University of Pune

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

SEMESTER I

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./Pr. (Hrs)	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
504501	Modeling and Simulation of Communication Networks	4	50	50	-	-	100	4
504502	Spread Spectrum and CDMA Systems	4	50	50	-	-	100	4
504503	Detection and Estimation Theory	4	50	50	-	-	100	4
504104	Research Methodology	4	50	50	-	-	100	4
504505	Elective I	5	50	50	-	-	100	5
504506	Lab Practice I	4	-	-	50	50	100	4
Total		25	250	250	50	50	600	25

SEMESTER II

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./Pr. (Hrs)	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
504507	Traffic Analysis and QoS	4	50	50	-	-	100	4
504508	Broadband Wireless Technologies	4	50	50	-	-	100	4
504509	Optical Networks	4	50	50	-	-	100	4
504510	Elective II	5	50	50	-	-	100	5
504511	Lab Practice II	4	-	-	50	50	100	4
504512	Seminar I	4	-	-	50	50	100	4
Total		25	200	200	100	100	600	25

SEMESTER III

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME					CREDITS
		Lect./ Pr	Paper		TW	Oral/ Presentation	Total	
			In Semester Assessment	End Semester Assessment				
604501	Mobile Computing	4	50	50	-	-	100	4
604502	Digital Communication Receivers	4	50	50	-	-	100	4
604103	Elective III	5	50	50	-	-	100	5
604504	Seminar II	4	-	-	50	50	100	4
604505	Project Stage I	08	-	-	50	50	100	8
Total		25	150	150	100	100	500	25

SEMESTER IV

CODE	SUBJECT	TEACHING SCHEME	EXAMINATION SCHEME				CREDITS
		Lect./ Pr	Paper	TW	Oral/ Presentation	Total	
604506	Seminar III	5	-	50	50	100	5
604507	Project Work Stage II	20	-	150	50	200	20
Total		25	-	200	100	300	25

Elective I	1. Coding and Modulation Techniques 2. High Speed Communication Networks 3. Mathematics for Communication Networks **4.** Neural Networks in Communications **5.** *LATEX
Elective II	1. Advanced Techniques for Wireless Reception 2. Network Security 3. SDR and Cognitive Radio 4. RF MEMS 5. * Software Tools
Elective III	1. Value Education, Human Rights and Legislative Procedures 2. Environmental Studies 3. Energy Studies 4. Disaster Management 5. Knowledge Management 6. Foreign Language 7. Economics for Engineers 8. Engineering Risk – Benefit Analysis 9. Technology Play 10. Optimization Techniques 11. Fuzzy Mathematics 12. Design and Analysis of Algorithms 13. CUDA

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

504501	Modelling & Simulation of Communication Network	

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

Module I

Simulation Methodology: Introduction, Aspects of methodology, Performance Estimation, Simulation sampling frequency, Low pass equivalent simulation models for bandpass signals, Multicarrier signals, Non-linear and time-varying systems, Post processing – Basic graphical techniques and estimations.

Module II

Random Signal Generation & Processing: Uniform random number generation, mapping uniform random variables to an arbitrary pdf, Correlated and Uncorrelated Gaussian random number generation, PN sequence generation, Random signal processing, testing of random number generators.

Module III

Monte Carlo Simulation: Fundamental concepts, Application to communication systems, Monte Carlo integration, Semi-analytic techniques, Case study: Performance estimation of a wireless system.

Network And Traffic Modeling: Queuing theory related to network modeling, Poissonian and Non-Poissonian modeling of network traffic; Specific Examples.

Module IV

Advanced Models & Simulation Techniques: Modeling and simulation of non-linearities: Types, Memory-less non-linearities, Non-linearities with memory, Modeling and simulation of Time varying systems: Random process models, Tapped delay line model, Modeling and simulation of waveform channels, Discrete memory-less channel models, Markov model for discrete channels with memory, Tail extrapolation, pdf estimators, Importance sampling methods.

References:

1. William.H.Tranter, K. Sam Shanmugam, Theodore. S. Rappaport, Kurt L. Kosbar, Principles of Communication Systems Simulation, Pearson Education (Singapore) Pvt. Ltd, 2004.
2. M.C. Jeruchim, P.Balaban and K. Sam Shanmugam, Simulation of Communication Systems: Modeling, Methodology and Techniques, Plenum Press, New York, 2001.

3. Averill. M. Law and W. David Kelton, Simulation Modeling and Analysis, McGraw Hill Inc., 2000.
4. Geoffrey Gorden, System Simulation, Prentice Hall of India, 2nd Edition, 1992.
5. Jerry Banks and John S. Carson, Discrete Event System Simulation, Prentice Hall of India, 1984.

MODELING & SIMULATION OF COMMUNICATION NETWORK

Laboratory Assignments/Experiments:

1. Write the MATLAB code for estimating the performance of following communication system using Monte Carlo Simulation
   a. AWGN Channel
   b. Binary Phase Shift Keying
   c. Binary Frequency Shift Keying

2. For uniform Random number use Monte Carlo integration method as an approximated integration technique. Integrate f(x) on {0,1} interval for the following integral function
   a. $F(x) = x$
   b. $F(x) = x^2$
   c. $F(x) = \cos(\pi x)$

3. A simulation of memory channel using Markov model is demonstrated and system error probability is computed. Assume errors can be produced in either state where the probability of error in good state will be less than error probability of bad state. Specifically we define conditional error probability as Pr{Eg}=0.0005 and Pr{Eb}=0.1000. Markov chain is defined by transition matrix

$$A=\begin{pmatrix} 0.98 & 0.02 \\ 0.05 & 0.95 \end{pmatrix}$$

504502	Spread Spectrum and CDMA Systems	

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

Module I

Binary Shift Register Sequences for Spread Spectrum Systems: Definitions, mathematical background and sequence generator fundamentals, Maximal length sequences, Gold codes, and nonlinear code generators

Initial Synchronization of the Receiver Spreading Code: Problem definition and the optimum synchronizer, Serial search synchronization techniques, generalized analysis of average synchronization time, Synchronization using a matched filter Synchronization by estimating the received spreading code, Tracking loop pull-in

Module II

Performance of Spread Spectrum Systems in Jamming Environments, with forward Error Correction: Spread spectrum communication system model, Performance of spread spectrum systems without coding, Elementary block coding concepts, Elementary convolutional coding concepts , Results for specific error correction codes, Interleaving , Coding bounds, Introduction to Fading Channels, Statistical model of fading, Characterization of the mobile radio channel , Requirement for diversity in fading channels .

Module III

Code Division Multiple Access Digital Cellular Systems: Cellular radio concept, CDMA digital cellular systems, Specific examples of CDMA digital cellular systems, North American DS-CDM digital cellular system (IS-95), Cooper and Nettleton DPSK-FHMA system , Bell Labs multilevel FSK frequency hop system, SFH900 system, GSM-SFH digital cellular system , Hybrid SFH TDMA/CDMA system for PCS applications,

Module IV

Diversity and the RAKE receiver, Physical and logical channels in IS-95; Medium access in cdma2000 and its extensions, Physical and logical channels in WCDMA; Medium access in WCDMA; Packet access, Radio resource management: Power control and soft handoff, Radio resource management in IS-95, cdma2000 and WCDMA; HSDPA, Network planning for CDMA - IS-95 and WCDMA systems, miscellaneous topics in spread spectrum - GPS (positioning), jamming, and military systems.

References:

1. R. L. Peterson, R. E. Ziemer, and D. E.Borth, Introduction to Spread Spectrum Communications, Prentice Hall, 1995. (ISBN 0-02-431623-7)
2. Vijay K. Garg, Wireless Network Evolution: 2G to 3G, Prentice Hall, 2002, ISBN: 0-13-028077-1
3. J. S. Lee and L. E. Miller, CDMA Systems Engineering Handbook, Artech House, 1998. (ISBN 0-89006-990-5)
4. J. Viterbi, CDMA: Principles of Spread Spectrum Communication, Addison-Wesley, 1995.
5. R. C. Dixon, Spread Spectrum Systems with Commercial Applications, 3rd ed., John Wiley & Sons, 1994.
6. T. S. Rappaport, Wireless Communications: Principles and Practice (2nd Edition), Prentice Hall, 2001.
7. H. Holma and A. Toskala, WCDMA for UMTS, John Wiley and Sons, 2000.

Spread Spectrum and CDMA Systems

Laboratory Assignments/Experiments:

1. Discuss the mathematical analysis on the average bit error rate for multi-users in a single channel of the spread spectrum, Code Division Multiple Access (SS-CDMA) mobile radio system. Present expressions of BER performance of CDMA systems for a wide range of interference conditions for both synchronous case and asynchronous case, including Gaussian approximations (GA), Improved Gaussian Approximation (IGA), and Simple Improved Gaussian Approximation (SIGA).
2. Discuss the key idea of the multiuser detection in the CDMA systems for high speed data transmission and develop the multiuser CDMA system model.
3. Comment on the use of spread spectrum technology is the North American Code Division Multiple Access (CDMA) Digital Cellular (IS-95) standard.
4. Reason out the following with proper examples
   - Tight synchronization is required to use orthogonal codes, which then break in a multipath channel anyway
   - Quasi-orthogonal codes cause self-interference, which dominates the performance in most CDMA systems
   - Near-far problem is a serious hindrance, requiring fast and accurate power control (that uses up bits we could otherwise send information with)
   - For all this, the required bandwidth is now J times largerthan it was before, so there doesn't appear to be a capacity gain
   - How did Qualcomm convince people to use this stuff
5. Highlight the features of RAKE Receiver and discuss the practical implementation of the same

504503	Detection And Estimation Theory	
Teaching Scheme: Lectures 4Hrs/ Week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

Classical Detection and Estimation Theory: Introduction: Signals and Systems: System theory, stochastic process and their representation, Gauss – Markov models, likelihood and efficiency. Detection theory: Hypothesis testing, Decision criterion, multiple measurements, multiple and composite hypothesis system, CFAR detection. Detection of signals in noise: detection of known signals in white noise, co- relation receiver, Maximum SNR criterion estimation theory, composite hypotheses, general Gaussian problem, performance bounds and approximations.

Module II

Representations of Random Processes: Introduction, orthogonal representations, random process characterization, homogenous integral equations and eigen-functions, periodic processes, spectral decomposition, vector random processes.

Estimation of Continuous Waveforms: Introduction, derivation of estimator equations, a lower bound on the mean-square estimation error, multidimensional waveform estimation, nonrandom waveform estimation.

Module III

Detection of Signals – Estimation of Signal Parameters: Estimation theory: Estimation of parameters, random and non-random, Bayer's estimates properties of estimators, linear mean square estimation. Estimation of waveform: Linear MMSE estimation of waveform, estimation of stationary process, Weiner filters, estimation of non- stationary process, detection and estimation in white Gaussian noise, detection and estimation in non-white Gaussian noise, signals with unwanted parameters, multiple channels and multiple parameter estimation.

Module IV

Linear Estimation: Properties of optimum processors, realizable linear filters, Kalman-Bucy filters, fundamental role of optimum linear filters. Weiner filters, estimation of non- stationary process, Kalman filters. Relation between Weiner filters and Kalman filters, non-linear estimation. Application to RADAR signal processing, estimation of range detection of object, it's size etc. Linear prediction and optimum linear filters: Forward and backward linear prediction, properties of linear prediction error filters, AR lattice and ARMA lattice ladder filters, Weiner filters for filtering and prediction

References:

1. Harry L. Van Trees, "Detection, Estimation, and Modulation Theory," Part I, John Wiley & Sons, USA, 2001.
2. M.D. Srinath, P.K. Rajasekaran and R. Viswanathan, "Introduction to Statistical Signal Processing with Applications," Pearson Education (Asia) Pte. Ltd. /Prentice Hall of India, 2003.
3. Steven M. Kay, "Fundamentals of Statistical Signal Processing," Volume I: "Estimation Theory", Prentice Hall, USA, 1998;
4. Steven M. Kay, "Fundamentals of Statistical Signal Processing", Volume II: "Detection Theory," Prentice Hall, USA, 1998.
5. K Sam Shanmugam, Arthur M Breipohl, "Random Signals: Detection, Estimation and Data Analysis", John Wiley & Sons, 1998

Detection And Estimation Theory

Laboratory Assignments/Experiments:

Develop the design steps for RADAR signal detection and estimation by various prediction techniques and filters. Comment on the same by simulating the design using MATLAB.

1. Highlight the estimation parameters for detection of random and non-random signals.
2. Write a note on application of Markov models in estimation process. Design atleast one of them.

504104	Research Methodology	
Teaching Scheme: Lectures 4Hrs/ Week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

Research Problem

Meaning of research problem, Sources of research problem, Criteria / Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem.

Basic instrumentation

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

Module II

Applied statistics

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

Module III

Modeling and prediction of performance

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

Module IV

Developing a Research Proposal

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

References

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

Research Methodology

Laboratory Assignments/Experiments:

1. Regression analysis of any given problem.
2. Applying PCA for a given problem.
3. For a given system, design a computer model to test the performance of the system. Draw graphs for to study the trends.
4. Develop a research proposal for any system in your mind and present it in front of the committee.

Course Outcomes:

- The student will show understanding of regression analysis and principal component analysis.
- The student will exhibit the knowledge of design a computer model for a system.
- The student will be able to do asymptotic analysis.
- The student will demonstrate the preparation of a research proposal.

504505	Coding And Modulation Techniques	
ELECTIVE-I		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Definitions, Uniquely Decodable Codes, Instantaneous Codes, Krafts Inequality, McMillan's Inequality, Optimal Codes, Binary Huffman Codes, r-ary Huffman codes, Information and Entropy, Properties of Entropy Function, Entropy and Average Word-Length, Shannon-Fano Coding, Shannon's First Theorem, Information Channels, Binary Symmetric Channel, System Entropies, System Entropies for Binary Symmetric Channel, Extension of Shannon's First Theorem to Information Channels, Mutual Information, Mutual Information for the Binary Symmetric Channel, Hamming Distance, Shannon's Second (Fundamental) Theorem, Converse of Shannon's Theorems.

Module II

The Lee Metric, Hadamard Codes, Golay Codes (Binary and Ternary), Reed Muller Codes, and Kerdock Codes. Bounds on Codes: Gilbert Bound, Upper Bound, Linear Programming Bounds, Hamming's Sphere – Packing Bound, Gilbert Varshamov Bound, Hadamard Matrices and Codes. Reed-Solomon Codes, Quadratic Residue Codes, Generalized Reed-Muller Codes. Perfect Codes and Uniformly Packed Codes: Lloyd's Theorem, Characteristic Polynomial of a Code, Uniformly Packed Codes, Nonexistence Theorems. Galois Rings over Z4, Cyclic Codes over Z4, Goppa Codes. Algebraic Curves, Divisors, Differentials on a Curve, Riemann – Roch Theorem, Codes from Algebraic Curves. Arithmetic Codes: AN Codes, Mandelbaum – Barrows Codes, Convolutional Codes.

Module III

Advanced Digital Modulation and Demodulation Techniques, QPSK, Continuous Phase PSK (CPPSK), GMSK, QAM, Trellis Coded Modulation (TCM) Clock and Carrier Recovery Schemes. Frequency hopping multiple access (FHMA) principle and functional block diagram, DSSS, Code division multiple access, Mathematical representation, Effect of multipath propagation on CDMA. CDMA systems, Multi-user detection.

Module IV

Orthogonal Frequency Division Multiplexing (OFDM), Principle, Implementation of Transceivers, Frequency selective channels, channel estimation, Inter-carrier interference, multicarrier code division multiple access. Multi-antenna systems, smart antennas, capacity increase, receiver structures, algorithms for adaptation of antenna weights. Multiple input and multiple output systems, channel state information, capacity of non fading channels

References

1. G. A. Jones and J. M. Jones, "Information and Coding Theory", Springer, 2000.
2. J. H. van Lint, "Introduction to Coding Theory", Springer, 1999.
3. Cover Thomas, "Elements of Information Theory", and Wiley 2006.
4. Andreas F. Molish, "Wireless Communications" 2006, John Wiley & Sons
5. R. W. Hamming, "Coding and Information Theory", Prentice Hall, 1986.
6. T. M. Cover and J. A. Thomas, "Elements of Information Theory", Wiley, 1991

Coding And Modulation Techniques

Laboratory Assignments/Experiments:

1. Discuss the Reed-Solomon codes with respect to architecture and implementation highlighting the superiority for wireless communication systems
2. Develop the design steps for RADAR signal detection and estimation by various prediction techniques and filters. Comment on the same by simulating the design using MATLAB

504505	High Speed Communication Networks	
ELECTIVE-I		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

High Speed Networks: Frame Relay Networks – Asynchronous transfer mode – ATM Protocol Architecture, ATM logical Connection, ATM Cell – ATM Service Categories – AAL. High Speed LAN's: Fast Ethernet, Gigabit Ethernet, Fiber Channel – Wireless LAN's: applications, requirements – Architecture of 802.11

Module II

Congestion and Traffic Management: Queuing Analysis – queuing Models – Single Server Queues – Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control.

Module III

TCP Congestion Control: TCP Flow Control – TCP Congestion Control – Retransmission – Timer Management – Exponential RTO back off – KARN's Algorithm – Window Management – Performance of TCP over ATM

Module IV

ATM Congestion Control: Traffic and Congestion control in ATM – Requirements – Attributes – Traffic Management Frame work, Traffic control – ABR traffic Management - ABR rate control, RM cell formats ABR Capacity allocations – GFR traffic management

Integrated and Differentiated Services: Integrated Services Architecture – Approach, Components, Services – Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services.

References

1. William Stallings, "High Speed Networks and Internet", Communication networks", Jean Harcourt Asia, Pvt. Ltd., II Edition, 2001
2. Irvan Pepelnjk, Jim Guichard and Jeff Apcar, "MPLS and VPN architecture", Cisco Press, Volume 1 and 2, 2003.
3. Tom Sheldon, "Encyclopedia of Networking and telecommunications" TMH, 2001

Laboratory Experiments :

1. Write an article on the latest development in the ATM congestion control.
2. Discuss in detail all the versions of the Architecture of 802.11.as applied to different radio access techniques.
3. Write a note on various queuing models for traffic congestion control highlighting their advantages, disadvantages and applications.
4. Comment on the various Integrated Services Architecture leading to QoS support with proper justification.
5. Design any one high speed communication network to give atleast on parameter related to QoS.

504505	Mathematics for Communication Networks	
ELECTIVE-I		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

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

Module II

Some Important Classes of Linear Systems:-Shift Invariant Systems and Topelitz Matrices, Operators and Square Matrices, Self Adjoint Operators and Hermitian Matrices, idempotent matrices and unitary matrices, Gram-Schmidt Orthogonalization.

Module III

Vector Space -Definition and properties of vector space; Definition and properties of vector sub-space; Algebra of subspaces; basis of a vector space; finite dimensional vector space; Linear independence of vectors.

Module IV

Random variable- CDF,PDF, Statistical averages, nth moments, central moments, probability models for discrete and continuous random variables, Binominal's, Poisson's, Gaussian, Uniform, Rician, 2D-random variables, autocorrelation, covariance, covariance coefficient.

Random processes- Ensemble, Stationary process, WSS, Ergodic process, Markov chain, Markov process, Poisson's process, Gaussian process, Weiner process, spectral representation of random signals, transmission of random process through LTI filter, effect of noise on random process, white noise, narrow band noise, SVD decomposition. Filtering Random processes, spectral factorization.

References :

1. K. Hoffman & R.Kunze, Linear Algebra- PHI, 1996
2. S.Andrilli & D.Hecker-Elementary linear Algebra-Else verinc 2003.
3. Paul R. Halmos, Finite-Dimensional Vector Spaces, Springer
4. Matrix Analysis- . R. Horn and C. Johnson, Cambridge U.P
5. Monson Hayes, Statistical Signal Processing, Wiley, 1996

6. A. Popoulis, Pillai-Probability, Random Variables & stochastic processors-TMH, 2004.
7. H.Stark& J.W.Woods-Probability, Random variables & eitimation theory for Engineer PHI-1994.
8. Kishor S. Trivedi - Probability, Random Variables & Random processors- Prentice hall
9. Simon Haykins - Communication system.
10. Taub & Schilling, Taubs Principals of Communication Systems, TMH 3rd edition.
11. Dr. Shaila D. Apte , Advanced Digital Signal Processing, Wiley India

Laboratory Assignments/Experiments:

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

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Course Outcomes:

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

504505	Neural Networks in Communications	
ELECTIVE-I		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Introduction to artificial neural networks, Learning rules, perceptron networks, Feed forward networks, Feedback networks, Radial basis function networks, Associative memory networks, self organizing feature map, Adaptive resonance theory,

Module II

Probabilistic neural networks, neocognitron, Optical neural networks, Simulated annealing, Support vector machines, Neuro-dynamic programming

Module III

Applications in Telecommunications: Efficient design of RF and wireless circuits, Neural networks for switching, ATM traffic control using neural networks, Neural model for adaptive congestion control in ATM networks.

Module IV

Neural network channel equalization, Static and Dynamic Channel assignment using simulated annealing, Traffic density determination using self organizing feature map.

References

1. S N Sivanandam, S Sumathi, S N Deepa, "Introduction to Neural Networks Using Matlab 6.0", Tata McGraw Hill Publication.
2. Fredric Ham and Ivica Kostanic, "Principles of Neuro-computing for science and Engineering", Tata McGraw Hill Publication
3. Simon Haykin, "Neural Networks: Comprehensive foundation", Prentice Hall Publication.
4. Ben Yuhas and Nerwan Ansari, "Neural Networks in Telecommunications", Kluwer Academic publishers

Neural Networks in Communications

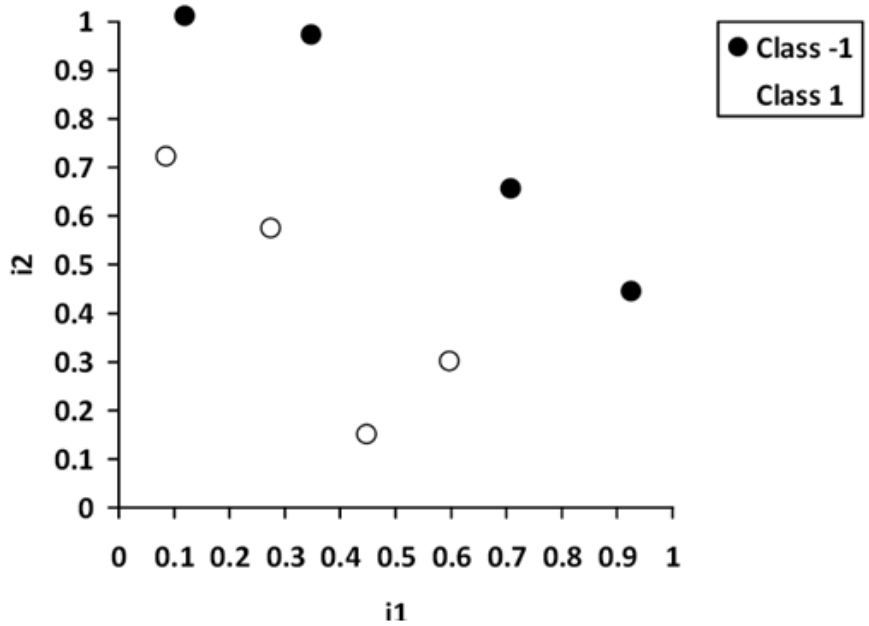
Laboratory Assignments/Experiments:

Q1) Consider the Back propagation algorithm operating on neurons which use the transfer function logsigmoid instead of the usual sigmoid function. That is assume that the output of a single neuron is

$\sigma = \log\sigma(w^{(T)}x)$. Remember $(\sigma(x))' = \sigma(x).(1- \sigma(x))$.

Given the weight update rules for output layer weights and for hidden layer weights.

Q2) The chart below shows a set of two dimensional input samples from two classes:



(a) It looks like there exists a perfect classification function for this problem that is linearly separable, and therefore a single perceptron should be able to learn this classification task perfectly. Let us study the learning process, starting with a random perceptron with weights w0= 0.2, w1= 1, and w2= -1, where of course w0is the weight for the constant offset i0= 1. For the inputs, just estimate their coordinates from the chart.

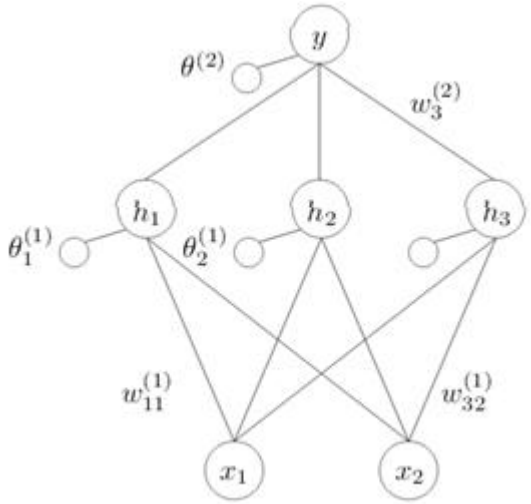
Now add the perceptron's initial line of division to the chart. How many samples are misclassified? Then pick anarbitrary misclassified sample and describe the computation of the weight update (you can choose η= 1 or any other value; if you like you can experiment a bit to find a value that leads to efficient

learning). Illustrate the perceptron's new line of division in the same chart or a different one, and give the number of misclassified samples. Repeat this process four more times so that you have a total of six lines (or fewer if your perceptron achieves perfect classification earlier). You can do the computations and/or graphs either by hand or by writing a computer program. If you write a program, please attach a printout, and let the program run until the perceptron achieves perfect classification (after how many steps?).

(b)If your perceptron did not reach perfect classification, determine a set of eights that would achieve perfect classification, and draw the separating line for those weights.

(c) Now let us assume that less information were available about the samples that areto be classified. Let us say that we only know the value for i1for each sample, which means that our perceptron has only two weights to classify the input as best as possible, i.e., it has weights w0and w1, where w0is once again the weight for the constant offset i0= 1. Draw a diagram that visualizes this one-dimensional classification task, and determine weights for a perceptron thatdoes the task as
best as possible (minimum error, i.e., minimum proportion of misclassified
samples). Where does it separate the inputspace, and what is its error?

Q3) A feed forward neural Network with 13 parameters.You will explore evaluating and learning in this model.



Hidden layer indexed by j = 1…….3
Input layer indexed by l = 1…….2

a) Evaluating the error function
   Write a program to compute $E_D(w)$ and evaluate $E_D(w')$ for
   W'=(0.1,0.1,0.1,0.1,-0.2,-0.3,-0.1,0.1-0.2,0.1,0.2,0.3,0.4).
b) Perturbing the weight vector.

Use your program to find for k= 1…….K

$$g_k(w') = [E_D(w'+\varepsilon\eta^{(k)}) - E_D(w')] / \varepsilon$$

where $\varepsilon = 10^{-6}$ and $\eta^{(k)}$) is a vector of zeroes with a one in position k:

$\eta_j^{(k)} = 1$ if j=k
= 0 otherwise

c) Learning the weight vector
   Describe and explain a method for using $g_k(w)$ to find a setting of w that predicts the outputs
   $t^{(n)}$ from the inputs $x^{(n)}$
   If you implement this (optional). Then include code and a solution for w .

504505	*LATEX	
ELECTIVE-I		
Teaching Scheme: **Theory 1 Hrs/ Week**		**Examination Scheme:** **Credits :1**
LaTeX /Document Structure, Document classes, Packages, The document environment, Book structure.		
References:		
http://miktex.org/ http://www.winedt.com/		
*For each Subject under Elective I the student Shall study LATEX for 1 credit.		

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

SEMESTER-II

504507	Traffic Analysis and QoS	
Teaching Scheme: Lectures 4 Hrs/ Week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

SNMP and Network Management: Basic foundations: Standards and Models, Organization Model, Information Model, Communication Model, Functional Model.
Network Management Tools, Systems and Engineering: System utilities for Management, Network Statistics, Measurement Systems, MIB Engineering, NMS Design, Network Management System

Module II

TMN and Applications Management: Telecommunication Management network: Conceptual Model, Standards, Architecture, Service architecture, integrated view, Implementation. Broadband Network Management: Network and Services, ATM Technology and Management, MPLS Network Technology and OAM Management, Optical and MAN Feeder Networks

Module III

High Speed Networks: High Speed LAN, Performance Modeling and Estimation: Self Similar Traffic.
Quality of Service in IP Networks: Integrated and Differential Services, Protocols for QoS Support.

Module IV

Congestion, Performance Issues and Traffic Management: Need for Speed and Quality of Service, Performance Requirement and Metrics, Effects of Congestion, Congestion Control in Data Networks and Internet, Link Level Flow and Error Control, TCP Traffic, Control Traffic and Congestion Control in ATM Networks

References

1. Network Management- Principles and Practices - Mani Subramanian, Pearson, Second Edition.
2. High-Speed Networks and Internets- Performance and QoS, William Stallings, Pearson, Second Edition.
3. Computer Networking with Internet Protocols and Technology, William Stallings, Pearson, Second Edition.
4. Traffic Management & Traffic Engineering for the future Internet - Valadas & Ruj

Traffic Analysis and QoS

Laboratory Assignments/Experiments:

1. Develop the design steps in the implementation of telecommunication networks.

2. Download a Network Management tool from WWW and install it on an appropriate platform where that tool works (Windows/Linux/Solaris, etc.) on your PC. You can also use an evaluation copy with limited usage time (e.g., 30 days). Some tools are available only in executable binary forms (especially those that run under Windows) while others are available with source code. You should build the tool from source code following developer's instructions on your platform (typically Linux). Each tool comes with some documentation about its use and a few examples. Execute at least two such examples and comment on the results provided by the tool

504508	Broadband Wireless Technologies	

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

Module I

OFDM & Block Based Transmissions: Block based transmissions, OFDM multiplexing systems, Single carrier cyclic prefix systems, orthogonal FDMA, interleaved FDMA, single carrier FDMA, CP based CDMA, receiver design.

MIMO Antenna Systems: MIMO system model, channel capacity, diversity and spatial multiplexing gain, SIMO & MISO systems, space-time coding, MIMO transceiver design, SVD based Eigen bean forming, MIMO for frequency selective fading channels, cyclic delay diversity.

Module II

UWB and Medium Access Control:

Time hopping UWB, Direct sequence UWB, Multiband, other types UWB, Slotted ALOHA MAC, Carrier sense multiple access with collision avoidance MAC, polling MAC, Reservation MAC, Energy efficient MAC, Multichannel MAC, Directional Antenna MAC, Multihop saturated Throughput of IEEE 802.11 MAC, Multiple Access Control.

Module III

Multihop Wireless Broadband Networks, Radio Resource Management and QOS: Multihop Wireless Broadband networks: Mesh networks, Importance of Routing Protocols, Routing Metrics, Classification of Routing Protocols, MANET routing protocols, Packet scheduling, Admission Control, Traffic Models, QoS in wireless systems, Out\age probability for vbideo services in a multirate DS- CDMA system.

WiMAX and Optical Access Networks: Point – multipoint WiMAX networks, Mesh mode, Mobility in WiMAX networks, Data link layer Protocols, Multi – point control Protocols, Dynamic BW allocation algorithm (DBA).

Module IV

Ethernet Passive Optical Networks (EPONS): Intra – ONU scheduling, QoS enabled DBA, QoS protection and Admission control in EPON, BW management for Multichannel EPONS, Separate/combined time and wavelength assignment

EPON – WiMAX, Hybrid WOBAN, Point – Point FTTx, Broadband Access Networks

Integrated Architectures for EPON and WiMAX, Design & operation Issues, WOBAN- a network for future, connectivity, routing, fault tolerance & self healing, fiber topology vs. transmission scheme, Architectural/deployment/operational/cost considerations, open fiber access, transmission technologies, broadband networks & network requirements, scalable broadband access networks, next generation access & backhaul.

References

1. David Tung Choug Wong, Peng Yong Kong, Ying Chang Liang, Lee Chaing Chua, Jon W. Mark, Wireless Broadband Networks, Wiley Publication.
2. Abdallah Shami, Martin Maier, Chadi Assi: Biswanath Mukharjee- series Editor, Broadband Access Networks Technologies Deployments, Springer.
3. Regis J. "Bud" Bates, Broadband Telecommunications Handbook, Mc GRAW - Hill

Broadband Wireless Technologies

Laboratory Assignments/Experiments:(at least two experiments from the list to be executed)

1. Study a specific case study on the deployment of any advanced broadband wireless technology and illustrate the details of its implementation. Also, describe its productivity gain, future benefits of the technology and the resultant economic growth.

2. Perform a study of new communication services and infer possible scenarios for applying open wireless broadband platform to new value-added scenarios such as broadcasting services, regional services, and disaster recovery.

3. Analyze the governance for open wireless broadband platforms: laws, systems, rules, assignment of radio frequencies, and propose the necessary strategies and policies that could be adopted.

4. Give details of validation of mobile communications technology including Proposal, validation of IP mobile communications protocol technology and study of network design schemes for open wireless platforms

5. Perform study of authentication techniques for realizing MVNOs on wireless networks and ways to integrate them with open standard authentication techniques on the internet.

6. Analyze the validation of non-preemptive handover technology between foreign wireless networks, Validation of seamless handover technology between wireless networks, and study the development of standardized handover technologies for foreign wireless networks

504509	Optical Networks	

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

Module I

Introduction to Optical Networks: Telecommunications Networks Architecture, Services, circuit switching and packet switching, Optical Networks: Multiplexing Techniques, Second generation Optical Networks, Optical Packet Switching, Transmission Basics: Wavelength, frequencies, and channel spacing, Wavelength standards, Optical power and loss, Network Evolution, Nonlinear Effects: Self-phase Modulation, Cross-phase Modulation, Four Wave mixing, Solitons.

Components: Couplers, Isolators and Circulators, Multiplexers and Filters, Optical Amplifiers, Transmitters, Detectors, Switches, Wavelength Converters.

Module II

Transmission System Engineering: System Model, Power Penalty, Transmitter, Receiver, Optical Amplifiers, Crosstalk, Dispersion, Wavelength Stabilization, Overall Design Considerations.

Optical Internets: Migration to IP optical networking, IP and Optical backbone, IP Routing table, MPLS and optical cross connect table, Protocol stack Alternatives, Internetworking SS7 and Legacy Transport, Internet transport network protocol stack.

Module III

SONET, SDH and Optical Transport Networks (OTNs): SONET and SDH: SONET multiplexing hierarchy, Frame structure, Functional Component, problem detection, concatenation.

Architecture of Optical Transport Networks (OTNs): Digital wrapper, in-band and out-of-band control signalling, Importance of Multiplexing and multiplexing hierarchies, SONET multiplexing hierarchies, SDH multiplexing hierarchies, New Optical Transport, OTN layered Model, Generic Framing Procedure (GFP).

Module IV

WDM, Network topologies, MPLS and Optical Networks: WDM: WDM operation, Dense Wavelength Division Multiplexing (DWDM), Erbium-doped Fiber (EDF), WDM amplifiers, Add-Drop Multiplexers, Wavelength Continuity Property, Higher dispersion for DWDM, Tunable DWDM Lasers.

Network topologies and protection schemes: Robust networks, Line and path protection switching, Types of topology, Point to point topology, bi-directional line-switched ring (BLSR), meshed topology, Passive optical networks, Metro optical networks

MPLS and Optical Networks: IS label switching, Forwarding equivalence class (FEC), Types of MPLS nodes, Label distribution and binding, label swapping and traffic forwarding, MPLS support of Virtual Private Networks (VPN), MPLS traffic engineering, Multi protocol Lambda switching (MPIS).

References

1. Optical Networks – Practical Perspective, 3rd Edition, Rajiv Ramaswami and Kumar Sivarajan, Morgan - Kaufmann Publishers.
2. Optical Networks, Third Generation Transport Systems, Uyless Black, Pearson Edition.

Optical Networks

Laboratory Assignments/Experiments:

1. Examine new elastic optical networking paradigm describing the drivers, building blocks, architecture, and enabling technologies for this new paradigm, as well as early standardization efforts
2. Explore the new paradigm for the access network with the introduction of OFDMA into a Passive Optical Network (PON) architecture
3. Give an overview of Optical network architectures and protocols design for wireless backhauling
4. Describe Next Generation Passive Optical Networks (NGPONs) and Next Generation Access Networks (NGANs)
5. Analyze Long-Reach Passive Optical networks for Metropolitan network consolidation and its impacts
6. How is the problem of routing and wavelength assignment (RWA) handled for increasing the efficiency of wavelength-routed all-optical network?

504510	Advanced Techniques for Wireless Reception	
ELECTIVE-II		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Wireless signalling environment. Basic signal processing for wireless reception. Linear receivers for synchronous CDMA. Blind and group-blind multiuser detection methods. Performance issues.

Module II

Robust multiuser detection for non Gaussian channels; asymptotic performance, implementation aspects. Adaptive array processing in TDMA systems. Optimum space-time multiuser detection.

Module III

Turbo multiuser detection for synchronous and turbo coded CDMA. Narrowband interface suppression. Linear and nonlinear predictive techniques. Code aided techniques. Performance comparison.

Module IV

Signal Processing for wireless reception: Bayesian and sequential Monte Carlo signal processing. Blind adaptive equalization of MIMO channels. Signal processing for fading channels. Coherent detection based on the EM algorithm. Decision-feedback differential detection. Signal processing for coded OFDM systems.

References

1. X.Wang & H.V.Poor, Wireless Communication Systems, Pearson, 2004.
2. R.Janaswamy, Radio Wave Propagation and Smart Antennas for Wireless Communication, Kluwer, 2001.
3. Mohamed Ibnkahla, Signal Processing for Mobile Communications, CRC Press, 2005.
4. A.V.H. Sheikh, Wireless Communications Theory & Techniques, Kluwer Academic Publications, 2004.
5. A.Paulraj etal, Introduction to Space-time Wireless Communications, Cambridge University Press, 2003.

Advanced Techniques for Wireless Reception

Laboratory Assignments/Experiments:

1. Design the steps of Monte Carlo sampling methods for Bayesian filtering

2. Develop a general variational Bayesian framework for iterative data and parameter estimation for coherent detection is introduced as a generalization of the EM-algorithm.

504510	Network Security	
ELECTIVE-II		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

Wireless Protocols: Wireless TCP, Session Mobility, MAC protocols for digital cellular systems such as GSM. IEEE 802.11 WLANs analysis, deployment of 802.11 infrastructures; Bluetooth, core protocols, MANETs and WSNs.

Module II

Mobile Ad Hoc networks: MAC Protocols - classification, comparative analysis, reactive and proactive routing, power-aware routing. Wireless Sensor Networks: Data Dissemination, Data Gathering, MAC Protocols, Sensor Management, Localization.

Module III

Conventional encryption, cipher-block, location of encryption devices, key distribution. Public key cryptography, RSA algorithm, diffie-hellman algorithms, message authentication, secure hash functions, HMAC, digital signatures, key management. Secrete Key Cryptography, DES, IDEA, AES.

Module IV

Network Security applications: Authentication applications email Security, PGP, SMIME IP Security, authentication on header, encapsulating security payload, combining security associations, key management. Web Security Requirements, SSL and TSL, SET.

References

1. William Stallings, " Cryptography and Network Security", 3rd edition, Pearson Education
2. Jochen Schiller, "Mobile Communications", Addison Wesley, 2000.
3. C. Siva Ram Murthy and B. S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols", Prentice Hall.
4. Ramjee Prasad and Luis Munoz, "WLANs and WPANs towards 4G wireless", Artech House, 2003.
5. Evangelos Kranakis, " Primality and Cryptography", John Wiley & Sons
6. Rainer A. Ruppel, " Analysis and Design of Stream Ciphers", Springer Verlag
7. Douglas A. Stinson, "Cryptography, Theory and Practice", 2nd edition, Chapman & Hall, CRC Press Company, Washington.

Network Security

Laboratory Assignments/Experiments:

1. Write a program that reads *n* and *e* from a file and text from another file and writes encrypted text to a third file. File names will be command line parameters. View each group of four characters as a 32-bit integer. Assume that characters in plain text are keyboard characters with ASCII values less than 128. Thus, the 32-bit integer will have a leading bit of 0. Since *n* must have a leading bit of 1 from above, the number will be from 0 to $n - 1$ and hence valid for the algorithm. The values of *n* and *e* can be assumed to be less than 2^{32}. Make sure that the format of your output file is such that your program can be run with *n* and *d* as input and reproduce the original input file.

2. Show that the Computational Diffie-Hellman problem has a random self reduction. Let G be a group of prime order q and let g be a generator of G. Define the function $F_{DH}(g^x, g^y) = g^{xy}$. Suppose there is an algorithm A that computes $F_{DH}(X, Y)$ in time T on fraction of the inputs (A outputs ? on all other inputs). Show that there is an algorithm B that computes F_{DH} on all inputs in expected time T/€.

504510	Software Defined and Cognitive Radio	
ELECTIVE-II		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 5**

Module I

Cognitive radio concepts & history, Benefits of Cognitive radio, Cognitive radio Forum. Low Cost Cognitive radio Platform, Requirements and system architecture, Convergence between military and commercial systems, The Future of Software Defined Radio.

Module II

Ideal Cognitive radio architecture, Cognitive radio Based End-to-End Communication, Worldwide frequency band plans.

Module III

Aim and requirements of the SCA, Architecture Overview, Functional View, Networking Overview, Core Framework, Real Time Operating Systems, Common Object Request Broker Architecture (CORBA), SCA and JTRS compliance.

Module IV

Radio Frequency design, Baseband Signal Processing, Radios with intelligence, Smart antennas, Adaptive techniques, Phased array antennas, Applying Cognitive radio principles to antenna systems, Smart antenna architectures.

References

1. Reed, Software Radio, Pearson Education, 2002
2. Kwang– Cheng Chen and Ramjee Prasad, Cognitive Radio Networks, Wiley Pub.
3. Dillinger, Madani, Alonistioti (Eds.): Software Defined Radio, Architectures, Systems and Functions, Wiley 2003
4. Paul Burns , Software Defined Radio for 3G, 2002
5. Tafazolli (Ed.): Technologies for the Wireless Future, Wiley 2005.
6. Bard, Kovarik: Software Defined Radio, the Software Communications Architecture, Wiley 2007.

Software Defined and Cognitive Radio

Laboratory Assignments/Experiments:

1. Design a Smart Antenna or sensor system to evaluate performance and gain an understanding of the operation and application of spatial filtering accomplished by adaptive array antenna systems.
2. Develop software platform that includes functions of sensing, (select adequate communication systems) on the widely-spread operation systems for Cognitive Radio.
3. Describe the various IEEE standards associated with Cognitive Radio
4. Illustrate the different hardware and software platform of a Cognitive Radio

504510	RF MEMS	
ELECTIVE- II		
Teaching Scheme: **Lectures 4 Hrs/ Week**		**Examination Scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

General overview of MEMS and RF MEMS. MEMS materials and Fabrication techniques. Analysis of the fundamental mechanical and electromagnetic properties of MEMS structures. RF MEMS relays and switches. Switch parameters. Actuation mechanism. Bistable relays and micro actuators.

Module II

Dynamics of switching operations. MEMS inductors and Capacitors. Micromachined inductor. Effect of inductor layout. Modeling and design issues of planar inductor. Gap tuning and area tuning capacitors. Dielectric tunable capacitors. Micrmachined RF filters.

Module III

Modeling of mechanical filters. Electrostatic comb drive. Micromechanical filters using comb drives. Electrostatic coupled beam structures. MEMS phase shifters. Types. Limitations. Switched delay lines.

Module IV

Micromachined transmission lines. Coplanar lines. Micromachined directional coupler and mixer. Micromachined antennas. Microstrip antennas – design parameters. Micromachining to improve performance. Reconfigurable antennas. One Detailed application of RF MEMS.

References

1. Gabriel M Rebeiz, “RF MEMS – Theory, Design and Technology”.
2. Vijay varadan, Zoelzer, “RF MEMS and their Application”.
3. Hector J.de.los Santos, “RF MEMS circuit Design for Wireless Communication”.
4. V.K.Varadhan & Jose, “RF MEMS and their Application”.
5. Stephen Lveyszyn, “Advanced RF MEMS”.

RF MEMS

Laboratory Assignments/Experiments:

1. Analyze the applications of RF MEMS technology for wireless communication systems.
2. Describe the various design issues in reconfigurable RF-MEMS Meta materials Filters
3. The antenna is a lossless end-fire array of 10 isotropic point sources spaced and operating with increased directivity. The normalized field pattern is

$$E_n = \sin\left(\frac{\pi}{2n}\right)\frac{\sin(^{n\psi}/_{2})}{\sin(^{\psi}/_{2})}$$

$$where\ \psi = \frac{\pi}{2}(\cos\emptyset - 1) - \frac{\pi}{n}\ and\ n = 10.$$

Since antenna is lossless, Gain = Directivity. Calculate

(a) Gain G.

(b) Gain from approximate equation

(c) What is the difference value between result (a) and (b)?

504510	***Software Tools**	
ELECTIVE-II		
Teaching Scheme: **Theory 1 Hrs/ Week**		**Examination Scheme:** **Credits :1**
Introduction to software tools such as Octave, MATLAB, LAB VIEW, RTLinux, VxWorks, µCOS-II, Tiny OS, ANDROID, Xilinx, Microwind, Tanner, TCAD Tools, NS-II, NS-III, OMNET++, OPNET, AWR Microwave office, CAD Feko, IE-3D.		
*For each Subject under Elective II the student Shall study open source/evaluation versions of at least two software tools mentioned above and should present term paper.		

504511	Lab Practice II	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Lab Practice II: The laboratory work will be based on completion of minimum two assignments/experiments confined to the courses of that semester.		

504512	Seminar I	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Seminar_I Shall be on state of the art topic of student's own choice approved by an authority. The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned Guide and head of the department/institute.		

SEMESTER-III

604501	Mobile Computing	
Teaching Scheme: **Lectures :04/week**		**Examination scheme:** **Theory : 50 Marks (In Semester)** **50 Marks (End Semester)** **Credits : 4**

Module I

An Overview of Wireless Systems: 1G to 4G mobile telephone technologies, Future Wireless Networks, Standardization Activities for Cellular Systems Fundamentals of Cellular Communications

Module II

Mobile Computing Architectures: History, Architecture, Design Considerations, Mobile Computing through: Telephony, WiMAX ,GSM, SMS, GPRS, Wireless Application Protocol, CDMA and 3G
Wireless LAN: WLAN Advantages, IEEE 802.11 Standards, Architecture, Mobility, Deploying in WLAN, Mobile Ad-hoc Sensor Networks WLAN Security, Hiper LAN, Wi-Fi vs 3G

Module III

Voice Over IP and Convergence: VoIP, Convergence Technologies, call routing, VoIP Applications, IP Multimedia Subsystem, Mobile VoIP, Voice Over WLAN.
Mobility Management in Wireless Networks: Mobility Management, Mobile Registration, Handoff

Module IV

Security in Wireless System: Security and Privacy Needs of a Wireless System, Required Features, Methods of Providing Privacy and Security, Wireless Security and Standards. Providing Privacy and Security, Wireless Security and Standards.

References

1. Wireless Communications and Networks, Vijay K. Garg.
2. Mobile Computing-Technology, Applications and Service Creation, Asoke K Talukder, Hasan Ahmad, Roopa R Yavagal
3. Introduction to Mobile Telephone Systems, 2nd Edition, 1G, 2G, 2.5G, and 3G Technologies and Services by Lawrence Harte
4. Wireless and Mobile Data Networks by Aftab Ahmad
5. Mobile Applications: Architecture, Design, and Development by Valentino Lee, Heather Schneider, and Robbie Schell

604502	DIGITAL COMMUNICATION RECEIVERS	
Teaching Scheme: Lectures 04/week		**Examination scheme: Theory : 50 Marks (In Semester) 50 Marks (End Semester) Credits : 4**

Module I

Review of Digital Communication Techniques: Base band and band pass communication, signal space representation, linear and non- linear modulation techniques, and spectral characteristics of digital modulation.

Module II

Optimum Receivers for AWGN Channel: Correlation demodulator, matched filter, maximum likelihood sequence detector, Optimum receiver for CPM signals, M-ary orthogonal signals, envelope detectors for M-ary and correlated binary signals.

Module III

Receivers For Fading Channels: Characterization of fading multiple channels, statistical models, slow fading, frequency selective fading, diversity technique, RAKE demodulator, coded waveform for fading channel

Module IV

Synchronization Techniques: Carrier and symbol synchronization, carrier phase estimation – PLL, Decision directed loops, symbol timing estimation, maximum likelihood and non-decision directed timing estimation, joint estimation.

Adaptive Equalization: Zero forcing algorithm, LMS algorithm, Adaptive decision – feedback equalizer, and equalization of Trellis-coded signals, Kalman algorithm, blind equalizers, and stochastic gradient algorithm, Echo cancellation

References

1. John. G. Proakis, “Digital Communication”, 4th Edition., McGraw Hill, NewYork, 2001
2. Bernard Sklar, “Digital Communication Fundamentals and Applications, Prentice Hall, 1998
3. Heinrich Meyer, Mare Moeneclacy, Stefan.A. Fechtel, “Digital Communication Receivers”, Vol I & II, John Wiley, New York, 1997
4. E.A. Lee and D.G. Messerschmitt, “Digital Communication”, 2nd Edition, Allied Publishers, New Delhi, 1994
5. Simon Marvin, “Digital Communication Over Fading channel; An unified approach to performance Analysis”, John Wiley, New York, 2000

ELECTIVE-III

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

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

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

Module I

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

Module II

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

Module III

Human Rights- Jurisprudence of human rights nature and definition, Universal protection of human rights, Regional protection of human rights, National level protection of human rights, Human rights and vulnerable groups.
Legislative Procedures- Indian constitution, Philosophy, fundamental rights and duties, Legislature, Executive and Judiciary, Constitution and function of parliament, Composition of council of states and house of people, Speaker, Passing of bills, Vigilance, Lokpal and functionaries

References:

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

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

Module I:

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

Module II

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

Module III:

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

References:

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

604103	Energy Studies	Group I

ELECTIVE- III

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

Module I:

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

Module II:

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

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

Module III:

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

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

References:

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

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

Module I

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

Module II

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

Module III

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

References:

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

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

Module I

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

Module II

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

Module III

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

References:

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

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

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

Module I:

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

Module II:

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

Module III:

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

Text Books:

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

Reference Books:

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

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

Module I :

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

Module 2:

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

Module 3:

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

Books:

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

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

Module I :

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

Module 2:

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

Books:

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

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

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

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

Module I :

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

Module II:

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

Books:

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

604504	Seminar II	
Teaching Scheme: **Practical 4 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :4**
Seminar II shall be on the topic relevant to latest trends in the field of concerned branch, preferably on the topic of specialization based on the electives selected by him/her approved by authority. The student shall submit the seminar report in standard format, duly certified for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		

604505	Project Stage- I	
Teaching Scheme: **Practical 8 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :8**

Project Stage – I

Project Stage – I is an integral part of the project work. In this, the student shall complete the partial work of the project which will consist of problem statement, literature review, project overview, scheme of implementation (Mathematical Model/SRS/UML/ERD/block diagram/ PERT chart, etc.) and Layout & Design of the Set-up. As a part of the progress report of Project work Stage-I, the candidate shall deliver a presentation on the advancement in Technology pertaining to the selected dissertation topic.

The student shall submit the duly certified progress report of Project work Stage-I in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

SEMESTER-IV

604506	Seminar III	
Teaching Scheme: **Practical 5 Hrs/ Week**		**Examination Scheme:** **Term Work : 50 Marks** **Oral/ Presentation: 50 Marks** **Credits :5**
Seminar III shall preferably an extension of **seminar II.** The student shall submit the duly certified seminar report in standard format, for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		

604507	Project Stage- II	
Teaching Scheme: **Practical 20 Hrs/ Week**		**Examination Scheme:** **Term Work : 150 Marks** **Oral/ Presentation: 50 Marks** **Credits :20**
Project Stage – II In Project Stage – II, the student shall complete the remaining part of the project which will consist of the fabrication of set up required for the project, work station, conducting experiments and taking results, analysis & validation of results and conclusions. The student shall prepare the duly certified final report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.		