport layer- process to process delivery, TCP, UDP.

Internetworking- motivation, goals and strategies, Routers and gateways, TCP / IP model, IP addressing, important features of IPv6.
Application layer – DNS, SMTP, FTP, HTTP, WWW
Network security -Cryptographic principle, DES, AES, RSA, Digital signature, Security in internet, VPN,
Firewalls.
Network management system - SNMP.
Advance Protocol-RTP, SIP.

Reference Books:

1. B. A. Forouzan, Data Communication and Networking, Tata Mc-Graw Hill.
2. W. Stallings, Data and Computer Communication, 5th Ed. PHI, 1998.
3. A. S. Tanenbaum, Computer Networks, Prentice-Hall India.
4. Miller, Data Communication and Networks, Vikas.
5. A. Leon-Garcia, Communication networks, Tata Mc-Graw Hill.
6. G. E. Keiser: Local Area Network, McGraw Hill. 1989.
7. D. Bertsekas and R. Gallagher: Data Networks, 2nd Ed. PHI, 1992.
8. F. Halshall: Data Communication, Computer Network and Open Systems, 3rd Ed. Addison Wesley, 1992.
9. D. Russell: The Principles of Computer Networking, Cambridge University Press, 1989.
10. M. Schwartz: Computer Communication network Design and Analysis, PHI, 1977

Telecommunication engineering
Code: MCE 105B
Contacts: 4-0-0
Credits: 4

Module 1: Telephone Network 12 L

- Introductory terminology – Blockage, Lost Calls, Grade of Service – Erlarg and Poisson Traffic formulas – one-way and both-way circuits – QOS
- Local Networks – subscriber loop design – shape and size of a serving area – voice Frequency Repeaters – Tandem Routing- Dimensioning of Trunks
- Switching & Signaling for analog Telephone networks – Switching concepts – Cross-bar switching – Supervisory signaling – E & M signaling – In-band & out-of-band signaling
- Design of long – distance links – design essentials for LOS Microwave systems – Path analysis or Link Budget – Fading – Diversity and Hot stand-by operation – Frequency management – VSAT networks Last Mile Broadband connectivity – ADSL – HDSL (High bit rate Digital Subscriber line)

Module 2: Digital Telephone Systems 12 L

- PCM – PCM line Codes – Regenerative repeaters – Signal to Gaussian noise ratio for PCM signals – North American DS1 – the European E1 digital hierarchy – Filter – distortion – echo – cross talk – SONET and SDH – PCM Switching – 'Time – space – Time Switch – 'Space – Time – Space' Switch – Digital Network Synchronization – Digital loss

Module 3: Local Area Networks 4 L

- LAN – topologies – overview of IEEE / ANSI LAN protocols – WLANS – different 802.11standards

Module 4: ISDN 8 L

- ISDN - background & goals of ISDN – protocols – structures – ISDN and OSI
- ATM and B-ISDN – User-Network interface (UNI) configuration and architecture – ATM cell structure – cell delineation algorithm – ATM layering & B-ISDN – CLNAP Protocol Data Unit (PDU)

Text Books:

1. Wiley Series in Telecommunications and Signal Processing by Roger L. Freeman
2. Telecommunication System Engineering, By N. N. Deb

Statistical communication
Code: MCE 105C
Contacts: 4-0-0
Credits: 4

Revision of linear algebra:
Special matrix forms – diagonal matrix, exchange matrix, triangular matrix, Toeplitz matrix, Hankel matrix, symmetric matrix, parametric matrix, centro symmetric matrix.
Eigen values, Eigen value solutions.

Random process:
Definition and description of random processes with practical examples.
Time average, ensemble average, covariance, autocorrelation, cross correlation.
Stationary process, ergodic process, WSS process, power spectrum of random processes.
Filtering of random processes – filtering of white noise, spectral shaping filter, spectral factorization.
Special random processes – Autoregressive moving average process, autoregressive process, moving average process, harmonic process.

Signal modeling:
Least square method, Padé approximation method, filter design using Padé approximation, Prony's method of signal modeling, filter design using Prony's method, FIR least square inverse filter, iterative prefilters,
Stochastic models – ARMA model, AR model, MA model.

Binary symmetric channel:
Principle, properties, bit error properties.

Theories and hypothesis:

Decision theory, Bay's likihood ratio, ideal observer strategy, Neyman-Pearson strategy, Bay's strategy for single and multiple sample values, optimum linear estimation composite hypothesis testing, optimum detection with incomplete knowledge of the signal, adaptive detection and estimation.

Filters:
Principle of optimum filter, matched filter, achievable bit error rate.
FIR Wiener filter – principle and design.
Linear prediction in noise, noise cancellation
IIR Wiener filter – causal, non causal.
Kalman filter.

Text Books:

1. Digital communication, 4th ed. - J. G. Proakis, MGH International edition.
2. Digital and Analog Communication Systems, 7th ed. – Leon W. Couch, PHI.
3. Digital Communication – Zeimer, Tranter.
4. Statistical digital signal processing and modeling, - Monson N. Hays – Wiley.

Microwave applications
Code: MCE 105D
Contacts: 4-0-0
Credits: 4

Sl. No.	Topic	Hrs
1	**Applications in satellite communication:** Evolution of communication satellites , orbital and altitude control , satellite transponder and other subsystems , satellite link design , system noise temperature , G/T ratio , downlink design , spectrum allocation and bandwidth consideration , Digital transmission modulation and demodulation , Multiple access techniques –FDMA , TDMA , VSAT , Coding : Error Detection and correction method ,Earth station technology .	20
2	**Application in RADAR:** Introduction to basic radar system , radar equation , detection of signal in noise , receiver noise & SNR , Probability of detection & false alarm , Radar cross-section of target & its fluctuation , MTI & Doppler radar , Tracking radar , Radar clutter & Radar antenna , Radar transmitter & receiver , Monopulse radar	20

TEXT BOOKS:-

1. MONOJIT MITRA : Satellite communications , Prentice Hall of India
2. S. KINGLEY & S. QNEGAN: Understanding radar systems , Standard Publisher & Distribution .
3. SKOLNIK : Introduction to radar systems , TMH

Remote sensing techniques & applications.
Code: MCE 105E
Contacts: 4-0-0
Credits: 4

Transmission of Solar Radiation through the Atmosphere : Solar radiation spectrum; Radio infrared and optical windows of the earth's atmosphere; Spectrum of solar radiation transmitted through the atmosphere, Emissions from the disturbed sun, Reflection, Absorption and Emission from Earth and Atmosphere.

Variation of the earth's reflectivity with angle of incidence, wavelength and geographical location; Seasonal variation of reflectivity; Solar radiation reflected from the earth; Absorption of solar radiation by the earth; Thermal radiation from the earth; Thermal radiation from the atmospheric constituents; Thermal emission from cloud, rain, snow and fog; Radio noise and interference at satellite heights.

Sensors and Cameras: Optical and infrared detectors and filters, Optical and infrared cameras; Microwave and Millimetrewave radiometers; Scanning systems, Mechanical and Electronic systems; Scatterometer; Altimeter.

Remote Sensing Satellites: Orbits of remote sensing satellites; Remote sensing satellites – LANDSAT; Indian Remote Sensing (IRS) Satellites; INSAT, NOAA Series; NASA's Upper Atmosphere Research Satellites (UARS); TRMM satellite.

Remote Sensing of Atmosphere and Sea State: Passive and active remote sensing; Side Looking Airborne Radar (SLAR); Synthetic Aperture Radar (SAR); Along Track Scanning Radiometer
(ATSR), Laboratory measurements of remote sensing parameters; Tropical rainfall measurements; Microwave sensing of sea surface.

Interpretation of Sensing Data : Photo-interpretation, image and pattern recognition; Spectral interpretation of remote sensing imagery; Interpretation of thermal maps; Colour coding and enhancement;

Computer interpretation of images.

Text & Reference Books:

Advanced communication Lab
Code: MCE 191
Contacts: 0-0-3
Credits: 2

Experiments on hardware/ kits in order to acquire sufficient knowledge and understand practical limitations/ implications of various communication techniques.
Suggested topics are (not exclusive),

1. Detailed receiver and transmitter parameters of a typical radio communication system – SINAD, fidelity, image rejection, modulation sensitivity, transmission bandwidth etc.
2. Data communication through fiber optic link – losses, power budget, stability etc.
3. Sampling, quantization, coding – sampling rate, quantization error, signal bandwidth etc.
4. QPSK, MPSK – signal bandwidth, distinguishability, effect of noise etc.
5. Binary symmetric channel – noise & P_e etc.
6. PC2PC communication – protocol standards, frame/ packet/ UDP structure etc.
7. Multiple channel DSSS – spreading, dispreading, decoding etc.
8. Important characteristics of different types of transmission lines.
9. Impedance measurement of microwave window applying Smith chart.
10. Microwave phase shifter – calibration.
11. Measurement of dielectric constants – solids & liquids.
12. Horn, microstrip antenna – radiation pattern, gain etc.

Lab II: Design and Simulation Lab
Code: MCE 192
Contacts: 0-0-3
Credits: 2

Designing graphical user interfaced models of various communication systems/ subsystems with the help of suitable advanced software e.g. MATLAB/ LABVIEW/ NS/ PUFF/ IE3D/ ANSOFT/ HFSS/ CST/ QUALNET/ MICROWAVE OFFICE etc. for

detail study of their operating principle and their performance vis-à-vis practical limitations like, channel bandwidth, noise, attenuation etc.
Suggested topics are (not exclusive),

1. ADPCM – granular noise & quantization noise.
2. MPSK – signal bandwidth, PSD, distinguishability, scatter plot etc.
3. Digital filters – ripples in pass band & stop band, slope in transition band, poles & zeros etc.
4. Optimum filters for receiving base band random binary data – P_e vs. S/N.
5. Signal bandwidth and P_e vs. S/N in different modes of line coding.
6. Signal bandwidth and P_e vs. S/N in different modes of modulation.
7. Error rates in error control for different types of error control coding.
8. Throughput vs. input density in different MAC protocols.
9. DSSS – error rate due to different types of chip code.
10. Fading channel/ multipath transmission and Rake receiver.
11. Cellular architecture, WiFi, WiMAX using QUALNET.
12. OFDM using QUALNET.
13. Different routing algorithms & protocols.
14. Characterization of micro strip antenna.
15. Characterization of transmission lines.
16. Study of important parameters and practical considerations in microwave circuits.

Second Semester

Photonics and Optical Communication
Code: MCE 201
Contacts: 4-0-0
Credits: 4

Photonics:

- Introduction to Photonic materials and Photonic Devices.
- Optical waveguides.
- Optical fibers - application specific optical fibres, Photonic Bandgap Optical Fibers.
- Coupling of waves and modes
- Optical couplers;
- Fibre.Bragg gratings
- Electro-optic devices
- Semiconductor lasers and light-emitting diodes
- Photodetectors
- fibre lasers
- Optical Amplifiers,
- Fiber Raman Amplifiers,
- Semiconductor laser amplifiers,
- Doped–fiber amplifiers

Optical Communication:

- Analog and Digital Optical Transmitters and Receivers concepts,
- Loss- limited and dispersion- limited lightwave systems,
- Long-haul systems with In-Line Amplifiers,
- Dispersion compensation techniques in optical communication systems,
- Power budget and rise-time.

Coherent lightwave systems:

- Modulation and Demodulation schemes for coherent communication,
- System performance issues.

Multichannel Lightwave systems:

- WDM components and devices,
- Multiplexing techniques and system performance issues.

Optical Networks:

- Network topologies,
- SONET/SDH,
- Broadcast-and- Select WDM Networks- single-hop networks, multihop Networks,
- Wavelength routed networks,
- Photonic packet switching,

Error control coding
Code: MCE 202
Contacts: 4-0-0
Credits: 4

- **Introduction: Brief** description of a digital communication system, Cause of errors and need for error control coding, broad classes of error and classes of error correcting codes, general expression of the probability of error in a binary symmetric Gaussian channel, Principle of maximum likelihood decoding.

- **Linear algebra:**
  - Groups- definition, order of a group, modulo-m addition and multiplication tables, modulo-m subtraction and division.
  - Fields- Definition, binary field, Galois field.
  - Polynomials- The concept of polynomial expression, addition/subtraction/multiplication/division of polynomials over GF(2). Irreducible polynomials, primitive polynomials.
  - Vector space, sub space, dual space – their properties and interrelations.
  - Numerical exercises with manual computation and by using MATLAB.

- **Linear block code:**
  - Definition of linear block code.
  - Generator matrix, properties of generator matrix.
  - Parity check matrix and its properties.
  - Encoding circuit- operating principle.
  - Syndrome- definition, most likelihood principle of error detection. Syndrome circuit- operating principle.
  - Hamming distance, minimum distance, minimum weight, error detecting & error correcting capabilities.
  - Standard array- construction, error detection with syndrome.
  - Decoder-operating principle.

- **Hamming code:**
  - Construction, error detection and correction capabilities.

- **Error detection/ correction performance of block codes**
  - Distance properties of block codes and their dual codes, concept of distance space and decoding sphere.
  - Effect of code rate on random bit error probability.
  - Probability of undetected word error, uncorrected word error and residual bit error.
  - Simulation test of above for data transmission through Gaussian binary symmetric channel.

- **Cyclic code**:
  - Definition, generator polynomial, properties of cyclic code and generator polynomial.
  - Generator matrix, parity check matrix, their properties and interrelations.
  - Design and operation of encoder.
  - Design and operation of syndrome circuit.
  - Design & operation of Meggitt decoder.
  - Simulation test of above for data transmission through Gaussian binary symmetric channel.
  - Cyclic Hamming code.

- **BCH code:**
  - Construction of Galois field GF(2^m)- power representation, polynomial representation, n-tupple representation.
  - Properties of GF(2^m), conjugate roots, minimal polynomial, determining minimal polynomials.
  - Description of BCH code, encoding, parity check matrix, error trapping and decoding.

- **Reed-Solomon code**:

- Brief qualitative discussion.

- **Convolutional code**:
  - Definition, encoder, generator sequences, generator matrix, principle of constructing code words, numerical examples, code rate, constraint length, fractional rate loss.
  - Finite state machine analysis of coder, state diagramme, code tree, Trellis.
  - Principle of maximum likelihood decoding of convolutional code, Viterbi algorithm, Numerical examples of decoding and error detection/correction using Trellis, numerical examples using Trellis by MATLAB.
  - Simulation test of above for data transmission through Gaussian binary symmetric channel.
  - Distance properties of convolutional codes.

- Multiple error/ Burst error correcting codes:
  - Shortened cyclic code, Hadamard code, Golay code, brief qualitative description of Kasami decoder.

- **Application:**
  - Brief qualitative discussion of practical application of error control in processors, data storage, data exchange between CPU and peripherals, in CDMA etc.

Text & Reference Books:

1. Error Control Coding Fundamentals and Applications. – Shu Lin, Daniel J. Costello, Jr. - Prentice Hall.
2. Information Theory Coding and Cryptography. – Ranjan Bose, - TMH.
3. Fundamentals of Convolutional Coding. - Roft Johannesson and K. S. Zigangirov. - OUP.
4. Information and Coding Theory. – gareth A. Jones & J. Mary Jones. - Springer.
5. Error Correcting Codes. - Paterson, W. W. and Weldon, Jr. E. J. - Prentice Hall.
6. Applied Coding and Information Theory for Engineers. – Richard B. Wells. – Pearson Education
7. Introduction to Error Control Codes. – Salvatore Gravano. – Oxford.

Mobile communication
Code: MCE 203
Contacts: 4-0-0
Credits: 4

Introduction - evolution of mobile radio communications, mobile radio systems around the world, trends in cellular radio and personal communication, first generation (1G), second generation (2G), third generation (3G) mobile cellular networks. --2L

Cellular concept – Limitations of conventional mobile system, Introduction to mobile cellular communication, concept of frequency reuse, cluster size, cellular system architecture, channel assignment strategies, call handoff strategies - hard handoff and soft handoff, prioritizing handoff; interference and system capacity, improving capacity in cellular systems – cell splitting, sectoring, microcell zone concept. --8L

Different mobile communication systems – GSM services and features, system architecture, GSM radio subsystem, GSM channel types, location updating and call setup,
WAP, SCSD, GPRS, EDGE, 3G W-CDMA; CDMA digital cellular standard, comparison between GSM and CDMA, 3G cdma2000, IMT-2000. --8L

Radio Channel Characterisation – Free space propagation, Multipath propagation, diversity techniques, Co-channel interference, Propagation effects - scattering, ground reflection, fading, Log-normal shadowing. --4L

Wireless networks – Advantages and applications of Wireless LAN, WLAN technology – RF and IR wireless LAN, diffuse, quasi-diffuse and point-to-point IR wireless LAN, IEEE802.11, IEEE802.11 architecture, Physical layer, MAC layer, Introduction to WI-FI, HIPERLAN2, Bluetooth – Bluetooth architecture. --8L

Mobile network and transport layer – Introduction to Mobile IP, requirements, IP packet delivery, Agent discovery, Registration, Tunneling and encapsulation, Optimization, Reverse tunneling; Mobile adhoc networks – Routing, Destination sequence distance vector, Dynamic source routing and Alternative metrics; Traditional TCP – Congestion control, Slow start,

Fast retransmit / fast recovery, Implications of mobility; classical TCP improvements – Indirect TCP, Snooping TCP, Mobile TCP, Fast retransmit. --10L

Future of mobile communication – 3G to 4G. --1L

Text & Reference Books:

1. Theodore S. Rappaport, Wireless communications: principles and practice, PHI / Pearson education.
2. J. Schiller, Mobile communications, Addison-Wesley.
3. William C. Y. Lee, Mobile cellular telecommunication – analog and digital systems, McGraw Hill, 2nd ed.
4. Wang, Wireless communication System, Pearson Education
5. Talukdar, Mobile computing, TMH
6. J.W.Mark, W. Zhuang, Wireless Communication and Networking, PHI
7. A. Santamaria et al, Wireless LAN systems, Artech House.
8. Stallings, Wireless Communication & Networks, Pearson Education
9. K. Feher, Wireless digital communications, Prentice Hall of India.
9. Roy Blake, Wireless communication technology, Thomson Delmer.

Cryptography & network security
Code: MCE 204A
Contacts: 4-0-0
Credits: 4

Introduction: Principles of security, Overview of network security and cryptography, OSI Security architecture, model for network security, classification of attacks (Reply, Reflection, Man – in – the – middle), Virus, Worm, Trojan Horse, Spam etc.

Symmetric ciphers: Algorithm types and modes, classical encryption techniques, block ciphers and Data Encryption Standard (DES), Advanced Encryption Standard (AES), Contemporary Symmetric Ciphers, and confidentiality using symmetric encryption.

Public Key Cryptography: Public key Infrastructure (PKI), RSA, key management, Diffe-Hellman key exchange, elliptic curve arithmetic, elliptic curve cryptography.

Message Authentication and Hash Functions: Authentication requirements, authentication functions, message authentication codes, Hash functions, security of Hash functions and MACs.

Hash Algorithms: MD5 Message Digest Algorithm, Secure Hash Algorithm, Digital Signature Algorithm, Digital Signature Standard.

Network Security Applications: Authentication Applications (Kerberos), Electronic Mail Security (SMIME), IP Security (IPSec), Web Security (SSL and TLS), E – cash and Secure Electronic Transaction (SET), System security using Firewalls and VPNs.

Advance Applications of Network Security: Smart cards and security, Enterprise Application Security, Biometric Authentication, Database Access Control, Security and Privacy Issues in RFIDs.

Text and Reference Books:

1. William Stallings, Cryptography and Network Security—Principles and Applications, Pearson Edu.
2. Atul Kahate, Cryptography and Network Security, Tata McGraw Hill.
3. Trappe & Washington, Introduction to Cryptography with Coding theory, Pearson Education.
4. William Stallings, Network Security Essentials, Pearson Education.
5. Kaufman, Perlman & Speciner, Network Security, Pearson Education.
6. Behrouz A. Forouzan, , Cryptography and Network Security, McGraw – Hill Education.

Artificial intelligence & soft computing
Code: MCE 204B
Contacts: 4-0-0
Credits: 4

Introduction: Definition of AI, The disciplines of AI, Application of AI techniques.

General Concepts of Knowledge: Definition and importance of knowledge, components of a knowledge-based system.

Dealing with Inconsistencies and Uncertainties: Nonmonotonic reasoning, Truth Maintenance System (TMS), Default Reasoning and closed world assumption, Fuzzy Logic and natural language computation, Fuzzy sets, various operations, reasoning with Fuzzy logic.

Problem solving by intelligent search: General problem solving approaches: Breadth first search, Depth first search, Hill climbing, Simulated Annealing

Learning: Supervised Learning-Inductive learning, unsupervised learning-Reinforcement learning, learning automata.

Basics of pattern recognition: Concept of a pattern: feature, feature vectors and classifiers. Importance of pattern recognition. Fuzzy pattern recognition.

Classifiers: Classifiers based on Baye's decision theory: Bayesian classification for normal distribution, Bayesian inference. Estimation of unknown probability distributions. Baye's error. Linear classifiers: linear discriminant functions and decision hyperplanes. The peceptron algorithm. Suport Vector Machine (SVM): separable and nonseparable classes. An introduction to nonlinear classifiers: the XOR problem, the two layer perceptron and radial basis function (RBF) network. Context dependent classification.

Clusterings: Basic concept of cluster analysis. Applications of cluster analysis. Proximity measures: between two points, Proximity function: between a point and a set. Different clustering algorithms: Sequential, Hierarchical, Schemes based on function optimization . Cluster validity.

Evolutionary algorithms: Genetic Algorithm**:** Cycle of genetic algorithms, crossover, mutation, fitness function, schema, fundamental theorem of GA (Schema theorem). Differential Evolution (DE), Modified Differential Evolution(MoDE). Multi-objective optimization using evolutionary algorithms. Hybridization with clustering. Genetic programming.

Application Areas: Qualitative discussions on different application areas of A.I and Soft Computing *e.g.* Image pattern recognition: Image classification using clustering (hard and fuzzy). *etc*.

Text and Reference Books:

1. Dan W. Patterson, Introduction to Artificial Intelligence and Expert Systems, Prentice Hall of India.
2. Nils J. Nilsson, Artificial Intelligence: A new Synthesis, Harcourt Asia PTE Ltd., Morgan Kaufmann.
3. Elaine Rich, Kevin Knight, Artificial Intelligence, TMH.
4. Eugene Charnaik, Drew McDermott, Introduction to Artificial Intelligence, Pearson Education Asia.
5. George F. Luger, Artificial Intelligence: Structures and Strategies for Complex Problem Solving, Pearson Education.
6. A. Konar, Artificial Intelligence and Soft Computing.
7. Anil K. Jain and R.C.Dubes, Algorithms for Clustering Data, Prentice Hall
8. S. Theodoridis and K. Koutroumbus, Pattern Recognition, Elsevier
9. D. E. Goldberg, Genetic Algorithms in search, Optimization & Machine Learning, Pearson Education

Integratable circuits & Design
Code: MCE 204C
Contacts: 4-0-0
Credits: 4

Integrated circuit devices and modeling: Semiconductors and p-n junction, advanced MOS modeling, bipolar junction transistors MOS devices in weak inversion. 5 L

Basic current mirrors and single stage amplifiers: Simple CMOS current mirror, common source amplifier, source follower, common gate amplifier, source generated current mirrors, high output impedance current mirrors, cascade gain stages, MOS differential pairs, bipolar current mirrors, bipolar gain stages, class AB output stages. 7 L

Internal amplifiers: Switched capacitor amplifiers, switched capacitor integrators. 6 L

Non linear circuits: Phase locked loop.

MOS inverter: Switching characteristics, static and dynamic behaviors delay. 8 L

Combinational MOS logic circuits: pseudo NMOS, dynamic logic, domino logic, NORA, differential CMOS gates, X-gate and pass transistors.	
Sequential MOS logic circuits: CMOS clocked latches, static and dynamic CMOS latches, D, SR, JK, T and edge triggered SR flip-flop.	
Digital integrated system building blocks: Multiplexers and decoders, barrel shifters, counters, digital adders, modified booth multipliers	5 L
CMOS timing and I/O considerations: Delay of CMOS circuits, junction capacitors, interconnect capacitors, delay of CMOS logic gates, input protection circuits, output circuits and driving large capacitors, three state outputs.	5 L
Noise in integrable circuits: Noise in circuits, types of noise, time domain analysis, frequency domain analysis, noise models for circuit elements – resistors, capacitors, diode, BJT and MOSFET.	4 L
Text books: • Analog integrated circuit design, *David Johns and Ken Martin*, John Wiley and sons (UK), 2002 • Digital integrated circuit design, *Ken Martin*, Oxford University Press, New York, 2000	

References:
- Analysis and Design of Analog Circuits, *Paul Grey, Paul Hurst, Stephen Lewis and Robert Mayer*, John Wiley and Sons (UK), 4th edition.
- Digital Integrated Circuits - A Design Perspective, *Rabaey, Chandrakasan and Nokolic*, PHI (2nd Edition), 2008
- CMSO Digital Integrated Circuits - Analysis and Design, *Sung-Mo Kang & Yusuf Lablebici*, Tata McGraw Hill, (New Delhi), 2003

Microwave measurement Techniques
Code: MCE 204D
Contacts: 4-0-0
Credits: 4

a) **Introduction to Radio Frequency & Microwave Measurements-** Introduction Radio Frequency Band, microwave and millimeter wave.
b) **Power Measurement-** High Power Measurement, calorimeter technique, Low power Measurement, bolometer technique, Very Low Power Measurement.
c) **Frequency Measurement -** Different Technique to measure frequency, Slotted Line Technique, maxima & minima, wavelength & frequency measurement.
d) **Impedance Measurement-** Measurement of unknown load impedance of a transmission line, Slotted Line Technique to measure unknown impedance.
e) **Distortion & Frequency Translation Measurement-** Different types of distortion occurred at microwave frequencies, Procedures for frequency translation.
f) **Detectors& Sensors:** Definition of Detectors; Different type of microwave detectors functions and applications, Sensors Definition & working principle, applications.
g) **Vector Network Analyzer (VNA):** Concept of vector network analyzer, measurement of Scattering parameters, Basic block diagram of vector network analyzer (VNA), Application of vector network analyzers.
h) **Scalar Network Analyzer (SNA):** Definition of network analyzer, Difference between SNA&VNA, Basic block diagram Scalar Network Analyzer.
i) **Spectrum Analyzer:** Basic block diagram of a spectrum analyzer, functions & applications of a spectrum analyzer.
j) **Time Domain Electrometer (TDR) & IC Technology:** Introduction to Electrometer, Measurement of reflection coefficient using electrometer technique, Basic block diagram of a time domain electrometer.

Recommended Books:

1. G.H.Bryant- Principles of Microwave Measurements- Peter Peregrinus Ltd.
2. D.Pozar- Microwave Engineering, 2nd Ed, John Wiley
3. T.S.Laverghetta- Hand book on Microwave Testing
4. S.F.Adam- Microwave Theory & Application- Prentice Hall, Inc
5. HP Application Notes
6. A.E. Bailey, Ed. Microwave Measurements- Peter Peregrinus Ltd
7. M. Engelson-Moder Spectrum Analyser: Theory & Applications Artech Hous

Satellite communication
Code: MCE 205A
Contacts: 4-0-0
Credits: 4

Introduction: A brief history of satellite communication, future scope satellite communication.

Orbital Mechanism: Orbits, look angle, orbital period and velocity, azimuth and orbital inclination, coverage angle slant range, orbital perturbation, placement of satellite in geostationary orbit.

Satellite Subsystems: Communication, telemetry, ranging & command, power, altitude control, tracking, antenna subsystems.

Earth Station: Earth station antenna, gain, pointing loss, G/T variation and it's measurement, antenna tracking, power amplifier, low noise amplifier, up converter, down converter, transponder hopping, polarization hopping, redundancy configuration.

Satellite transponder: transponder model, transponder channelization, frequency plans, processing transponders.

Satellite Link Design: Basic link analysis, interference analysis, attenuation due to rain, link with and without frequency reuse.

Multiple Access Techniques:

Frequency Division Multiple Access: SPADE, FDM-FM-FDMA, Companded FDM-FM-FDMA and SSB-AM-FDMA, intermodulation products in FDMA, optimized carrier-to-intermodulation plus noise ratio.

Time division Multiple Access: Principle, TDMA frame structure, TDMA Burst structure, TDMA Superframe structure, Frame acquisition and synchronization. Satellite position determination. TDMA timing. Demand Assignment Multiple Access and Digital Speech interpolation. ERLANG B Formula. Type of demand assignment, DAMA characteristics, Real time frame reconfiguration, DAMA interfaces, SCPC-DAMA, Digital Speech interpolation. Satellite packet communication.

Propagation effects: Propagation effects and their impact on satellite earth link.

Introduction to VSAT systems: low earth orbit and non-geostationary satellite systems. Direct broadcast Television and Radio. Satellite Navigation and the global positioning system. Network configuration, multiaccess and networking, network error control poling VSAT network.

Mobile satellite network: Operating environment. MSAT network concept, CDMA MSAT relink. Worldwide timing by satellite relay.

Text and Reference Books:

1. Tri T. Ha, Digital Satellite Communication, TMH.
2. Timothy Pratt, Charles Bostian, Teremy Allnutt, Satellite Communication, John Wiley & Sons.
3. J. J. Spilker, Jr., Digital Communication by Satellite, Prentice Hall.
4. Bruce R. Elbert, Satellite Communication Applications Hand Book, Artech House.

Image processing & pattern recognition
Code: MCE 205B
Contacts: 4-0-0
Credits: 4

Objective: Students will have an idea about basic image processing in spatial domain/ image space, extraction of pixel-patterns from an image and construction of different feature spaces, application of pattern clustering and

classification techniques to analyze/ recognize an image. Some hints on advance and more recent research topics like *change detection in remotely sensed imagery, Eigen face recognition, image miming, content based image retrieval* will also be provided.

Prerequisite: Basic concept of vectors and matrices (relation between a column matrix and vector), inner product of two vectors, matrix multiplication, inversion, extracting Eigenvectors and Eigen values of a matrix, covariance matrix. Perception of dimensionality and hyper plane. Distance measures in Euclidean space between two points (e.g. Euclidean distance) and a point with a group of points (Mahalanobis distance). Knowledge about statistical distributions (e.g. Normal/ Gaussian), statistical independence, probability distribution function, condition probability, the law of total probability and Bayes rule.	
Part – A : Image Processing	6 L
Basics: Image definition, a simple image formation model, basic concepts of image sampling and quantization, representing a digital image, concept of pixel/ pel, spatial and gray level resolution, some basic relationships between pixels : Neighbors of a pixel, Adjacency, Connectivity, Path, Connected component, Connected component labeling. Distance measures: the three essential properties. Euclidean, City-Block and Chess-Board distance, concept of image operations on a pixel basis.	6 L
Popular image processing methodologies: Spatial domain technique : contrast stretching, basic point processing, thresholding function, concept of mask/ sub image, mask processing/ filtering, gray-level slicing, bit-plane slicing. Basics of spatial filtering : convolution mask/kernel, concept of sliding mask throughout the image-space, smoothing(averaging) filter/ low pass filter. Image segmentation by global and local gray level thresholding, region growing, region splitting and merging techniques. Morphological algorithms: thinning, thickening, skeletons.	8 L
Color image processing: Perception of color: color fundamentals. Two popular color models: RGB & HSI, concept of RGB & HSI space and their conceptual relationships, mathematical conversion from RGB to HSI space and vice versa.	2 L
Part – B : Pattern Recognition	
Basics of pattern recognition: Concept of a pattern: feature, feature vectors and classifiers. Importance of pattern recognition. Basic concept of fuzzy pattern recognition, linearly separable and inseparable classes, classes with some overlapping regions, convex and non-convex paradigm in this aspect.	2 L
Clustering: Basic concept of cluster analysis. Similarity (Proximity) metrics (indices) and clustering criteria. Partitional clustering: Extraction of natural groups that are inherent in some data set by hard c-means (k-means), fuzzy c-means. Concept of getting stuck to a local optimum (in objective functional space) by k-means and fuzzy c-means due to their initiation/ starting point. Fuzzy cluster validity index: Xie-Beni index.	8 L
Classification and prediction: Definition of classification and prediction. Basic task of a classifier. Concept of training & testing data and overfitting. Bayes classification: Bayes' Theorem, Naïve Bayesian classification. Classification by Backpropagation: Multilayer Perceptron (MLP) neural network and Backpropagation algorithm.	6 L
Global optimization techniques: Genetic Algorithms (Gas): Cycle of genetic algorithms, selection (Roulette wheel and Tourment) crossover, mutation, evaluation of fitness function, incorporation of elitism in GAs. Multi-objective optimization using GAs. Simulated Annealing (SA): Analogy with physical annealing process, concept of energy and mechanism of energy minimization using SA. Necessity of an uphill movement during the process. Hybridization with partitional clustering techniques.	4 L
Part – C : Image analysis	
Image clustering applications: Mechanism of extracting pixel-patterns from a ***gray-scale*** image in various ways: e.g. forming feature space (like a two column matrix) treating the gray-value of center-pixel (of a local window) as the first feature and averaged value over a square-shaped local window (3x3 or 5x5 or like that) as the second feature. construction of high-dimensional feature space: e.g. treating all the pixel-gray-values of a local window as features (i.e. for 3x3 window 9-dimensional feature space will result). Application of partitional clusterings in the above mentioned feature-space to recognize the objects in the concerned image.	2 L
Applications in multispectral and multitemporal remotely sensed imagery: Identification of different land cover types from multispectral remote image data using supervised/ unsupervised classification: Clustering by Histogram peak selection & and its limitation in this context (i.e. remote image analysis). Unsupervised Change Detection using squared-error clustering methodologies: The algorithm, process, key challenges, error estimations like missed alarms, false alarms and overall error, need of *ground truth*.	2 L

Image mining: Need, Image search and retrieval. Bottleneck of Text based image mining/ retrieval, Visual feature based image mining: Content-based image retrieval (CBIR). 2 L

Image based face recognition: Basic technique for Eigen face generation & recognition.

Intended outcomes: After completion of the course students will be able to analyze about the spatial image processing (in image space) and superiority of image pattern recognition. They will also get the idea about how to deal in an environment with high vagueness and/or ill-fashioned classes (or objects in some image) using fuzzy concept (fuzzy pattern recognition), function of basic and multilayer perceptron model to classify a data set. Some optimization processes (e.g. GA) to enhance the chance to reach a global optimum. Research and development kind of analyses should be realized by them concerning the recent trends in this aspect.	2 L

Text and Reference Books:

1. R. C. Gonzalez and R. E. Woods, *Digital Image Processing*, Pearson Education Asia, 2004
2. S.K. Pal, A.Ghosh, and M.K. Kundu, *Soft Computing for Image Processing*, Physica
3. Verlag, (Springer), Heidelberg,1999.
4. R. O. Duda, P.E. Hart and D. G. Stork, *Pattern Classification*, John Wiley & Sons (Low Priced Edition).
5. Anil K. Jain and R.C.Dubes, *Algorithms for Clustering Data*, Prentice Hall.
6. S. Theodoridis and K. Koutroumbus, *Pattern Recognition*, Elsevier.
7. A. Ghosh, S. Dehuri, and S. Ghosh (editors). *Multi-Objective Evolutionary*
8. *Algorithms for Knowledge Discovery from Databases*. Springer, Berlin,
9. 2008.
10. Anil K. Jain, *Fundamentals of Digital Picture Processing*, Prentice Hall.
11. D. E. Goldberg, *Genetic Algorithms in search, Optimization & Machine Learning*, Pearson
12. Education.
13. 9. *Remote Sensing Digital Image Analysis : An Introduction* by J.A Richards and X. Jia. Springer.
14. *Data Clustering: A Review* by Anil K. Jain, ACM Comput. Surv., Vol. 31, No. 3. (September 1999), pp. 264-323.
15. Pattern Recognition: The Journal of the Pattern Recognition Society.
16. *IEEE* Transactions on (i) Pattern Analysis and Machine Intelligence (TPAMI), (ii) on *Neural* Networks, (iii) on *Fuzzy* Systems.

Multimedia communication
Code: MCE 205C
Contacts: 4-0-0
Credits: 4

Sl. No.	Topic	Hrs
1	Multimedia Introduction: Media and Data Streams, Classification of media and Properties of multimedia system.	4
2	Sound, Images & Video : Speech synthesis, Speech Recognition, Raster display, Image recognition, TV, HDTV, Speech transmission, Image transmission	6
3	Compression : Huffman Coding, Runlength coding, JPEG, MPEG, DVI, H.261	6
4	Storage Media : CDDA, CDROM, CDROM (XA)	2
5	Multimedia Operating system: Resource Management, Process Management: EDF, Rate monotonic Algorithms, System Architecture: Quick Time, MDBMS	6
6	Synchronization: Lip & Pointer Synchronization, Synchronization Reference Model, Case Study.	4
7	Multimedia Communications: Delay compensation, QoS negotiation protocols, Architectures and Issues for Distributed Multimedia Systems, Prototype Multimedia systems: Video-on-Demand, Video conferencing. Multimedia Information: Delay-sensitive and Time-based Media data Modeling	12
References:		

1. Ralf Steinmetz and KlaraNahrstedt, "Multimedia: Computing, Communications and Applications", Prentice Hall PTR, 1995.
2. Franklin Kuo, Wolfgnag and J.J. Garsia, "Multimedia Communications, Protocols and Applications", Prentice Hall PTR 1998.

Advanced antenna and wave propagation
Code: MCE 205D
Contacts: 4-0-0
Credits: 4

Antenna:

- Wire antennas, Aperture Antennas, Antenna gain, Antenna Temperature and other Antenna parameters.
- Relationships between antenna parameters. Reciprocity, Review of microwave antennas-Parabolic Reflector, Cassigrain feeds, Horn Antennas, Open-ended wave guides, lens antennas, Dielectric rod Antennas, Antennas for mobile communication. Applications of reaction concept and vocational principles in antennas and propagation, Frequency- independent antennas, Scattering and diffraction. Selected topics in microwave antennas, Internal-equation methods, current distribution: Self and mutual impedances: arrays: design and synthesis.
- Full wave analysis of Microstrip Antenna(MSA),Active Integrated MSA, Compact MSA with enhanced gain, Broadband Antenna(MSA), Dual frequency & Dual polarized MSA
- Application of broadcasting, microwave links, satellite communication and radio astronomy.
- Antenna Measurements
- Standardization and characterization of antennas, Anechoic Chamber, Open-air test range.

Propagation:

- Review of modes of propagation: Surface wave, Ground wave, Sky wave, Space wave, Troposphere propagation.
- Propagation over plane-Earth, Spherical Earth, Refraction, Anomalous Propagation, Diffraction, Modified refractive index- Its effects on wave propagation, Duct and other nonstandard propagation. Environmental noise, EMI - EMC, Radiation Hazards.
- Microwave & millimeter wave propagation, Effects on atmospheric precipitations: Rain, Fog, Snow, Ice, and other atmospheric gases.
- Low frequency propagation, Propagation through seawater, Sea clutter, Land clutter, Surface clutter, Radar equation,
- Microwave link considerations- multi-path Fading, its characteristics- Techniques for more link availability
- Earth space systems

Text & **Reference Books:**

1. R.E Collin, Antennas & Radio wave propagation (McGraw-Hill Book Co.)
2. Jordan and Balmain, Electromagnetic Waves and Radiating Systems (PrenticeHall of India)
3. M.L Skolink, Introduction to radar systems (McGraw-Hill Book Co.)
4. P Bhartia and I.J. Bhal, Millimeter wave Engineering & Applications
5. Albart Smith, Radio Engineering Principle and Applications
6. M. Dolukhanov, Propagation of Radio Waves (Mir Publication)
7. R.Garg,P.Bhartia,Indu Bhal,A.Ittipibom ; Microstrip Antenna Design hand book –Artech House
8. Girish Kumar & K.P.Roy—Broad band Microstrip Antenna-=Artech. House
9. Kin. Lu. Wong ; Compact and Broadband Microstrip Antenna—John Willey & Sons.

Communication systems Lab
Code:
Contacts: 0-0-3
Credits: 2

Experiments on complete systems to acquire an overall knowledge about the system architecture, its important GOS parameters and its detail working principle.
Suggested topics are (not exclusive),

1. GPS
2. ISDN
3. Satellite communication system
4. GSM system
5. CDMA mobile system
6. Optical data communication system
7. Bluetooth communication system
8. Wireless channels.

Third Semester

Management

Code: MCE 301
Contacts: 4-0-0
Credits: 4

EMI/EMC
Code: MCE 302A
Contacts: 4-0-0
Credits: 4

Prerequisite:

Transmission Line Theory - Definitions, Different Types of Transmission line, Transmission Line Parameters, The Lumped element circuit model for a transmission line, Transmission Line Equation, Condition for lossless line, condition for distortion less line, Relation between Neeper & dB, The Terminated lossless transmission line: Input Impedance, Reflection Co-efficient, Return Loss, SWR, Special cases of lossless terminated lines, Power delivered to load, Transient on transmission line.

Micro-strip Line - Pattern of EM field distribution in a Micro-strip Line, Derivation of Effective Dielectric Constant, Characteristic impedance & Attenuation, Different Micro-strip line design examples.

Impedance Matching & Tuning - Purpose of Impedance matching, Factors important in the selection of a particular matching network, Different types of Impedance matching, Single stub matching, double stub matching, The quarter-wave transformer, Quarter-wave transformer bandwidth calculation, The theory of small reflection, Single-section Transformer, Multi-section Transformer, Binomial Multi-section matching transformer, Binomial transformer design examples, Chebyshev Transformer, Chebyshev Polynomials, Chebyshev transformer design.

Introduction To EMI - Definitions, Different Sources of EMI(Electro-magnetic Interference), Electro-static discharge(ESD),Electro-magnetic pulse(EMP),Lightning, Mechanism of transferring Electro-magnetic Energy: Radiated emission, radiated susceptibility, conducted emission, conducted susceptibility, Differential & common mode currents.

Introduction To EMC - Concepts of EMC, EMC units.

EMC requirements for electronic systems - World regulatory bodies- FCC, CISPR etc. Class-A devices, class-B devices, Regulations of the bodies on EMC issues.

Different Mitigation Techniques For preventing EMI

- **Grounding:** Fundamental grounding concepts, Floating ground, Single-point & Multi-point ground, advantages & disadvantages of different grounding processes.
- **Shielding:** Basic concepts of shielding, Different types of shielding, Shielding effectiveness(S.E),S.E of a conducting barrier to a normal incident plane wave, multiple reflection within a shield, mechanism of attenuation provided by shield, shielding against magnetic field & Electric field, S.E for Electronic metal & Magnetic metal, Skin-depth,S.E for far-field sources, shield seams.
- **Cross-talks & Coupling, Measurement set for measuring Cross-talk.**
- **Filtering & decoupling.**

Non-ideal behavior of different electronic components - Examples: Microwave oven, Personal Computers, Health Hazards-limits, EMC in healthcare environment.

Antennas - Characteristics of antennas, fields due to short electric dipole & small magnetic pole, near field & Far-field sources & their characteristics. Broadband antenna measurements, antenna factor.

EMI-EMC Measurements - EMC measurement set, Power losses in cable, calculation of signal source output for a mismatched load, Measuring & Test systems, Test facilities, measurements of radiated emission in open test range & in Anechoic chamber, Conducted emission testing by Line Impedance Stabilization network (LISN).

Time-domain & Frequency-domain Analysis Of Different Signals - Fourier series & Fourier transform of different signals, identifying the frequency, phase & power spectrum of different signals. Time-domain Reflectrometry (TDR) basics for determining the properties of a transmission line.

System Design For EMC - Simple susceptibility models for wires & PCB, Simplified lumped model of the pick-up of incident field for a very short two-conductor line.

EMP & ESD

Recommended Books:

1. *Introduction to Electromagnetic compatibility*-Clayton R.Paul(John wiley & Sons)

2. *EMC Analysis Methods & Computational Models*-Frederick M Tesche, Michel V.Ianoz, Torbjorn Karlsson(John Willey & Sons, Inc)

Reference Books:

1. *EMI/EMC Computational modeling Hand Book*- by Archambelt.

2. *Electrostatic Discharge In Electronics*-Willian D.Greason(John Wiley & Sons, Inc).

3. *The ARIAL RFI Book*-Hare,WIRFI published by-The American Radio Relay League Newington.

4. *Applied Electromagnetic Compatibility*-Dipak L Sengupta & Valdis V Liepa(John Wiley & Sons Inc).

5. *Electromagnetic waves & Radiating Systems*-Jordan & Balmain (Prentice Hall Publication)

6. *Elements Of Electromagnetic*-Matthew N.O.Sadiku (Oxford University Press)

7. *Microwave Engineering*-David M.Pozar(John Wiley & Sons, INC).

8. *Microwave Circuits & Passive Devices*-M.L Sisodia & G S Raghuvanshi(New Age International Limited)

Ad-hoc networking
Code: MCE 302B
Contacts: 4-0-0
Credits: 4

- Ad hoc wireless Network: Introduction, Basic concept on ad hoc network, static and mobile ad hoc network, transmitter-receiver constraints, Applications.
- MAC protocol: Hidden terminal, Exposed terminal, IEEE802.11 in ad hoc mode.
- Routing protocols: Proactive, Reactive and hybrid routing protocol, Destination sequenced distance vector algorithm, Dynamic source routing, Ad hoc on-demand routing, Location aided routing, Link reversal routing.
- Analysis of TCP performance in wireless ad hoc network: TCP window management and problems, different solution schemes, QoS in wireless ad hoc network
- Achieving energy efficiency in wireless ad hoc network: Different schemes to increase the lifetime of the node in ad hoc network – MAC layer protocol, Routing protocol.
- Localization Management: Location acquisition technique, location sensing technique, location aware routing protocol.
- Security for wireless ad hoc network: Security goals, threats and challenges, Different schemes of security in ad hoc network, routing security.
- Case study: Sensor Network, Wi – Max.

Optical signal processing
Code: MCE302C
Contacts: 4-0-0
Credits: 4

Convergence in communication technology
Code: MCE 302D

Contacts: 4-0-0
Credits: 4

Sl No	Module	No. of Lectures
1	**Emerged Technologies:** PSTN, Cellular (GSM/CDMA / EDGE, 3G), WLAN, ISDN, ATM, Frame Relay.	6
2	**Integrated Services and Convergence**: Reservation Protocols- RSVP, MPLS, All-IP Network, digital convergence, inter-networking.	6
3	**Voice over IP (VoIP):** VoIP architecture and network components, Gateways and gate keepers, VoIP functions, Signaling protocols, Routing calls over analog voice ports, Call signaling over digital voice ports, Direct inward dialing (DID), Dial peers.	8
4	**Gateway Control Protocols:** H.323 and MGCP gateways.	4
5	**Session Initiation Protocol:** SIP overview and architecture, SIP call flow, SIP addressing and configuration.	4
6	**IP Multimedia Service**	4
	IP Integration with Optical Networks	
7	Optical Networks: IP/OTN (Optical Transport Networks).Optical switching: IP/ASON (Automatic Switched Optical Networks). IP based Optical metro networks.	4
	Telecommunications Policy and Regulations	
8	Policy and technology perspectives of the telecommunications sectors. Impact of regulatory change on telecom operations; Universal service, the WTO, spectrum auction, regulatory environment of mobile multi-media services.; Telecommunication in the business innovation.	4

Books:

1. Olivier Hersent, David Gurle, Jean- Pierre Petit - *IP Telephony- Packet Based Multimedia System*- Pearson
2. Kelvin Wallace- *Authorized Self-Study Guide Cisco Voice over IP*, 3/e, Pearson Education, 2009
3. Houston H. Carr and Charles A. Snyder (2003) *The Management of Telecommunications*, McGraw-Hill Irwin: Boston
4. Steven Sheppard- *Telecommunications Convergence*, 2/e, McGraw-Hill Publishing