W.E.F. 2019-20

MTECH-19

DETAILED

SYLLABUS

for

M Tech Degree Course

(Semester System)

COMMUNICATION ENGINEERING & SIGNAL PROCESSING

w.e.f 2019-2020

COURSE STRUCTURE MTECH-19

DEPARTMENT OF ELECTRONICS &COMMUNICATION ENGINEERING

VELAGAPUDI RAMAKRISHNA

SIDDHARTHA ENGINEERING COLLEGE

(AUTONOMOUS)

(An Autonomous, ISO 9001:2008 Certified Institution)

(Approved by AICTE, Accredited by NAAC with 'A' Grade, Affiliated to JNTUK, Kakinada)

(Sponsored by Siddhartha Academy of General & Technical Education)

Kanuru, Vijayawada

Andhra Pradesh - 520007, INDIA.

www.vrsiddhartha.ac.in

List of Program Outcomes :: Communication Engineering & Signal Processing

After completion of the M Tech (Communication Engineering & Signal Processing) program, the students will be able to

PO1: Independently carry out research /investigation and development work to solve practical problems.

PO2: Write and present a substantial technical report/document.

PO3: Demonstrate a degree of mastery over the area as per the Communication Engineering & Signal Processing program.

PO4:Devise and apply appropriate techniques and modern engineering tools to complex engineering activities with an understanding of the limitations

PO5:Recognize the need for and an ability to engage in lifelong learning to keep oneself abreast of the knowledge to be competent.

ELECTRONICS AND COMMUNICATION ENGINEERING
Curriculum, Scheme of Examination and Syllabi
for
M.Tech Degree Program
in
Communication Engineering & Signal Processing
being offered at
Velagapudi Ramakrishna Siddhartha Engineering College
w.e.f 2019-2020
FIRST SEMESTER

Contact hours 23

S. No	Course Type	Course Code	Title of the course	L	T	P	C	CE	SE	Total
1.	Programme Core -I	19ECSP1001	Modern Wireless Communications	3	0	0	3	40	60	100
2.	Programme Core -II	19ECSP1002	Advanced Digital Signal Processing	3	0	0	3	40	60	100
3.	Programme Core -III	19ECSP1003	Probability Theory And Random Variables	3	0	0	3	40	60	100
4.	Programme **Elective – I**	19ECSP1014/1	Linear Algebra	3	0	0	3	40	60	100
		19ECSP1014/2	Optimization Techniques							
		19ECSP1014/3	Statistical Signal Processing							
		19ECSP1014/4	Open/Industry offered elective							
5.	Programme **Elective – II**	19ECSP1015/1	Discrete Spectral Analysis	3	0	0	3	40	60	100
		19ECSP1015/2	Radar Signal Processing							
		19ECSP1015/3	DSP Processors & Architecture							
		19ECSP1015/4	Open/ Industry offered elective							
6.	Mandatory Learning Course	19MTMC 1026	Research Methodology and IPR	2	0	0	0	40	60	100
7.	Laboratory - I	19ECSP1051	Advanced Communication Lab	0	0	3	1.5	40	60	100
8.	Laboratory - II	19ECSP1052	Advanced Digital signal processing Lab	0	0	3	1.5	40	60	100
			Total	**17**	**0**	**6**	**18**	**320**	**480**	**800**

L – Lecture, T-Tutorial, P – Practical, C – Credits
CE: Continuous Evaluation SE: Semester End Evalution Total: Total Marks

SECOND SEMESTER

Contact hours 25

S.No	Course Type	Course Code	Title of the course	L	T	P	C	CE	SE	Total
1.	Programme Core -1V	19ECSP2001	Digital Image and Video Processing	3	0	0	3	40	60	100
2.	Programme Core -V	19ECSP2002	5G Communication	3	0	0	3	40	60	100
3.	Programme Core -VI	19ECSP2003	Information Theory and Coding Techniques	3	0	0	3	40	60	100
4.	Programme Elective – III	19ECSP2014/1	Microstrip Components and Antennas	3	0	0	3	40	60	100
		19ECSP2014/2	MIMO OFDM Communication Systems							
		19ECSP2014/3	RF and Microwave Circuit Design							
		19ECSP2014/4	Software Defined Radio and Cognitive Radio							
		19ECSP2014/5	Open/ Industry offered elective/AI/ IOT/ Green Communication							
5.	Programme Elective – IV	19ECSP2015/1	Machine Learning	3	0	0	3	40	60	100
		19ECSP2015/2	Biomedical Signal Processing							
		19ECSP2015/3	Remote sensing and its applications							
		19ECSP2015/4	Open/Industry offered elective/Data analytics/Data Structures/Space Techniques and applications							
6.	Audit course	19MTAC2036	Technical Report Writing	2	0	0	-	0	0	0
7.	Term paper	19ECSP2063	Term Paper #	0	0	2	1	40	60	100
8.	Laboratory-I	19ECSP2051	Digital Image and Video Processing Lab	0	0	3	1.5	40	60	100
9.	Laboratory - II	19ECSP2052	Communication Modeling and Simulation Lab	0	0	3	1.5	40	60	100
			Total	**17**	**0**	**8**	**19**	**320**	**480**	**800**

*****Students to be encouraged to go industrial training for at least Six weeks during semester break. (After II Sem)

#Students should conduct the Literature Survey for the proposed research topic and they need to develop a prototype or simulation based (must be outcome oriented) – the same to be presented in any conference (national or international)

THIRD SEMESTER

Contact Hours: 24

S.No	Course Type	Course Code	Title of the course	L	T	P	C	CE	SE	Total
1.	Self-learning	19ECSP3011	Programme Elective – V	0	0	0	3	-	100 #	100
2.	Project (Part-A)	19 ECSP3061	Project- Part A*	0	0	20	10	40	60	100
3.	Internship	19 ECSP3052	Internship	0	0	4	2	-	100	100
			Total	**0**	**0**	**24**	**15**	**40**	**260**	**300**

Evaluation done by MOOCS providers will be considered.

Program Elective V may be completed in semester I or II by satisfying the pre-requisites

*To be continued in the IV Semester

FOURTH SEMESTER

Contact Hours: 32

S.No	Course Type	Course Code	Title of the Course	L	T	P	C	CE	SE	Total
1.	Project (Part-B)	19 ECSP 4061	Project- Part B	0	0	32	16	40	60	100

Total Credits: 68

Course Type

Programme Core - 0
Programme Elective - 1
Mandatory Course -2
Audit Course -3
Open Elective - 4
Internship/ Laboratory - 5
Term Paper/Project- - 6

Semester	Credits
1	19
2	19
3	14
4	16

Program Core	**6**
Program Ele	**5 (V IS MOOCS)**
Program lab	**4**
MLC	**1**
Audit Course	**1**

19ECSP1001: Modern Wireless Communications

Course Category:	**Program Core - I**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Communications**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyzethe basic propagation mechanisms.				
	CO2	Characterize various Equalization and Diversity techniques.				
	CO3	Analyze and learn the characteristics of various Multiple Access techniques.				
	CO4	Analyze the capacity of channels in MIMO systems.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M		L	L	H
	CO2	M		L	L	H
	CO3	M		L	L	H
	CO4	M		L	L	H
Course Content	**UNIT I:** **INTRODUCTION TO MOBILE RADIO PROPAGATION:** Introduction to Radio Wave Propagation, Large scale path Loss, Free Space Propagation Model, Propagation Mechanisms, Reflection, Ground Reflection (Two-Ray) Model, Diffraction, Scattering. Small-Scale Multipath propagation, Impulse Response Model of a Multipath Channel, Small-Scale Multipath Measurements, Parameters of Mobile Multipath Channels, Types of Small-Scale Fading, Rayleigh and Ricean Distributions, Statistical Models for Multipath Fading Channels. **(15 Hrs)** **UNIT II:** **EQUALIZATION AND DIVERSITY TECHNIQUES:** Introduction, Fundamentals of Equalization, Training a Generic Adaptive Equalizer, Equalizers in a communication Receiver, Survey of Equalization Techniques, Linear					

	Equalizers, Non Linear Equalization, Adaptive Equalization, Fractionally spaced Equalizers, Diversity techniques- Selection diversity improvement, Maximal ratio combining, Practical space diversity considerations-selection diversity, Feedback diversity, Maximal Ratio combining, Equal gain combining, Polarization diversity, Frequency diversity, time diversity, Interleaving. **(15 Hrs)** **UNIT III:** **MULTIPLE ACCESS TECHNIQUES: FDMA/TDMA, SDMA,SPREAD SPECTRUM AND CDMA:** Introduction to Multiple access, Frequency Division Multiple Access, Time division Multiple Access, Spread Spectrum Multiple Access, Space Division Multiple Access, Spread spectrum, Direct sequence Modulation, Spreading Codes, Advantages of CDMA for wireless, Frequency hopped Spread spectrum. **(12 Hrs)** **UNIT – IV:** **MULTIPLE INPUT MULTIPLE OUTPUT SYSTEMS**: Introduction to MIMO Antenna systems, MIMO capacity for channel known at the receiver, Singular value decomposition of the channel matrix, space time codes for MIMO wireless communications. **(12 Hrs)**
Text books and Reference books	**Text Books:** 1. T.S. Rappaport "Wireless Communication, principles & practice" , PHI 2. Simon Haykin and Michael Moher "Modern Wireless Communications" Person Education **Reference Books:** 1. Andrea Goldsmith "Wireless Communications" , Cambridge University press. 2. G.L Stuber "Principles of Mobile Communications" 2nd edition, Kluwer Academic Publishers. 3. R.L Peterson, R.E. Ziemer and David E. Borth "Introduction to Spread Spectrum Communication",Pearson Education. 4 A.J.Viterbi."CDMA- Principles of Spread Spectrum" Addison Wesley
E-resources and other digital material	1. https://www.tutorialspoint.com/wireless_communication/wireless_communication_wan.htm 2. https://nptel.ac.in/courses/117104115/35 3. https://www.electronics-notes.com/articles/antennas-propagation/mimo/multiuser-mu-mimo.php

19ECSP1002: Advanced Digital Signal Processing

Course Category:	**Program Core - II**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Digital signal processing**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Design a sample rate converter that reduces/increase by a given factor.
	CO2	a) Design a linear phase FIR filter for given specifications. b) Analyze and synthesize FIR filter for given multistructure filter bank.
	CO3	Evaluate the optimum reflection coefficients for the lattice forward and backward predictors.
	CO4	Analyze the concepts of wavelet transforms and apply them for the analysis of image signals.

Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			H		
	CO2			H		
	CO3			M		
	CO4			M		

Course Content

UNIT – I

MULTIRATE DIGITAL SIGNAL PROCESSING

Introduction, Relationship Between Analog and Digital Frequency, Up sampler, Down sampler, Decimation by a factor D, Interpolation by a factor I, Sampling Rate Conversion by a Rational Factor I/D, Implementation of Sampling Rate Conversion: Polyphase Filter Structures, Interchange of Filters and Down samplers/Up samplers, Sampling Rate Conversion with Cascaded Integrator Comb Filters, Polyphase Structures for Decimation and Interpolation Filters, Structures for Rational Sampling Rate Conversion. **(13Hrs)**

UNIT – II

MULTISTAGE FIR FILTER DESIGN

Multistage Implementation of Sampling Rate Conversion, Applications of Multirate Signal Processing: Design of Phase Shifters, Interfacing of Digital Systems with Different Sampling Rates, Implementation of Narrowband Lowpass Filters, Subband Coding of Speech Signals, Digital Filter Banks: Polyphase Structures of Uniform

	Filter Banks, Trans multiplexers, Two channel Quadrature Mirror Filter Bank: Elimination of aliasing, Condition for Perfect reconstruction, Polyphase form of the QMF Bank. **(13 Hrs)** **UNIT – III** **LINEAR PREDICTION** : Lattice structure for FIR Systems, Forward and Backward Linear Prediction – Forward Linear Prediction, Backward Linear Prediction, Optimum reflection coefficients for the Lattice Forward and Backward Predictors. Solution of the Normal Equations: Levinson Durbin Algorithm, Schur Algorithm. Properties of Linear Prediction Filters. **(12 Hrs)** **UNIT – IV** **WAVELET TRANSFORM** The origin of wavelets, Functions and Function Spaces, Orthogonal Basis Functions, Continuous Wavelet Transform (CWT), The Uncertainty Principle and Time frequency Tiling, Properties of wavelets in CWT, Introduction to the Discrete Wavelet Transform (DWT), Continuous versus Discrete Wavelet Transform, Haar Scaling Functions and Function Space, Translation and scaling, Orthogonality of Translates, Function Space, Nested Spaces, Haar Wavelet Function, Scaled Haar Wavelet Functions, Orthogonality of Haar scaling function and Haar wavelet function. **(15 Hrs)**
Text books and Reference books	**TEXT BOOKS:** 1. J.G.Proakis&D.G.Manolokis Digital Signal Processing: Principles, Algorithms & Applications , 4th ed., PHI.(Units-I, II, & III) 2. K.P. Soman and K.I Ramachandran,N.G.Resmi "Insight into Wavelets from Theory to Practice",3rd edition, Eastern Economy Edition May 2011 (Unit IV) **REFERENCE BOOKS :** 1. P.P.Vaidyanathan "Multirate Systems and Filter Banks" Pearson Education 2. S.Salivahanan, A.Vallavaraj, C.Gnanapriya "Digital Signal Processing" , 2000,TMH 3. JaidevaC.Goswami, Andrew K. Chan, Fundamentals of Wavelets Theory, Algorithms and Applications, John Wiley & Sons, 2nd Edition, 2009. 4. Raghuveer M. Rao, AhitS.Bopardikar, Wavelet Transforms - Introduction to Theory and Applications, Pearson Education Asia, 1999.
E-resources and other digital material	1. https://nptel.ac.in/courses/108105055/ 2. http://nptel.iitm.ac.in/courses/Webcourse-ontents/IITKANPUR/Digi_Sign_Pro/ui/TOC.htm

19ECSP 1003- Probability Theory and Random Variables

Course Category:	**Program Core-III**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Mathematics**	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Apply the theory of probability and develop probability distribution,density functions and to compare the statistical parameters				
	CO2	Develop the conditional, joint distribution and density functions of multiple random variables and compare statistical parameters of multiple random variables				
	CO3	Apply random process as the model for random signals that arise in communication, control and signal processing techniques				
	CO4	Analyze LTI systems excited by Wide Sense Stationary signals and to use Low Pass representation of Band Pass signals				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2			M		
	CO3			M		
	CO4			M		
Course Content	**UNIT-I** **Probability** Probability introduced through Sets and Relative Frequency, Joint Probability and Conditional Probability, Independent Events, Combined Experiments, Bernoulli trials. **Random Variables** The Random Variable Concept, Distribution, Function and Density function, Q Function, Error Function, The Gaussian Random Variable, Other Distribution and Density Examples. Conditional Distribution and Density Functions. Operations on One Random Variable: Expectation, Moments, Functions that give Moments, Transformations of a Random Variable. **(12 Hrs)** **UNIT-II** **Multiple Random Variables** Vector Random Variables, Joint Distribution and its Properties, Joint Density and					

	its Properties, Conditional Distribution and Density, Statistical Independence, Distribution and Density of Sum of Random Variables, Central Limit Theorem (Proof not expected). **Operations on Multiple Random Variables** Expected Value of a Function of Random Variables, Joint Characteristic Functions, Jointly Gaussian Random Variables. **(12 Hrs)** **UNIT-III** **Random Processes** Basic definitions; Some important Random processes; Continuous time linear systems with random inputs ; Some useful classifications of random processes. Wide-sense stationary processes and LSI systems; Periodic &cyclostationary processes; Vector Processes & State equations. **(12 Hrs)** **UNIT- IV** **Advanced Topics in Random Processes** Mean Square(M.S) Calculus, M.S stochastic integrals, M.S stochastic differential equations, Ergodicity, Karhunen- Loeve Expansion , Representation of band limited & periodic processes. **(12 Hrs)**
Text books and Reference books	**Text Books:** 1. Peyton Z Peebles, "Probability, Random Variables and Random Signal Principles", TMH 4th Edition 2001 2. Stark John and W. Woods, "Probability and Random Processes with Applications to Signal Processing", Prentice Hall, 3rd Edition, 2002 **Reference Books:** 1. Simon Haykin, "Communication Systems", John Willy and Sons 5th Edition, 2009. 2. AthanasiosPapoolis and S UnnikrishnaPillai, "Probability , Random Variables and Stochastic Processes", PHI 4th Edition, 2002
E-resources and other digital material	1. https://nptel.ac.in/courses/111/102/111102111/ 2. https://nptel.ac.in/courses/108/103/108103112/ 3. https://nptel.ac.in/courses/108/103/108103112/

19ECSP1014/1 : Linear Algebra

Course Category:	Program Elective - I	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Mathematics	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:															
	CO1	Apply matrix methods to solve system of linear equations.														
	CO2	Apply the concepts of linear operators and linear transformations..														
	CO3	Apply the concepts of orthonormal sets to vector spaces.														
	CO4	Think logically, analytically, and abstractly.														
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1			PO2			PO 3			PO 4			PO5		
	CO1								M							
	CO2								M							
	CO3								M							
	CO4								M							

Course Content

UNIT I:
Linear Equations & Vector Spaces.

Linear Equations:-Field-definition, examples; Sub-field; System of Linear equations-homogeneous and non-homogeneous, equivalency of two systems; Matrices and Elementary Row Operations; Row-reduced Echelon Matrices; Matrix Multiplications; Invertible Matrices;
Vector Spaces:- Vector spaces; Subspaces; Bases and Dimension; Coordinates; Summary of Row-equivalence; Computations Concerning Subspaces.**(12 Hrs)**

UNIT II:
Linear Transformations
Linear Transformations; The Algebra of Linear Transformations; Isomorphism; Representation of Transformations by Matrices; Linear Functionals. **(12 Hrs)**

	UNIT III: **Polynomials & Determinants** Polynomials - Algebras : The Algebra of Polynomials; Lagrange Interpolation; Polynomial Ideals; The Prime Factorization of a Polynomial; Determinants-Commutative Rings; Determinant functions; Permutations and the Uniqueness of Determinants; Additional Properties of Determinants; Modules; Multilinear Functions; The Grassman Ring. **(12 Hrs)** **UNIT – IV: Elementary Canonical Forms & Inner Product Spaces** Elementary Canonical Forms -Introduction; Characteristic Values; Annihilating Polynomials; Invariant Subspaces; Inner Product Spaces-Inner Products; Inner Product Spaces; Linear Functionals and Adjoints; Unitary Operators; Normal Operators. **(12 Hrs)**
Text books and Reference books	**Text Books:** 1. Kenneth Hoffman and Ray Kunze, "Linear Algebra", 2nd Ed., Printice Hall, Inc.., Englewood Cliffs, New Jersy, USA, 1971. 2. Paul R .Halmos,"Finite Dimensional Vector Spaces", Springer, 2011(UTM). **Reference Books:** 1. S. Long, "Linear Algebra ", Springer, 1989, UTM 2. I. N. Herstein," Topics in Algebra", 2nd Edition, John Wiley, 1999. 3. S. Kumeresan, " Linear Algebra: A Geometric Approach", Prentice Hall of India, 2004
E-resources and other digital material	

19ECSP1014/2: Optimization Techniques

Course Category:	Programme Elective – III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Mathematics	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Apply basic concepts of mathematics to formulate an optimization problem				
	CO2	Analyze and appreciate variety of performance measures for various optimization problems.				
	CO3	Apply various modern optimization techniques to solve engineering problems.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2				M	
	CO3			M		
Course Content	**UNIT I:** **Introduction to Optimization Theory:** Preliminary remarks, formulation of optimization problems, overview of various optimization techniques, the simplex optimization techniques, application of simplex, test functions, Problems **(10 Hrs)** **UNIT II:** Gradient techniques: Introduction, Quadratic interpolation for a specific direction, the gradient, the steepest-descent optimization technique, applications of steepest descent, the Fletcher-Powell optimization technique, Problems. **(10 Hrs)** **UNIT III:** **The least-pthoptimization technique:** introduction, the least squares algorithm, the least - p^{th}algorithm, application to least –squares data fitting, Chebyshev approximations. Constrained optimization problems: introduction, active constraints versus inactive constraints, transformations, penalty functions.**(12 Hrs)**					

	UNIT – IV: **Modern Methods of Optimization:** Introduction, Genetic Algorithms: Introduction, Representation of Design Variables, Representation of Objective, Function and Constraints, Genetic Operators, Algorithm, Numerical Results Simulated Annealing: Introduction, Procedure, Algorithm, Features of the Method , Numerical Results Particle Swarm Optimization: Introduction , Computational Implementation of PSO , Improvement to the Particle Swarm Optimization Method, Solution of the Constrained Optimization Problem, Ant Colony Optimization: Basic Concept, Ant Searching Behavior , Path Retracing and Pheromone Updating , Pheromone Trail Evaporation , Algorithm Optimization of Fuzzy Systems: Fuzzy Set Theory , Optimization of Fuzzy Systems , Computational Procedure , Numerical Results Neural-Network-Based Optimization **(15 Hrs)**
Text books and Reference books	**Text Books:** 1. Richard W. Daniels, "An Introduction to numerical methods and optimization techniques" Elsevier North-Holland, 1978 (Unit I-III) **2.** S. S. Rao, "Engineering Optimisation : Theory and Practice", Wiley, 2008.(Unit- IV) **Reference Books:** 1. K. Deb, "Optimization for Engineering design algorithms and Examples", Prentice Hall, 2005. 2. C.J. Ray, "Optimum Design of Mechanical Elements", Wiley, 2007. 3. R. Saravanan, "Manufacturing Optimization through Intelligent Techniques, Taylor & Francis Publications, 2006. **4.** D. E. Goldberg, "Genetic algorithms in Search, Optimization, and Machine learning", Addison-Wesley Longman Publishing, 1989.
E-resources and other digital material	https://nptel.ac.in/courses/111105039/#

19ECSP1014/3: Statistical Signal Processing

Course Category:	**Programme Elective – II**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**DSP**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Formulate a detection problem as a binary hypothesis test				
	CO2	Formulate a classical estimation problem				
	CO3	Formulate and analyze Bayesian estimation problem				
	CO4	Evaluate the performance of a detector and maximum likelihood estimator				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M				
	CO2				M	
	CO3					L
	CO4			M		
Course Content	**UNIT- I** **Estimation Theory** Introduction, the mathematical estimation problem, minimum variance unbiased estimation (MVUE), unbiased estimators, minimum variance criterion, existence of the MVUE, finding MVUE. Cramer-Rao Bound,Introduction, estimation accuracy considerations, Cramer Rao lower bound (CRLB), general CRLB for signals in white Gaussian noise, transformation of parameters. Linear models- Definition and properties, linear model examples, general MVUE, sufficient statistics, finding sufficient statistics, using sufficiency to find MVUE. **(12 Hrs)** **UNIT- II** **Detection Theory** Introduction, detection theory in signal processing, the detection problem, the					

	mathematical detection problem, hierarchy of detection problems, summary of important pdfs. Statistical Decision Theory I-Introduction, Neyman Pearson theorem, receiver operating characteristics, irrelevant data, minimum probability of error, Bayes risk, multiple hypothesis testing. Statistical Decision Theory II-Composite hypothesis testing, Bayesian approach, Generalized likelihood ratio test (GLRT), performance of GLRT for large data records, Equivalent large record tests. **(12 Hrs)** **UNIT- III** **Estimation Methods** Maximum likelihood estimation (MLE) Introduction, an example, finding the MLE, MLE for transformed parameters, numerical determination of MLE. Bayesian philosophy-Introduction, prior knowledge and estimation, choosing a prior pdf, properties of Gaussian probability density function (PDF), Bayesian linear model, nuisance parameters, Bayesian estimation for deterministic parameters. **(12 Hrs)** **UNIT- IV** **Detection Methods** Detection of Deterministic signals Matched filters, development of detector, performance analysis, Generalized matched filters (GMF), performance analysis of GMF, multiple signals, binary case, performance for binary case, linear model. Deterministic signals with unknown parameters, signal modeling and detection performance, unknown amplitude, GLRT, Bayesian approach. Detection of Random Signals Introduction, estimator correlator, linear model, estimator correlator for large data records, general Gaussian detection. **(12 Hrs)**
Text books and Reference books	**TEXTBOOKS:** 1. Steven M. Kay, Fundamentals of statistical signal processing volume I: Estimation theory, Pearson education, 1993. 625pp. 2. Steven M. Kay, Fundamentals of statistical signal processing volume II: Detection theory, Pearson education, 1993. 560pp. **REFERENCE BOOK:** 1. L. Scharf, Statistical signal processing: detection, estimation, and Time Series Analysis, Pearson Education, 2010, 520pp. 2. R. Gray and L. Davisson, An introduction to Statistical Signal Processing, Cambridge University Press, 2010, 478pp.
E-resources and other digital material	

19ECSP1015/1: Discrete Spectral Analysis

Course Category:	**Programme Elective – II**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**DSP**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Translate a relevant real-world problem into a mathematical spectral estimation problem
	CO2	Construct and solve non parametric spectral estimation problem
	CO3	Formulate a parametric & non-parametric spectral estimation problems
	CO4	Apply advanced spectral estimation methods for spatial filtering problems

Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2			M		
	CO3	M				
	CO4			H		

Course Content

UNIT –I:

Introduction, Basic Concepts, Introduction, Energy Spectral Density of Deterministic Signals, Power Spectral Density of Random Signals, First Definition of Power Spectral Density, Second Definition of Power Spectral Density, Properties of Power Spectral Densities, The Spectral Estimation Problem

Nonparametric Methods: Introduction, Periodogram and Correlogram Methods-Periodogram, Correlogram, Periodogram Computation via FFT, Radix–2 FFT, Zero Padding, Properties of the Periodogram Method, Bias Analysis of the Periodogram, Variance Analysis of the Periodogram. **(15Hrs)**

UNIT- II

The Blackman–Tukey Method, The Blackman–Tukey Spectral Estimate, Non-

	negativeness of the Blackman–Tukey Spectral Estimate, Window Design Considerations. Parametric Methods for Rational Spectra: Introduction, Signals with Rational Spectra, Covariance Structure of ARMA Processes, AR Signals, Yule–Walker Method, Least Squares Method, Order–Recursive Solutions to the Yule–Walker Equations, Levinson–Durbin Algorithm, Delsarte – Genin Algorithm, MA Signals. **(12Hrs)** **UNIT- III** ARMA Signals, Modified Yule–Walker Method, Two–Stage Least Squares Method, Multivariate ARMA Signals, ARMA State–Space Equations, Subspace Parameter Estimation. Parametric Methods for Line Spectra- Introduction, Models of Sinusoidal Signals in Noise, Nonlinear Regression Model, ARMA Model, Covariance Matrix Model, Nonlinear Least Squares Method, High–Order Yule–Walker Method, Pisarenko and MUSIC Methods. **(12Hrs)** **UNIT- IV** **Filter Bank Methods** Introduction, Filter Bank Interpretation of the Periodogram, Refined Filter Bank Method, Slepian Baseband Filters, RFB Method for High–Resolution Spectral Analysis, RFB Method for Statistically Stable Spectral Analysis, Capon Method, Derivation of the Capon Method. **Spatial Methods** Introduction, Array Model, The Modulation–Transmission–Demodulation Process, Derivation of the Model Equation.**(12Hrs)**
Text books and Reference books	**TEXTBOOK:** 1. Peter Stoica and Randolph Moses, Spectral Analysis of Signals, Prentice Hall, Upper Saddle River, New Jersey, 2005. **REFERENCE BOOK:** 1. W. Gardner, Statistical spectral analysis a non probabilistic theory, Prentice Hall, Englewood Cliffs, New Jersey, 1998, 591pp
E-resources and other digital material	1. https://www.it.uu.se/edu/course/homepage/spekana/ht03/sm-slides-2up.pdf 2. http://people.stat.sfu.ca/~lockhart/richard/804/06_1/lectures/Periodogram/web.pdf 3. http://www.laurent-duval.eu/Documents-Common/Schuster_G_2010_lect_spectrum_upbw.pdf

19ECSP1015/2 : Radar Signal Processing

Course Category:	**Program Elective II**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Communication Engineering**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Formulate the models of the radar signals including target component, clutter and noise.				
	CO2	Analyze basic problems and challenges in radar data acquisition.				
	CO3	Formulate radar waveform design problem to achieve desired properties.				
	CO4	Analyze Doppler aspects of radar signals.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2			M		
	CO3			M		
	CO4			M		

Course Content

UNIT I:Introduction to Radar Systems & Signal Models:

Introduction to Radar Systems: Introduction, basic radar functions**,** elements of pulsed radar, review of selected signal processing concepts, preview of basic radar processing.

Signal Models: Components of a radar signal, amplitude models, simple point target radar range equation, distributed form of range equation, radar cross section (RCS), RCS for meteorological targets, statistical description of RCS, Clutter, behaviour of σ_0 , signal-to-clutter ratio, temporal and spatial correlation of clutter, compound models of RCS, noise model and signal-to-noise ratio, jamming, frequency models: the Doppler shift, simplified approach to Doppler shift, the stop and hop assumption and spatial Doppler.**(15Hrs)**

UNIT II: Sampling and Quantization of Pulsed Radar Signals

Domains and Criteria for sampling radar signals: Time and frequency samples, spatial samples, sampling criteria; Sampling in Fast Time dimension, sampling in slow time, Sampling the Doppler spectrum: the Nyquist rate in

	Doppler, Straddle loss; Sampling in spatial and angle dimension: Phased array element spacing, Antenna beam spacing; Quantization. **(15Hrs)** **UNIT III: Radar Waveforms** Introduction, The waveform Matched Filter: the matched filter, matched filter for the simple pulse, all range matched filtering, range resolution of matched filter; Matched filtering of moving targets; The Ambiguity function: Definition and properties of ambiguity function, ambiguity function of the simple pulse; The Pulse Burst Waveform: Matched filter for the pulse burst waveform, Pulse-by-pulse processing, range ambiguity, Doppler response of the pulse burst waveform, Ambiguity function for the pulse burst waveform, relation of the slow time signal to ambiguity function; Frequency-Modulated Pulse Compression Waveform: Linear frequency modulation (LFM), the principle of stationary phase, ambiguity function of the LFM waveform, Range-Doppler coupling.**(15Hrs)** **UNIT – IV: Doppler Processing** Moving platform effects on the Doppler Spectrum, Moving Target Indication (MTI): Pulse cancellers, vector formulation of the matched filter, matched filters for clutter suppression, blind speeds and staggered PRF, MTI figures of merit, limitation of MTI, Pulse Doppler Processing: the DTFT of a moving target, sampling the DTFT: the Discrete Fourier Transform(DFT), matched filter and filterbank interpretation of pulsed Doppler processing with the DFT, fine Doppler estimation, Modern spectral estimation in pulsed Doppler processing.**(15Hrs)**
Text books and Reference books	**Text book :** 1. Mark A. Richards, "Fundamentals of Radar Signal Processing", Tata McGraw-Hill Edition, 2005 **Reference Book:** **1.** Bassem R. Mahafza, " Radar Signal Analysis and Processing using MATLAB", Chapman and Hall/CRC , 2008
E-resources and other digital material	

19ECSP1015/3: DSP Processors and Architecture

Course Category:	Programme Elective – II	Credits:	3
Course Type:	Theory	Lecture - Tutorial -Practice:	3-0-0
Prerequisites:	Digital signal processing	Continuous Evaluation: Semester end Evaluation: Total Marks:	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyze architecture of DSP Processor- TMS320C5X				
	CO2	Apply basic DSP algorithms using DSP Processors				
	CO3	Develop high performance Advanced Digital Signal Processors.				
	CO4	Design high-end application processors				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1				M	
	CO2				M	
	CO3			M	M	
	CO4			M	M	
Course Content	**UNIT I:** Computational Accuracy in DSP Implementations: Number Formats for Signals and Coefficients in DSP Systems, Dynamic Range and Precision, Sources of Error in DSP Implementations, A/D Conversion Errors, DSP Computational Errors, D/A Conversion Errors. Architectures for Programmable DSP Devices: Basic Architectural Features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External Interfacing. **(15Hrs)** **UNIT II:** Programmable Digital Signal Processors: Commercial Digital Signal-Processing Devices, Data Addressing Modes of TMS320C54XX DSPs, Data Addressing Modes of TMS320C54XX Processors, Memory Space of TMS320C54XX Processors, Program Control, TMS320C54XX Instructions and					

	Programming, On-Chip Peripherals, Interrupts of TMS320C54XX Processors, Pipeline Operation of TMS320C54XX Processors. **(15Hrs)** **UNIT III :** Implementations Of Basic DSP Algorithms: The Q-notation, FIR Filters, IIR Filters, Interpolation Filters, Decimation Filters, PID Controller, Adaptive Filters, 2-D Signal Processing. Implementation Of FFT Algorithms: An FFT Algorithm for DFT Computation, A Butterfly Computation, Overflow and Scaling, Bit-Reversed Index Generation, An 8-Point FFT Implementation on the TMS320C54XX, Computation of the Signal Spectrum.**(15Hrs)** **UNIT – IV:** Interfacing Memory and I/O Peripherals, Programmable DSP Devices: Memory Space Organization, External Bus Interfacing Signals, Memory Interface, Parallel I/O Interface, Programmed I/O, Interrupts And I/O, Direct Memory Access (DMA). A Multichannel Buffered Serial Port (MCBSP), MCBSP Programming, A CODEC Interface Circuit, CODEC Programming, A CODEC-DSP Interface Example.**(15Hrs)**
Text books and Reference books	**Text Books:** 1. Avatar Singh and S.Srinivasan, "DSP Processors and Architectures", 2004, Thomson Publications. (Units-I,III& IV) 2. Lapsley et al, "DSP Processor Fundamentals, Architectures & Features" 2000, S. Chand & Co (Unit-II) **Reference Books:** 1. B. Venkataramani and M. Bhaskar, "Digital Signal Processors, Architecture, Programming and Applications" , 2002, TMH. 2. Jonatham Stein, "Digital Signal Processing", 2005, John Wiley.
E-resources and other digital material	1. www.ti.com/lit/ug/spru131g/spru131g.pdf 2. http://en.wikipedia.org/wiki/Digital_signal_processor

19MTMC 1026: Research Methodology and IPR

Course Category:	Mandatory Learning Course	**Credits:**	2
Course Type:	Theory	**Lecture - Tutorial -Practice:**	2
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:	
	CO1	Acquire an overview of the research methodology and techniques to define research problem
	CO2	Review the literature and identify the problem
	CO3	Analyze the optimum sampling techniques for collected data
	CO4	Apply various forms of the intellectual properties for research work.

Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M				
	CO2					M
	CO3				M	
	CO4		L	M		

Course Content

UNIT I

Research Methodology: Introduction, Meaning of Research, Objectives of Research, Motivation in Research, Research Approaches, Significance of Research, Research and Scientific Methods, Research Process, Criteria of Good Research, and Problems Encountered by Researchers in India.

Research Problem: Defining theResearch Problem, Selecting the Problem, Necessity of Defining the Problem, Technique Involved in Defining a Problem, an Illustration.

UNIT II

Reviewing the literature: Place of the literature review in research, improving research methodology, broadening knowledge base in research area, enabling contextual findings.

Research Design: Meaning of Research Design, Need for Research Design, Features of a Good Design, Important Concepts Relating to Research Design, Basic Principles of experimental Designs, Important Experimental Designs.

	UNIT III **Design of Sampling**: Introduction, Sample Design, Sampling and Non-sampling Errors, Sample Survey versus Census Survey, Measurement and Scaling: Qualitative and Quantitative Data, Classifications of Measurement Scales, Goodness of Measurement Scales, sources of error in measurement tools. **Data Collection**: Experimental and Surveys, Collection of Primary Data, Collection of Secondary Data, Selection of Appropriate Method for Data Collection, Case Study Method **Testing of Hypotheses:** Hypothesis, Basic Concepts, Testing of Hypothesis, Test Statistics and Critical Region, Critical Value and Decision Rule, Procedure for Hypothesis Testing. **UNIT IV** **Interpretation and Report Writing**: Meaning of Interpretation, Technique of Interpretation, Precaution in Interpretation, and Significance of Report Writing **Intellectual Property:** The Concept, Intellectual Property System in India, Development of TRIPS Complied Regime in India, Patents Act, 1970, Trade Mark Act, 1999, The Designs Act, 2000, The Geographical Indications of Goods (Registration and Protection) Act1999, Copyright Act, 1957, Trade Secrets, Utility Models WTO, Paris Convention for the Protection of Industrial Property, National Treatment, Right of Priority, Common Rules, Patents, Marks, Industrial Designs, Trade Names, Indications of Source, Unfair Competition, Patent Cooperation Treaty (PCT), Trade Related Aspects of Intellectual Property Rights(TRIPS) Agreement.
Text books and Reference books	**Text Books:** 1. Research methodology: Methods and Techniques, **C.R. Kothari, GauravGarg,** New Age International, 4th Edition, 2018. 2. Research Methodology a step-by-step guide for beginners. **Ranjit Kumar, SAGE Publications** Ltd.,3rd Edition, 2011 3. Study Material, Professional Programme Intellectual Property Rights, Law and Practice, **The Institute of Company Secretaries of India**, Statutory Body under an Act of Parliament, September 2013. **Reference Books:** 1. An introduction to Research Methodology, Garg B.L et al ,RBSA Publishers 2002 2. An Introduction to Multivariate Statistical Analysis Anderson T.W, Wiley 3rd Edition, 3. Research Methodology, Sinha, S.C, Dhiman, EssEss Publications2002 4. Research Methods: the concise knowledge base ,Trochim ,Atomic Dog Publishing ,2005 5. How to Write and Publish a Scientific Paper, Day R.A, Cambridge University Press 1992 6. Conducting Research Literature Reviews: From the Internet to Paper, Fink A, Sage Publications, 2009 7. Proposal Writing, Coley S.M. Scheinberg, C.A, Sage Publications, 1990 **8.** Intellectual Property Rights in the Global Economy, Keith Eugene Maskus,

	Institute for International Economics.
E-resources and other digital material	

19ECSP1051: Advanced Communication Lab

Course Category:	**Laboratory - I**	**Credits:**	1.5
Course Type:	**Lab**	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	Digital Communications	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Design optimum receiver for various channels and analyze Tx and Rx systems of satellite communications.				
	CO2	Analyze the behavior of channel during communication and different modulation, demodulation techniques				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1				M	
	CO2				M	
Course Content	**List of Lab Exercises** **<u>Experiments using Hardware:</u>** 1. Measurement of C/N ration and S/N ratio of analogy FM/FDM TV satellite link. 2. Generation and detection of QAM signal 3. PCM generation and detection using codec chip 4. Study and Analysis of CDMA-DSSS technique. 5. Study and Analysis of S-parameter of Microstrip patch antenna using Network Analyzer. 6. Establish audio and video satellite link between transmitter and receiver.					

	Experiments using MATLAB: 1. Measurement of BER for BPSK 2. Simulate the modulation and demodulation using FHSS &DSSS techniques 3. Generation and Detection of QPSK and DQPSK 4. Deduce Link Budget for satellite communication and evaluate Carrier to NoiseRatio. 5. Design optimum receiver for the AWGN channel. 6. Simulation of Generation and detection of DQAM signal 7. Effects of fading channels (Rayleigh, Ricean and Nakagami distribution) 8. Probability of error in fading channels. 9. Study of MIMO diversity antenna parameters using 3-D Electro Magnetic simulation tool **NB:** A total of 10(Ten) experiments (minimum of three from each group) have to be performed and recorded by the candidate to attain eligibility for External Practical Examination
E-resources and other digital material	1. https://nptel.ac.in/courses/108102096/

19ECSP1052: Advanced Digital signal processing Lab

Course Category:	**Laboratory-II**	**Credits:**	1.5
Course Type:	**Lab**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Digital signal processing**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyze and observe Power Spectrum Estimation of Parametric methods and non Parametric methods				
	CO2	Develop DSP algorithms like convolution, correlation, DFT, in software using a computer language such as C with TMS320C6713 floating point Processor.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1				H	
	CO2				M	
Course Content	1. Program to verify Decimation and Interpolation of a given Sequences. 2. Program to Convert CD data into DVD data 3. Filter bank design 4. Estimation of Power Spectrum using Bartlett and Welch methods 5. Parametric methods of Yule-Walker and Burg of Power Spectrum Estimation 6. Estimation of data series using Nth order Forward Predictor and comparing to the Original Signal 7. Design of LPC filter using Levinson-Durbin Algorithm 8. Computation of Reflection Coefficients using Schur Algorithm 9. Implementation of FIR filter using LMS algorithm 10. Implementation of Adaptive filter using RLS algorithm 11. Experiment based on spectrum estimation.					

	12. Experiments based on Simulink and signal processing block set **Code Composer Studio** 13. ASK, FSK, PSK waveform generation 14. Linear and Circular convolution. 15. Correlation 16 DFT and IDFT NB: A total of 10(Ten) experiments have to be performed and recorded by the candidate to attain eligibility for External Practical Examination
Text books and Reference books	**TEXTBOOKS:** 1. Digital Signal Processing: Principles, Algorithms & Applications - J.G.Proakis&D.G.Manolokis, 4th ed., PHI.(Units-I,II,III & IV)
E-resources and other digital material	1.http://vlab.co.in/ba_labs_all.php?id=1 2.http://web.stanford.edu/class/ee264/ 3.http://dsp.rice.edu/software

19ECSP2001: Digital Image and Video Processing

Course Category:	Programme Core -1V	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Signals and Systems Digital Signal Processing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyze the applications of image and processing of color images.				
	CO2	Efficiently reduce the storage, band width using compression techniques, identify and recognize the objects in the given images using segmentation techniques.				
	CO3	Apply operations on video and Estimate the motion of two dimensional video.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M				M
	CO2	H			H	
	CO3	H			M	
Course Content	**UNIT I** **Introduction** to Image processing, Fundamental steps in Image Processing, components of image processing system, elements of visual perception, image sensing and acquisition, Image sampling, Quantization, some basic relationship between the pixels, Applications of Digital image processing . **Color Image processing** : color fundamentals, , color models, pseudo color image processing, Basics of full color image processing, smoothing and sharpening of color images, color segmentation, color compression. **(12Hrs)** **UNIT II** **Image compression**: Need for image compression, Redundancy in images, Classification of redundancy in images, image compression system, some basic compression methods: Run length coding, LZW coding, Huffman coding, Arithmetic coding, Predictive coding, Transformed based compression, Image					

	compression standard, and Wavelet-based image compression. **Image segmentation** :Introduction to image segmentation, Classification of segmentation techniques, Region approach to image segmentation, clustering techniques, Image segmentation based on thresholding, Edge based segmentation, Edge detection and linking, Hough transform. **(12Hrs)** **UNIT III** **Video Processing**: Video Formation, Perception and Representation, Video capture and display, Analog video raster, Analog color television systems, Digital video.**(10Hrs)** **UNIT IV** **Two Dimensional Motion Estimation** : Optical flow, General methodologies, Pixel based motion estimation, Block Matching algorithm, Deformable block matching algorithms, Mesh based motion estimation, Global motion estimation, Region Based motion estimation, Application of motion estimation in video coding. **(12Hrs)**
Text books and Reference books	**Text Books** : 1. R.Gonzalez, R.E.Woods, "Digital Image Processing", 3rd Edition, Pearson Education, India, 2009. 2. Yao Wang,JornOstermann and Ya Qin Zhang "Video processing and Communications" Prentice Hall Publishers, 2002, ISBN 0-13-017547-1 **Reference Books**: 1. S.Jayaraman, S.Esakkirajan and T.VeeraKumar, "Digital Image processing, Tata McGraw Hill publishers, 2009 2. John W.Woods, "Multidimensional Signal, Image and Video Processing and Coding"Elsevier Academic Press Publications2006, ISBN-13: 978-0-12– 088516-9.
E-resources and other digital material	**1.** http://sdeuoc.ac.in/sites/default/files/sde_videos/Digital%20Image%20Processing%203rd%20ed.%20-%20R.%20Gonzalez%2C%20R.%20Woods-ilovepdf-compressed.pdf. 2. file:///C:/Users/CIVIL/Downloads/Digital%20Image%20Processing_S.%20Jayaraman,%20S.%20Esakkirajan%20And%20T.%20Veerakumar.pdf

19ECSP2002: 5G Communication

Course Category:	Programme Core -V	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Communication Systems	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyse the characteristics and functioning of 5G wireless communication.				
	CO2	Analyze the new challenges on cloud-as-a-service for the future Internet.				
	CO3	Comprehend the key challenges facing cognitive radio and white spaces for 5G.				
	CO4	Design next-generation handsets 'devices', with common base-band functionality and analyze the concepts of smart Antennas.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2			M		
	CO3			M		
	CO4			M		
Course Content	**UNIT - I:** **Drivers for 5G: The 'Pervasive Connected World'** Introduction, Historical Trend of Wireless Communications, Evolution of LTE Technology to Beyond 4G , 5G Roadmap,10 Pillars of 5G. **The 5G Internet** Introduction, Internet of Things and Context Awareness, Networking Reconfiguration and Virtualisation Support, Mobility, Quality of Service Control. **(12Hrs)** **UNIT - II:** **Small Cells for 5G Mobile Networks** Introduction, What are small cells, Capacity Limits and Achievable Gains with Densification, Mobile Data Demand, Demand vs Capacity, Small Cell Challenges, Conclusions and Future Directions. **Mobile Clouds: Technology and Services for Future Communication Platforms** Introduction, The Mobile Cloud, Mobile Cloud Enablers, Network Coding. **(12Hrs)**					

	UNIT - III: **Cognitive Radio for 5G Wireless Networks** Introduction , Overview of Cognitive Radio Technology in 5G Wireless, Spectrum Optimization using Cognitive Radio, Relevant Spectrum Optimization Literature in 5G , Cognitive Radio and Carrier Aggregation Energy-Efficient Cognitive Radio Technology , Key Requirements and Challenges for 5G Cognitive Terminals. **The Wireless Spectrum Crunch: White Spaces for 5G** Introduction, Background, TV White Space Technology, White Space Spectrum Opportunities and Challenges, TV White Space Applications International Efforts, Role of WS in 5G. (**12Hrs)** **UNIT – IV** **Green Flexible RF for 5G** Introduction, Radio System Design, Antenna Design for 5G, Passive Front End Design Using SIW for 5G Application.RF Power Amplifiers, Nonlinear Crosstalk in MIMO Systems **Spatial Processing for Wireless Systems:** Key benefits of Smart Antenna Technology, Introduction to Smart antenna technology, The vector Channel Impulse Response and the Spectral Signature, Spectral Processing Receivers, Fixed Beam forming Networks, Switched beam Systems, Adaptive antenna Systems **(12Hrs).**
Text books and Reference books	**Text Books** 1. Jonathan Rodriguez -Fundamentals of 5G Mobile Networks, John Wiley & Sons, Ltd. 2015. (Unit-I-IV) 2. Joseph C. Liberti& Theodore S. Rappaport Smart Antennas for Wireless Communication, Prentice Hall Communication Engineering Series.1999. (Unit-IV) **Reference Books:** 1. Erik Dahlman, Stefan Parkvall, Johan Skold- 5G NR: The Next Generation Wireless Access Technology , Academic Press , An imprint of Elsiver, 2018 2. AfifOsseiran, Jose F. Monserrat, Patrick Marsch - 5G Mobile and Wireless Communications Technology Cambridge University Press, 2016 3. VWS Wong, R Schober, DWK Ng, LC Wang - Key technologies for 5G wireless systems,Cambridge University Press 2017 4. Fa-Long Luo, Charlie Jianzhong Zhang- Signal Processing for 5G: Algorithms and Implementations John Wiley & Sons.
E-resources and other digital material	https://www.digimat.in/nptel/courses/video/117102062 http://www.ict-medieval.eu http://www.dynamicspectrumalliance.org https://link.springer.com/article/10.1007/s11277-015-2467-2

19ECSP2003: INFORMATION THEORY AND CODING TECHNIQUES

Course Category:	**Programme Core**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:		**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Apply Information theory and error control strategies in channel coding				
	CO2	Apply linear block codes and & cyclic codes for error detection and correction				
	CO3	Analyze the performance of BCH codes and convolution codes.				
	CO4	Analyze the decoding of Burst Error Correction of cyclic codes and Automatic Repeat Request Strategies				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M		M		
	CO2	M		M		
	CO3	M		M		
	CO4	L		L		

Course Content

UNIT I

Introduction:

Fundamental limits in Information theory: Introduction, uncertainty, information and entropy, source-coding theorem, data compaction, discrete memory less channels, mutual information, channel capacity, channel coding theorem, differential entropy and mutual information for continuous ensembles, information capacity theorem, implications of the information capacity theorem (bandwidth efficiency diagram).

Fundamentals of Error Control Strategies: Types of Errors, Error Control Strategies.

Introduction to Algebra: Groups, Fields, Field Arithmetic, Construction of Galois field GF(2^m), Basic properties of Galois field GF(2^m), Computations using Galois field GF(2^m) arithmetic.

	UNIT II **Linear Block Codes:** Introduction to Linear Block Codes, Syndrome and Error Detection, Minimum Distance of a Block code, Error-Detecting and Error-correcting Capabilities of a Block code, Standard array and Syndrome Decoding, Probability of an undetected error for Linear Codes over a BSC, Hamming Codes **Cyclic Codes:** Description of cyclic code, Generator and Parity-check Matrices, Encoding, Syndrome Computation and Error Detection, Decoding, Cyclic Hamming Codes. **UNIT III** **BCH Codes**: Description of the Codes, Decoding of the BCH Codes. **Convolutional Codes** Encoding of Convolutional Codes, Structural properties of convolutional codes. **Maximum likelihood decodingofConvolutional Codes**, The Viterbi Algorithm, Sequential decoding- The Stack Algorithm, The Fano Algorithm. **UNIT IV** **Burst –Error-Correcting Codes:** Decoding of Single-Burst Error Correcting Cyclic codes, Single-Burst-Error-Correcting Cyclic codes, Interleaved codes, Phase Burst Error-Correcting Capability, Burst- and –Random- Error-Correcting codes **Automatic Repeat Request Strategies:** Basic ARQ Schemes, Selective-Repeat ARQ System with Finite Receiver Buffer, ARQ Schemes with Mixed Modes of Retransmission, Hybrid ARQ Schemes.
Text books and Reference books	**Text Books:** 1 Simon Haykins, "Communication Systems", 4th edition, John Wiley & Sons Inc. 2 Shu Lin, Daniel J.Costello,Jr, "Error Control Coding- Fundamentals and Applications", Prentice Hall, Inc. 3 K Deergha Rao, "Channel Coding Techniques for Wireless Communications", Springer. **Reference Books:** 1. John G. Proakis , "Digital Communications" , 5th ed., 2008, TMH. 2. Bernard Sklar "Digital Communications-Fundamental and Application", 2nd edition, PE.
E-resources and other digital material	1. http://www-math.ucdenver.edu/~wcherowi/courses/m7823/codln.html 2. https://web.stanford.edu/class/ee387/handouts/notes17.pdf 3. https://www.ics.uci.edu › ~magda › Courses › netsys270 › ch10_2_v1

19ECSP2014/1: Microstrip Components and Antennas

Course Category:	**Program Elective - I**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3
Prerequisites:	**Antennas**	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Comprehend the properties of microstrip transmission lines and components.				
	CO2	Analyze the performance characteristics of low pass, high pass, band pass and Band stop filters.				
	CO3	Analyze various parameters of rectangular microstrip antennas.				
	CO4	Understand behavior of broadband and loaded microstrip antennas.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2				M	
	CO3			M		
	CO4				M	
Course Content	**UNIT I:** **MICROSTRIP TRANSMISSION LINES AND COMPONENTS** **Microstrip Lines-** Microstrip Structure, Waves in Microstrip, Quasi-TEM Approximation , Effective Dielectric Constant and Characteristic Impedance, Guided Wavelength, Propagation Constant, Phase , Velocity, and Electrical Length, Synthesis of W/h, Effect of Strip Thickness, Dispersion in Microstrip, Microstrip Losses, Effect of Enclosure, Surface Waves and Higher-Order Modes. **Coupled Lines -** Even- and Odd-Mode Capacitances, Even- and Odd-Mode Characteristic Impedances and Effective, Dielectric Constants, More Accurate Design Equations. **Discontinuities and Components** - Microstrip Discontinuities, Microstrip Components, Loss Considerations for Microstrip Resonators, Other Types of Microstrip Lines.**(10 Hrs)** **UNIT II:** **LOW PASS AND BAND PASS FILTERS:** **Low pass Filters-** Stepped-Impedance L-C Ladder Type Low pass Filters, L-C					

	Ladder Type of Low pass Filters using Open-Circuited Stubs, **Band pass Filters-** End-Coupled, Half-Wavelength Resonator Filters, Parallel-Coupled, Half-Wavelength Resonator Filters, Hairpin-Line Band pass Filters, Inter digital Band pass Filters, **HIGHPASS AND BANDSTOP FILTERS:** **High pass Filters-** Quasilumped High pass Filters, Optimum Distributed High pass Filters. **Band stop Filters-** Narrow-Band Band stop Filters, Band stop Filters with Open-Circuited Stubs, Optimum Bandstop Filters, Bandstop Filters for RF Chokes.**(10 Hrs)** **UNIT III:** **MICROSTRIP RADIATORS** Review of various Microstrip antenna configurations, Feeding techniques and modelling, Radiation fields, Surface waves. **ANALYTICAL MODELS FOR MICROSTRIP ANTENNAS** Introduction, Transmission line model, Cavity model, generalized cavity model, multiport network model. **RECTANGULAR MICROSTIP ANTENNAS** Introduction, Models for Rectangular patch antennas, Design considerations of rectangular patch antennas.**(15 Hrs)** **UNIT – IV:** **BROADBANDING OF MICROSTIP ANTENNAS** Introduction, Effects of substrate parameters on bandwidth, Selection of suitable patch shape, Selection of suitable feeding technique. **LOADED MICROSTRIP ANTENNAS & APPLICATIONS** Introduction, Polarization diversity using microstrip antennas, Frequency agile microstrip antennas, Radiation pattern control of microstrip antennas, loading effect of short, compact patch antennas.**(10 Hrs)**
Text books and Reference books	**Text Books:** 1. Microstrip Filters for RF / Microwave Applications- JIA- Sheng Hong, M.J.Lancaster, John Wiley & Sons. 2001. (Unit I and II) 2. Microstrip Antenna Design Hand Book – Ramesh Garg, PrakashBhartia,InderBahl, ApisakIttipiboon, Artech House,2001. (Unit III and IV) **Reference Books:** 1. PrakashBhartia and InderBahlMicrostrip Antennas Artech House. 2. Girish Kumar, K.P.Ray Broad Band Microstrip Antennas , Artech House,2003. 3. Charles A. Lee &G.ConrodDelman Microwave Devices Circuits and their Applications, John Wiley & Sons. **4.** Kin-Lu Wong Compact Broad Band Microstrip Antennas, John Wiley & Sons. 2002
E-resources and other digital material	https://nptel.ac.in/courses/108101112/ https://nptel.ac.in/courses/108101092/

19ECSP2014/2: MIMO OFDM Communication Systems

Course Category:	**Program Elective-II**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**None**	**Continuous Evaluation:**	40
		Semester end Evaluation:	60
		Total Marks:	100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Develop an understanding of MIMO channel modeling and determining the capacity of these MIMO channels.				
	CO2	Characterize and understand OFDM and OFDMA systems.				
	CO3	Analyze and learn performance issues in OFDM and OFDMA systems for enhancing performance of advanced communication systems.				
	CO4	Analyze MIMO systems and develop an understanding of diversity techniques, space-time coding, and multi-user MIMO				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M		L	L	H
	CO2	M		L	L	H
	CO3	M		L	L	H
	CO4	M		L	L	H
Course Content	**UNIT I:MIMO Channel Models:** Statistical MIMO model, Statistical model of Correlated MIMO fading channel, Generation of correlated MIMO channel coefficients, I-METRA MIMO channel model, 3GPP MIMO channel model, SCM MIMO channel model. **MIMO Channel Capacity:** Useful matrix theory, Deterministic MIMO channel capacity, Channel capacity of random MIMO channels**. (12 Hrs)** **UNIT II:Introduction to OFDM:** Single-carrier transmission, Multi-carrier transmission, Single-carrier vs. Multi-carrier transmission, Basic principle of OFDM, Coded OFDM, OFDMA-Multiple access extensions of OFDM, Duplexing. **(12 Hrs)** **UNIT III: PAPR Reduction:** Definition of PAPR, Distribution of OFDM					

	Signal, PAPR and oversampling, Clipping and SQNR, PAPR reduction technique – Clipping and filtering. **Inter-Cell Interference Mitigation Techniques:** Inter-cell Interference coordination technique, inter-cell interference randomization technique, Inter-cell interference cancellation technique. **(10 Hrs)** **UNIT – IV: Antenna Diversity and Space-Time coding Techniques:** Antenna Diversity, Space-Time Coding (STC)-overview, Space-Time Block code (STBC). **Multi-User MIMO:** Mathematical model for multi-user MIMO System, Channel capacity of Multi-user MIMO system, Transmission methods for Broadcast channel. **(12 Hrs)**
Text books and Reference books	**Text Books:** 1. Yong Soo Cho, Jaekwon Kim, Won Young Yang, and Chung G. Kang, "MIMO-OFDM Wireless Communications with Matlab", John Wiley & Sons (Asia) Pte Ltd, 2010. (Units - I, II, III, IV). **Reference Books:** 1. Junyi Li, Xinzhou Wu, and Rajiv Laroia, "OFDMA Mobile Broadband Communications: A Systems Approach", Cambridge University Press, 1st Edition, 2013. 2. Ramjee Prasad, "OFDM for Wireless Communications Systems", Artech House Inc, 2004. 3. Hamid Jafarkhani, "Space-Time Coding: Theory and Practice", Cambridge University Press, 1st Edition, 2005.
E-resources and other digital material	4. https://onlinecourses.nptel.ac.in/noc16_ec19/preview 5. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-452-principles-of-wireless-communications-spring-2006/ 6. https://web.stanford.edu/class/ee359/lectures.html

19ECSP2014/3: RF and Microwave Circuit Design

Course Category:	Programme Elective III	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Electromagnetic Theory and Microwave Engineering	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course Outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Demonstrate on the RF design concept and impart knowledge on design and implementation of high frequency Transceiver system.				
	CO2	Analyze various components of RF communication system architecture.				
	CO3	Analyze the structure, characteristics, operation and other important aspects of microwave solid state active devices				
	CO4	Demonstrate on the MMIC, their applications, advantages, various fabrication techniques, encapsulation and mounting of active devices.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L - Low, M - Medium, H - High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	L		M	L	M
	CO2	H		M	H	H
	CO3	H		M	H	H
	CO4	M		M	H	M
Course Content	**UNIT I:** Importance of RF Design. Dimension and Units. Frequency Spectrum. RF Behavior of Passive Components: High Frequency Resistors, High-Frequency Capacitors and High-Frequency Inductors. Chip Components and Circuit Board Considerations: Chip Resistors, Chip Capacitors and Surface-Mounted Inductors. **(10 Hrs)** **UNIT II:** A brief overview of RF Filter : Filter Types and Parameters, Low-Pass Filter, High-Pass Filter, Bandpass and Band stop Filters, Insertion Loss, Butterworth-Type, Chebyshev and Denormalization of Standard Low-Pass Design. Filter Implementations: Unit Elements, Kuroda's Identities and Examples of Microstrip Filter Design. Coupled Filter : Odd and Even Mode Excitation, Bandpass Filter Section, Cascading Bandpass Filter Elements, Design Examples. Characteristics of Amplifier. Amplifier Power Relations: RF Source,					

	Transducer Power gain and Additional Power Relations. Stability Considerations : Stability Circles, Unconditional Stability and Stabilization Methods. Constant Gain : Unilateral Design, Unilateral Figure of Merit, Bilateral Design and Power Gain Circles. Noise Figure Circles. Constant VSWR Circles. Broadband, High-Power and Multistage Amplifiers.**(15 Hrs)** **UNIT III:** Semiconductor Basics : Physical Properties of Semiconductors, PN Junction and Schottky Contact. RF Diodes :Schottky, PIN, Varactor, IMPATT, Tunnel, TRAPATT, BARRITT and Gunn Diodes. Bipolar Junction, RF Field Effect and HighElectron Mobility Transistors : Construction, Functionality, Frequency Response, Temperature Behaviour and Limiting Values. **(10 Hrs)** **UNIT IV:** Introduction, Materials : Substrate Materials, Conductor Materials, Dielectric Materials and Resistive Materials. Monolithic Microwave Integrated Circuits (MMICs) and their advantages over discrete circuits. Monolithic Microwave Integrated Circuit Growth : MMIC Fabrication Techniques and Fabrication Examples. MOSFET Fabrication : MOSFET Formation, NMOS Growth, CMOS Development and Memory Construction. Thin-Film Formation : Planar Resistor Film, Planar Inductor Film and Planar Capacitor Film. Hybrid Integrated Circuit Fabrication. **(10 Hrs)**
Text Books and Reference Books	**Text Books:** 1. "RF Circuit Design: Theory & Applications, Pearson, 2nd Edition, 2009" by Reinhold Ludwig and Gene Bogdanov. (Unit I-III) 2. "Microwave Devices & Circuits, Pearson, 3rd Edition, 2003" by Samuel Y. Liao. (Unit IV) **Reference Books:** 1. "Microwave Integrated Circuits, Wiley" by K. C. Gupta and Amarjit Singh. (For Unit 4)
E-resources and Other Digital Material	1. NPTEL Online Course - RF Integrated Circuits by Dr. ShouribrataChatterjee, IIT Delhi. (Website Link : https://nptel.ac.in/courses/117102012/) 2. NPTEL Online Course - Design Principles of RF and Microwave Filters and Amplifiers by Dr. Amitabha Bhattacharya, IIT Kharagpur. (Website Link : https://nptel.ac.in/courses/117105138/) 3. NPTEL Online Course - Microwave Integrated Circuits by Dr. Jayanta Mukherjee, IIT Kharagpur. (Website Link : https://nptel.ac.in/courses/117101119/)

19ECSP2014/4: Software Defined Radio and Cognitive Radio

Course Category:	Program Elective - I	**Credits:**	3
Course Type:	Theory	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Communication Systems	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyze the software and hardware architecture of on Software Defined Radio.				
	CO2	Identify the essential functionalities and requirements in development of Software Defined Radios and their usage for Cognitive Radio.				
	CO3	Identify the Cognitive Radio Available Technologies and research fields.				
	CO4	Apply the concepts of Spectrum Sensing techniques for Cognitive Radio Applications				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M				
	CO2	M			M	
	CO3	H				
	CO4	M			M	
Course Content	**UNIT I:** Software Defined Radio Basic SDR– Software and Hardware Architecture of an SDR – Spectrum Management–Managing unlicensed spectrum–Noise Aggregation **(12Hrs)** **UNIT II:** SDR AS PLATFORM FOR COGNITIVE RADIO Introduction – Hardware and Software architecture – SDR development process and Design – Application software – Component development – Waveform development–cognitive waveform development. **(12Hrs)** **UNIT III:** Cognitive Radio Technology Introduction – Radio flexibility and capability – Aware – Adaptive – Comparison of Radio capabilities and Properties – Available Technologies – Funding and Research in CRs. **(14Hrs)**					

	UNIT – IV: Spectrum Sensing For Cognitive Radio Applications Introduction - Challenges- Spectrum Sensing Methods for Cognitive Radio- Cooperative Sensing- External Sensing- Statistical Approaches and Prediction- Sensing Frequency- Hardware Requirements and Approaches- Multi-dimensional Spectrum Awareness- Spectrum Sensing in Current Wireless Standards. **(16Hrs)**
Text books and Reference books	Text Books: 1. Bruce A Fette, "Cognitive Radio Technology", 2nd edition Academic Press, 2009. 2. HuseyinArslan, "Cognitive Radio, Software Defined Radio and Adaptive wireless system, Springer, 2007. **Reference Books:** 1.Mitola, J. and J. Maguire, G. Q., "Cognitive radio: making software radios more personal," IEEE Personal Commun. Mag., vol. 6, no. 4, pp. 13–18, Aug. 1999. 2. TevfikY¨ucek and H¨useyinArslan, "A Survey of Spectrum Sensing Algorithms for Cognitive Radio Applications" , IEEE Communications Surveys & Tutorials, Vol. 11, No.1, First Quarter 2009, Pp 116-130.
E-resources and other digital material	1. https://nptel.ac.in/courses/108107107/3 2. https://nptel.ac.in/courses/117104099/1

19ECSP2015/1: Machine Learning

Course Category:	**Programme Elective – IV**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	Probability Theory and Random Processes	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Apply Bayesian decision theory for pattern classification				
	CO2	Analyze linear models for Regression and Classification				
	CO3	Analyze Back propagation algorithm for Multilayer Neural Networks				
	CO4	Apply SVM for classification and Regression.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M		
	CO2			M	M	
	CO3			M	M	
	CO4			M	M	

Course Content

UNIT I

Introduction to Pattern Recognition: Machine perception, An example, Pattern Recognition Systems, the design cycle, learning and adaptation

Bayesian Decision Theory: Bayesian Decision Theory – Continuous Features, Minimum-Error-Rate Classification, Classifiers, Discriminant Functions and Decision Surfaces, The Normal Density, Discriminant Functions for the Normal Density, Error Bounds for Normal Densities, Bayes Decision Theory — Discrete Features, Missing and Noisy Features, Maximum Likelihood Estimation, Bayesian Estimation.**(15Hrs)**

UNIT II

Linear Models for Regression: Linear Basis Function Models, The Bias-Variance Decomposition, Bayesian Linear Regression

Linear Models for Classification: Discriminant Functions, Probabilistic

	Generative Models, Probabilistic Discriminative Models.**(12Hrs)** **UNIT III** **Multilayer Neural Networks:** Feedforward operation and classification, Network Training, Backpropagation algorithm, Back propagation as feature mapping.**(12Hrs)** **UNIT – IV** **Kernel Methods:** Dual Representations, Constructing Kernels, Radial Basis Function Networks **Sparse Kernel Machines:** Maximum Margin Classifiers, Overlapping class distributions, Relation to logistic regression, Multiclass SVMs, SVMs for regression, Computational learning theory.**(12Hrs)**
Text books and Reference books	**Text Books:** 1. Richard O. Duda, Peter E. Hart, David G. Stork, "Pattern Classification", 2nd Edition John Wiley & Sons, 2001. 2. C. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006. **Reference Books:** 1. Trevor Hastie, Robert Tibshirani, Jerome H. Friedman, "The Elements of StatisticalLearning", 2nd edition, Springer, 2009. 2. Tom Mitchell, "Machine Learning", McGraw-Hill Education (India) Private Limited, 1st edition, 2013. 3. EthemAlpaydin,"Introduction to Machine Learning", PHI Learning Private Limited, 2nd edition, 2012
E-resources and other digital material	1. https://nptel.ac.in/courses/106106139/ 2. https://nptel.ac.in/courses/106105152/

19ECSP2015/2 : Biomedical Signal Processing

Course Category:	**Program Elective-IV**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Digital Signal processing**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Apply and evaluate physical, electrical and mathematical models for the origin of bioelectrical signals in the cell, and their conduction in nerves and in tissue.				
	CO2	Describe and evaluate the most important bioelectrical measurement methods: The ECG, the EEG and the EMG, in relation to normal and pathological conditions.				
	CO3	Apply and evaluate different methods for signal processing of the ECG, the EEG and the EMG, with respect to time- and frequency domain analysis.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO 1	PO 2	PO 3	PO 4	PO 5
	CO1	M				
	CO2	M				
	CO3	M	M		H	
Course Content	**UNIT I** **Introduction To Biomedical Signals** - Examples of Biomedical signals - ECG, EEG, EMG etc., Tasks in Biomedical Signal Processing - Computer Aided Diagnosis. Origin of bio potentials - Review of linear systems - Fourier Transform and Time Frequency Analysis (Wavelet) of biomedical signals- Processing of Random &Stochastic signals – spectral estimation – Properties and effects of noise in biomedical instruments - Filtering in biomedical instruments. **(12Hrs)** **UNIT II** **Concurrent, Coupled and Correlated Processes** - Illustration with case studies – Adaptive and optimal filtering - Modeling of Biomedical signals - Detection of biomedical signals in noise -removal of artifacts of one signal embedded in another -Maternal-Fetal ECG - Muscle-contraction interference. Event detection – case					

	studies with ECG & EEG - Independent Component Analysis - Cocktail party problem applied to EEG signals -Classification of biomedical signals. **(12Hrs)** **UNIT III** **Cardio Vascular Applications**- Basic ECG - Electrical Activity of the heart- ECG data acquisition – ECG parameters & their estimation - Use of multi-scale analysis for ECG parameters estimation - Noise &Artifacts- ECG Signal Processing: Baseline Wandering, Power line interference, Muscle noise filtering – QRS detection -Arrhythmia analysis. Data Compression: **Lossless &Lossy- Heart Rate Variability** – Time Domain measures - Heart Rhythm representation - Spectral analysis of heart rate variability - interaction with other physiological signals.**(12Hrs)** **UNIT IV** **Neurological Application-** The electroencephalogram - EEG rhythms & waveform - categorization of EEG activity - recording techniques - EEG applications- Epilepsy, sleep disorders, brain computer interface. Modeling EEG- linear, stochastic models – Non-linear modeling of EEG - artifacts in EEG & their characteristics and processing – Model based spectral analysis - EEG segmentation - Joint Time-Frequency analysis – correlation analysis of EEG channels - coherence analysis of EEG channels. **(12Hrs)**
Text books and Reference books	**TEXT BOOKS** 1. D.C.Reddy, "Biomedical Signal Processing: Principles and techniques",Tata McGraw Hill, New Delhi, 2005. 2. Willis J Tompkins, "Biomedical Signal Processing", 1st ed, Prentice – Hall, 1993. **REFERENCES BOOKS** 1. R. Rangayan, "Biomedical Signal Analysis", Wiley 2002. 2. Bruce, "Biomedical Signal Processing & Signal Modeling", Wiley, 2001 3. Sörnmo, "Bioelectrical Signal Processing in Cardiac & Neurological Applications", 4. Enderle, "Introduction to Biomedical Engineering", 2/e, Elsevier, 2005
E-resources and other digital material	http://www.crcnetbase.com/doi/book/10.1201/b11148

19ECSP2015/3: Remote Sensing and its Applications

Course Category:	**Programme Elective – IV**	**Credits:**	3
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	3-0-0
Prerequisites:	**Basics of Image Processing**	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Analyze the basic concepts of Remote Sensing				
	CO2	Summarize the concepts of Remote Sensing Platforms and Sensors used by Indian government & GIS Fundamentals				
	CO3	Analyze the basics of image processing and its relevance to the remote sensing				
	CO4	Analyze the different possible applications of remote sensing in daily life				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1	M		M		
	CO2	M		M		
	CO3	M		M		
	CO4	M		M		
Course Content	**UNIT I:** **Concept of Remote Sensing:** Introduction, Distance of Remote Sensing, Definition of Remote Sensing, Data, Remote Sensing Process, Source of Energy, Interaction with Atmosphere, Interaction with Target, Recording of Energy by Sensor, Transmission-Reception and Processing, Interpretation and Analysis, Applications of Remote Sensing, Advantages of Remote Sensing, Limitations of Remote Sensing, Ideal Remote Sensing System.**(12Hrs)** **UNIT II:** **Remote Sensing Platforms and Sensors:** Introduction, Satellite System Parameters, Sensor Parameters, Imaging Sensor Systems, Earth resources Satellites, Cartosat Series, Resource SAT Series, Chandrayaan-1. **Fundamentals of GIS:** Introduction, Roots of GIS, Overview of Information System, The Four Ms, GIS Definitions and Terminology, GIS Architecture, Theoretical Models of GIS.**(12Hrs)**					

	UNIT III: **Digital Image Processing:** Introduction, Basic Character of Digital Image, Preprocessing, Image Registration, Image Enhancement Techniques, Spatial Filtering Techniques, Image Transforms, Image Classification, Performance Analysis of IRS-bands for land use/land cover classification system using Maximum Likelihood Classifier, Image Classification and GIS.**(12Hrs)** **UNIT – IV:** **Urban and Municipal Applications:** Introduction, The Role of Satellite Imagery and Other Data Sets, The Indicator Function of Urban Land Uses, Appropriate Methodologies, An Analysis System. **Forest Resources Management:**Introduction, Geomatics in Forestry, Forest Cover Mapping and Change Detection, Dynamics of Forest Ecosystem and Forest Canopy, Forest Damage Assessment. **Natural Disaster Management: Landslides:** Introduction, Major types of Landslides, Common Features of Landslides, Causes of Landslides and Related Phenomena, Landslide Analysis.**(12Hrs)**
Text books and Reference books	**Text Books:** 1. "Remote Sensing and GIS" by BasudebBhatta, Second Edition, Oxford Higher Education, 2008 2. "Textbook of Remote Sensing and Geographical Information Systems" by M Anji Reddy, Fourth Edition, BS Publications, 2017. **Reference Books:** 1. "Remote Sensing and Image Interpretation" by Thomas M Lillesand, Ralph W. Kiefer, Jonathan W. Chipman, Fifth Edition, Wiley, 2009.
E-resources and other digital material	1. https://nptel.ac.in/courses/105108077/ 2. https://nptel.ac.in/courses/121107009/

19MTAC2036- Technical Report Writing

<table>
<tr><td>Course Category:</td><td colspan="3">Audit Course</td><td>Credits:</td><td>0</td></tr>
<tr><td>Course Type:</td><td colspan="3">Theory</td><td>Lecture-Tutorial-Practice:</td><td>2-0-0</td></tr>
<tr><td>Prerequisites :</td><td colspan="3">Nil</td><td colspan="2" rowspan="2"></td></tr>
<tr><td colspan="4"></td></tr>
<tr><td rowspan="5">Course Outcomes</td><td colspan="5">Upon successful completion of the course, the student will be able to:</td></tr>
<tr><td>CO1</td><td colspan="4">Understand the significance of Technical Report writing.</td></tr>
<tr><td>CO2</td><td colspan="4">Develop Proficiency in writing technical reports.</td></tr>
<tr><td>CO3</td><td colspan="4">Apply the basic principles to prepare documentation using LATEX.</td></tr>
<tr><td>CO4</td><td colspan="4">Understand the need of Bibliography and references for quality report writing</td></tr>
<tr><td rowspan="6">Contribution of Course Outcomes towards achievement of Program Outcomes (L-Low, H- High)</td><td></td><td>PO1</td><td>PO2</td><td>PO 3</td><td>PO 4</td><td>PO5</td></tr>
<tr><td>CO1</td><td></td><td>M</td><td></td><td></td><td></td></tr>
<tr><td>CO2</td><td></td><td>M</td><td></td><td></td><td></td></tr>
<tr><td>CO3</td><td></td><td>M</td><td></td><td></td><td></td></tr>
<tr><td>CO4</td><td></td><td>M</td><td></td><td></td><td></td></tr>
<tr><td>Course Content</td><td colspan="5">UNIT I:
Writing scientific and engineering papers-Title, Abstract, Introduction, Materials And Methods, Result, Discussion, Conclusion, References, Acknowledgements, Appendices, Hedging and Criticizing, Paraphrasing and Plagiarism.</td></tr>
<tr><td colspan="5">UNIT II:
Effective use of charts, graphs and tables-Bar Chart, Line Chart, Pie Chart, Area Chart, Cylindrical Chart, Column Bars, Bubble Chart, Flow Diagram, Screen Capture, Tables
Writing Technical Reports-Objectives Of Technical Report, Types Of Reports, Steps In Writing A Technical Report, Guidelines For Writing A Technical Report.</td></tr>
<tr><td colspan="5">UNIT III:
LATEX-Introduction, Document Structure- Creating a Title, Sections, Labeling, Table of Contents
Typesetting Text- Font Effects, Colored Text, Font Sizes, Lists, Comments & Spacing, Special Characters</td></tr>
<tr><td colspan="5">UNIT IV:
Tables, Figures,Equations- Inserting Equations, Mathematical Symbols, Practical.</td></tr>
</table>

	Inserting References- Introduction, The Bib TeX file, Inserting the bibliography, Citing references, Styles, Practical.
Text books **Reference books**	**Text Book(s):** 1. Barun K Mitra, Effective Technical Communication-A Guide for Scientists and Engineers,Oxford University Press,2006, ISBN:978019568291. 2. LATEX for Beginners, Workbook Edition 5, March 2014 Document Reference: 3722-2014. **Reference Books:** 1. Goldbort R (2006) Writing for Science, Yale University Press (available on Google Books) 2. Day R (2006) How to Write and Publish a Scientific Paper, Cambridge University Press

19ECSP2063: TERM PAPER

Course Category:	**Term Paper**	**Credits:**	1
Course Type:	**Theory**	**Lecture - Tutorial -Practice:**	0-0-2
Prerequisites:	Research Methodology and IPR	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify and analyze the real world problems beyond the curriculum				
	CO2	Get awareness on current trends in specific area of interest				
	CO3	Prepare and write technical report on the topic selected after literature survey				
	CO4	Develop communication skills to explain and interact with a cross section of audiences				
Contribution of Course Outcomes towards achievement of Program Outcomes		PO1	PO2	PO 3	PO 4	PO5
	CO1	M		L		
	CO2	M			L	
	CO3		H			
	CO4					M

Course Content

The following method is adapted by the department for conducting Term Paper.

- Term Paper and Project Work are to be carried out individually by M.Techstudents under the supervision of a faculty member.
- The faculty member allotted to supervise the Term Paper in second semester shall continue to be the supervisor for the Project Work also.
- Each faculty member may be permitted to supervise not more than **TWO** students.
- If any student / batch left over without supervisor, HOD shall use his/her discretion to allot the supervisor as supervisors are to be selected by the students themselves.

Expected outcomes of Term Paper

- To carry out literature survey (Reputed international journals / Proceedings of international conferences).
- To select a technical topic related to area of specialization.
- To submit an abstract at the beginning of second semester.
- To critically review the topic selected, prepare a report on the topic reviewed under the guidance of supervisor and submit at the end of second semester.
- To present the term paper before PRC and assessment will be done based on scholarship of knowledge, report writing and presentation skills.

19ECSP2051: Digital Image and Video Processing Lab

Course Category:	Programme Core	**Credits:**	1.5
Course Type:	Practical	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	Digital Image and Video Processing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Implement different image enhancement, segmentation and compression methods for images.				
	CO2	Implement different video enhancement, segmentation, compression and motion estimation techniques.				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1			M	H	
	CO2			M	M	
Course Content	**List of Lab Exercises:** 1. Basic Arithmetic and Logic operations on images 2. Histogram Equalization 3. Image smoothing and Image sharpening 4. Image Compression 5. Edge detection with different gradient operators 6. Morphological Operations 7. Boundary and Regional features of an image 8. Video Enhancement 9. Video Segmentation 10. Video Compression 11. Motion Estimation 12. Image/Video classification					

	Software: 1. MATLAB 2. Python **NB:** A total of 10(Ten) experiments have to be performed and recorded by the candidate to attain eligibility for External Practical Examination
	Reference Book: Rafael C. Gonzalez, Richard E. Woods, Steven L. Eddins, **"Digital Image Processing Using MATLAB", 2nd Edition, Tata McGraw-Hill, 2010**

19ECSP2052: Communication Modeling and Simulation Lab

Course Category:	Laboratory IV	**Credits:**	2
Course Type:	Lab	**Lecture - Tutorial -Practice:**	0-0-3
Prerequisites:	Advanced Communication Systems	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Implementation of advance networking using communication concepts.				
	CO2	Implementation of different source coding and channel coding techniques				
Contribution of Course Outcomes towards achievement of Program Outcomes (L – Low, M - Medium, H – High)		PO1	PO2	PO 3	PO 4	PO5
	CO1				H	
	CO2				L	
Course Content	**List of Lab Exercises:** **Communication and Networking** 1. Develop a MAC protocol for 802.11 2. Develop a MAC protocol for 802.16 3. Simulate a Cellular Network model 4. Simulation of queuing model for M/M/1 5. System modelling and simulation of Mobility Management system 6. Implement D2D communication system 7. Implement and IoT communication system **MIMO OFDM Communication Systems** 8. Simulation of multipath transmission 9. Simulation of OFDMA system 10. Simulate MIMO Channel Communication Model using ALMOUTI and generalize it to m x n MIMO system					

	Information Theory and Coding 11. Simulation of Huffman code 12. Simulation of Shannon-Fano code 13. Simulations of Linear block codes. 14. Simulation of Cyclic codes. **Software Defined Radio & Cognitive Radio** 15. Generation and detection of Quadrature Phase Shift Keying signal using Software Defined Radio 16. Measurement of BER of M-ary PSK using Software Defined Radio 17. Implement Cognitive Radio based MAC protocol **NB:** A total of 10(Ten) experiments (minimum of three from each group) have to be performed and recorded by the candidate to attain eligibility for External Practical Examination
Text books and Reference books	**Text Books:** 1. Jonathan Rodriguez -Fundamentals of 5G Mobile Networks, John Wiley & Sons, Ltd. 2015. 2. Shu Lin, Daniel J.Costello,Jr, "Error Control Coding- Fundamentals and Applications", Prentice Hall, Inc
E-resources and other digital material	https://nptel.ac.in/courses/117105132/ https://nptel.ac.in/courses/117101051/

19ECSP3061:PROJECT- PART A

Course Category:	**Project**	**Credits:**	10
Course Type:	**Project**	**Lecture - Tutorial -Practice:**	0-0-20
Prerequisites:	Research Methodology and IPR Technical Report Writing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify a topic in relevant areas of Communication Engineering & Signal Processing.				
	CO2	Review literature to identify gaps and define objectives & scope of the work.				
	CO3	Understand the methods and processes from literature and apply appropriate research methodologies.				
	CO4	Develop an analytical/ computational model/ experimental set-up and prepare a report and develop competence in presenting.				
Contribution of Course Outcomes towards achievement of Program Outcomes		PO1	PO2	PO 3	PO 4	PO5
	CO1	M		L		
	CO2	M			L	
	CO3				H	
	CO4		H			M
Course Content	**Expected outcomes of the Project Work from Part-A:** • To select a technical topic(from the literature survey carried out as a part of Term Paper) related to specialization in consultation with supervisor and submit an abstract to Project Review Committee PRC at the beginning of the third semester. • To critically evaluate the recent literature for the problem identified • To carry out the project work under the guidance of supervisor on the topic selected. • To submit reports periodically and present before PRC for a review on the progress of work carried out. • To prepare a report on the work carried out and submit at the end of fourth semester.					

19ECSP 4061:: PROJECT- PART B

Course Category:	**Project**	**Credits:**	16
Course Type:	**Project**	**Lecture - Tutorial -Practice:**	0-0-32
Prerequisites:	Research Methodology and IPR Technical Report Writing	**Continuous Evaluation:** **Semester end Evaluation:** **Total Marks:**	40 60 100

Course outcomes	Upon successful completion of the course, the student will be able to:					
	CO1	Identify methods and resources to carry out analysis and experiments.				
	CO2	Reorganize the procedures with a concern for society, environment and ethics.				
	CO3	Find solutions to complex engineering activities using modern engineering tools				
	CO4	Analyze and discuss the results to draw valid conclusions.				
	CO5	Prepare a report and defend the work and publish the work in National /International Conferences/journals				
Contribution of Course Outcomes towards achievement of Program Outcomes		**PO1**	PO2	PO 3	PO 4	PO5
	CO1	M		L		
	CO2	M			L	
	CO3				H	
	CO4			M		M
	CO5		H			L
Course Content	**Expected outcomes of the Project Work from Part- B :** • To critically evaluate the recent literature for the problem identified • To carry out the project work under the guidance of supervisor on the topic selected. • To submit reports periodically and present before PRC for a review on the progress of work carried out. • To test the work carried out, report the results obtained and perform comparative analysis • To publish the paper in Peer reviewed journals/conferences • To prepare a report on the work carried out and submit at the end of fourth semester.					