KUMARAGURU COLLEGE OF TECHNOLOGY,

An autonomous Institution affiliated to Anna University, Chennai

COIMBATORE – 641 049.

M.E., COMMUNICATION SYSTEMS

REGULATIONS 2018

CURRICULUM AND SYLLABI

I to IV Semesters

Department of Electronics and Communication Engineering

VISION

To be a Centre of repute for learning and research with internationally accredited curriculum, state-of-the-art infrastructure and laboratories to enable the students to succeed in globally competitive environments in academics and industry.

MISSION

The Department is committed to:

- Motivate students to develop professional ethics, self-confidence and leadership quality.
- Facilitate the students to acquire knowledge and skills innovatively to meet evolving global challenges and societal needs.
- Achieve excellence in academics, core engineering and research.

PROGRAMME EDUCATIONAL OBJECTIVES (PEOs)

The Programme Educational Objectives of Postgraduate programme in Communication Systems are:

PEO I: Graduates will be working in multidisciplinary teams to develop feasible and sustainable solutions in the area of Digital Communication, RF & Microwave, Signal Processing and Networking.

PEO II: Graduates will develop lifelong learning through research in academic, industry and research organizations.

PEO III: Graduates will display ethics and social responsibilities in their career.

PROGRAMME OUTCOMES (POs)

1. Scholarship of Knowledge

Acquire in-depth knowledge of Communication systems, RF & Microwave, Signal Processing and Networking, including wider and global perspective, with an ability to discriminate, evaluate, analyze and synthesize existing and new knowledge, and integration of the same for enhancement of knowledge.

2. Critical Thinking

Analyze complex engineering problems critically, apply independent judgment for synthesizing information to make intellectual and/or creative advances for conducting research in a wider theoretical, practical and policy context.

3. Problem Solving

Think laterally and originally, conceptualize and solve engineering problems, evaluate a wide range of potential solutions for those problems and arrive at feasible, optimal solutions after considering public health and safety, cultural, societal and environmental factors in the core areas of expertise.

4. Research Skill

Extract information pertinent to unfamiliar problems through literature survey and experiments, apply appropriate research methodologies, techniques and tools, design, conduct experiments, analyze and interpret data, demonstrate higher order skill and view things in a broader perspective, contribute individually/in group(s) to the development of scientific/technological knowledge in Communication and allied domains.

5. Usage of modern tools

Create, select, learn and apply appropriate techniques, resources, and modern engineering and IT tools, including prediction and modelling, to complex engineering activities with an understanding of the limitations.

6. Collaborative and Multidisciplinary work

Possess knowledge and understanding of group dynamics, recognize opportunities and contribute positively to collaborative-multidisciplinary scientific research, demonstrate a capacity for self-management and teamwork, decision-making based on open-mindedness, objectivity and rational analysis in order to achieve common goals and further the learning of themselves as well as others.

7. Project Management and Finance

Demonstrate knowledge and understanding of engineering and management principles and apply the same to one's own work, as a member and leader in a team, manage projects efficiently in respective disciplines and multidisciplinary environments after consideration of economical and financial factors.

8. Communication

Communicate with the engineering community, and with society at large, regarding complex engineering activities confidently and effectively, such as, being able to comprehend and write effective reports and design documentation by adhering to appropriate standards, make effective presentations, and give and receive clear instructions.

9. Life-long Learning

Recognize the need for, and have the preparation and ability to engage in life-long learning independently, with a high level of enthusiasm and commitment to improve knowledge and competence continuously.

10. Ethical Practices and Social Responsibility

Acquire professional and intellectual integrity, professional code of conduct, ethics of research and scholarship, consideration of the impact of research outcomes on professional practices and an understanding of responsibility to contribute to the community for sustainable development of society.

11. Independent and Reflective Learning

Observe and examine critically the outcomes of one's actions and make corrective measures subsequently, and learn from mistakes without depending on external feedback.

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KUMARAGURU COLLEGE OF TECHNOLOGY

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REGULATIONS 2018

M.E. COMMUNICATION SYSTEMS

CURRICULUM

SEMESTER I							
Course Code	**Course Title**	**Course Mode**	**L**	**T**	**P**	**J**	**C**
P18INT0001	Research Methodology and Statistics	Theory	3	0	0	0	3
P18COT1001	RF and Microwave Integrated Circuits	Theory	3	0	0	0	3
P18COI1202	Advanced Signal Processing	Embedded	3	0	2	0	4
P18COI1203	Advanced Digital Communication Techniques	Embedded	3	0	2	0	4
P18MAT0101	Applied Mathematics	Theory	3	1	0	0	4
Total Credits							**18**
Total Hours per week							**20**
SEMESTER-II							
Course Code	**Course Title**	**Course Mode**	**L**	**T**	**P**	**J**	**C**
P18COT0004	High Performance Networks	Theory	3	0	0	0	3
P18COT2001	Wireless Sensor Networks	Theory	3	0	0	0	3
P18COI2202	Advanced Radiation Systems	Embedded	3	0	2	0	4
P18COI2203	Wireless Communication Systems	Embedded	3	0	2	0	4
P18COE____	Professional Elective I	Theory	3	0	0	0	3
Total Credits							**17**
Total Hours per week							**19**
SEMESTER-III							
Course Code	**Course Title**	**Course Mode**	**L**	**T**	**P**	**J**	**C**
P18COE____	Professional Elective II	Theory	3	0	0	0	3
	Audit Course						
P18COP3701	Project Phase I / Industry Project	Project	0	0	0	24	12
Total Credits							**15**
Total Hours per week							**27**
SEMESTER-IV							
Course Code	**Course Title**	**Course Mode**	**L**	**T**	**P**	**J**	**C**
P18COP4701	Project Phase II/ Industry Project	Project	0	0	0	36	18
Total Credits							**18**
Total Hours per week							**36**

Grand Total Credits: 68

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List of Programme Electives

Code No.	Course Title	Course Type	L	T	P	J	C
P18COE0001	Advanced Digital Image Processing	Theory	3	0	0	0	3
P18COE0002	Communication Network security	Theory	3	0	0	0	3
P18COE0003	Satellite Communication	Theory	3	0	0	0	3
P18COE0004	MIMO Communication	Theory	3	0	0	0	3
P18COE0005	Optical Networks	Theory	3	0	0	0	3
P18COE0306	LoRa Technology	Embedded	2	0	0	2	3
P18COE0007	VLSI Design Techniques	Theory	3	0	0	0	3
P18COE0008	Advanced Embedded Systems	Theory	3	0	0	0	3
P18COE0009	Computer Vision	Theory	3	0	0	0	3
P18AET2001	Machine Learning Techniques	Theory	3	0	0	0	3
P18INT0002	Product Design and Development	Theory	3	0	0	0	3

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SEMESTER I

P18INT0001 RESEARCH METHODOLOGY AND STATISTICS

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Understand and apply the concepts of research(K3)
CO2: Apply statistical and other research tools to analyze and interpret data(K4)
CO3: Demonstrate skills in writing research topics(K4)

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1				S		M			S		
CO2		M	M	S		M			S		
CO3				S		S	S		S		

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

INTRODUCTION TO RESEARCH METHODS 09 Hrs
Definition and Objectives of Research, Scientific Methods, Various Steps in Scientific Research, Research planning , Selection of a Problem for Research , Formulation of the Selected Problems, Purpose of the Research, Formulation of research objectives, Formulation of research questions, Hypotheses Generation and Evaluation, Literature search, and review, Research abstract.

INTRODUCTION TO STATISTICS 09 Hrs
Population and Sample, Sampling and sample size, Population Proportion and Population Mean, Sample Proportion and Sample Mean, Estimation of Standard Error and confidence Interval, Identifying the dependent and independent variables, Introduction to data, Types of data and their importance, Descriptive Statistics and Inferential Statistics, Summarizing and describing data, Measures of Central Tendency and Measures of Dispersion, Mean, Median, Mode, Range, Variance, Standard Deviation.

STATISTICAL MODELING AND ANALYSIS 09 Hrs
Probability Distributions, Normal, Binomial, Poisson, Fundamentals of Statistical Analysis and Inference, Hypothesis Testing, Confidence interval, Test of Significance, Comparison of Means (T test, Z test), Analysis

of variance (ANOVA), Measures of association/Relationship, Chi-square test, Simple Regression Analysis, Multiple Regression analysis, Correlation, Data visualization techniques.

RESEARCH DESIGN/PLAN **09 Hrs**

Types and Methods of Research, Classification of Research, Research Ethics, Sampling Techniques, Methods of Collecting Primary Data, Use of Secondary Data, Experimentation, Design of Experiments, Survey Research and Construction of Questionnaires, Pilot Studies and Pre-tests, Data Collection methods, Processing of Data, Editing, Classification and Coding, Transcription, Tabulation, Validity and Reliability.

RESEARCH REPORTS **09 Hrs**

Structure and Components of Research Report/thesis, Types of Report, Planning of Report/thesis Writing, Research Report Format, Layout of Research Report, Presentation of data and Data Analysis Reporting, Mechanism of writing a research report, Principles of Writing, Writing of Report.

Theory: 45	**Tutorial: 0**	**Practical: 0**	**Project: 0**	**Total: 45 Hours**

REFERENCES:

1. C.R. Kothari, "**Research Methodology Methods and Techniques**", 3rd Edition, New Age International Publishers, 2014.
2. Ranjit Kumar, "**Research Methodology A Step-by-Step Guide for Beginners**", 4th Edition, Sage Publishing, 2014
3. R. Pannerselvam, "**Research Methodology**", 2nd Edition, Prentice Hall India, 2014

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P18COT1001 **RF AND MICROWAVE INTEGRATED CIRCUITS**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Choose appropriate passive components for the design of radio frequency circuits(K3).
CO2: Analyze RF Transistor Amplifier performance parameters (K4)
CO3: Design RF oscillators and Mixers for the given parameters (K4)
CO4: Describe and analyze microstrip lines, components, slot line and CPWs (K4)
CO5: Describe lumped elements and Non reciprocal components (K2)

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S										
CO2	S		M	M							
CO3	S		M	M							
CO4	S			M							
CO5	S			M							

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

INTRODUCTION TO RF DESIGN **09 Hrs**
Importance of RF design, Electromagnetic Spectrum, RF behavior of passive Components, -High frequency resistors- high frequency capacitors- high frequency inductors, Chip components-chip resistors –chip capacitors and Circuit Board considerations, Scattering Parameters, Smith Chart and applications.

AMPLIFIER DESIGNS **09 Hrs**
Characteristics, Amplifier power relations, Transducer power gain Stability considerations, Constant gain, unilateral Design- Constant VSWR circles, Broadband, and high power amplifiers

OSCILLATORS,MIXERS and APPLICATIONS **09 Hrs**
Basic Oscillator model, High frequency oscillator configuration, Dielectric resonator oscillator, YIG –Tuned oscillator, Basic characteristics of Mixers, Single ended mixer, RF couplers -Wilkinson divider and Lange coupler, Detector and demodulator circuits.

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MICROSTRIP LINES.COUPLED MICROSTRIPS, SLOTLINE AND COPLANAR WAVEGUIDE **09 Hrs**

Microstrip line introduction and analysis-Coupled Microstrips – even and odd mode analysis – Microstrip directional couplers – Branch line couplers – periodic branch line couplers – Introduction to Slot line and Coplanar Waveguides.

LUMPED ELEMENTS AND NON-RECIPROCAL COMPONENTS **09 Hrs**

Micro strip Fabrication process – flat resistors – flat inductors – Interdigital Capacitors – sandwich capacitors – ferromagnetic substrates for non-reciprocal devices – Micro strip circulators – latching circulators – isolators – phase shifters

Theory: 45	**Tutorial: 0**	**Practical: 0**	**Project: 0**	**Total: 45 Hours**

REFERENCES:

1. Reinhold Ludwig and Powel Bretchko, "**RF Circuit Design – Theory and Applications**", Pearson Education Asia, 2nd Edition, 2009.
2. Joseph . J. Carr, "**Secrets of RF Circuit Design**" , McGraw Hill Publishers, Third Edition, 2001
3. Gupta,K.C, and Amarjit Singh, "**Microwave Integrated Circuits**", John Wiley and sons – Wiley Eastern Reprint, 1978.
4. Hoffmann, R.K, "**Handbook of Microwave Integrated Circuits**", Artech House, 1987

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P18COI1202 **ADVANCED SIGNAL PROCESSING**

L	T	P	J	C
3	0	2	0	4

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Apply the concepts of discrete random processes and parameter estimation (K3).
CO2: Analyze, implement and apply parametric and nonparametric methods of power spectrum estimation (K4)
CO3: Design Wiener filter for the given application (K4).
CO4: Compare and Implement adaptive filtering algorithms (K4).
CO5: Analyze multi-rate signal processing concepts (K4).

Pre-requisites: -

CO/PO Mapping: (S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak											
COs	**Programme Outcomes**										
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
CO1	S		S		S						
CO2	S		M		S						
CO3	S		M		S						
CO4	S		S		S						
CO5	S		S		S						

Course Assessment Methods:

Direct
1.Mid Term Examination (Theory component) 2.Research Assignment, Presentation (Theory component) 3. Pre/Post- Experiment Test/ Viva, Experiment Report for each experiment(Lab Component) 4. Model Examination 5. End Semester Examination(Theory and lab component)
Indirect
1. Course-end survey

DISCRETE RANDOM SIGNAL PROCESSING **09 Hrs**

Discrete Random Processes- Ensemble averages, stationary processes, Autocorrelation and Auto covariance matrices- Parameter estimation: Bias and consistency - Parseval's Theorem, White Noise, Power spectrum, Wiener-Khintchine Relation, Filtering random Processes, Spectral Factorization.

SPECTRUM ESTIMATION **09 Hrs**

Non-Parametric Methods - Periodogram Estimator, Performance Analysis of Estimators -Unbiased, Consistent Estimators- Modified Periodogram, Bartlett and Welch methods, Blackman –Tukey method. AR, MA, ARMA processes - Yule-Walker equations - Parametric methods of Spectral Estimation.

LINEAR ESTIMATION AND PREDICTION **09 Hrs**

Linear prediction- Forward and backward predictions, Lattice filter realization, Prony's all pole modeling, Solutions of the Normal equations- Levinson-Durbin recursion - Levinson recursion. Optimum filters- FIR Wiener filter –Causal and Non-causal IIR Wiener filter-Discrete Kalman filter

ADAPTIVE FILTERS **09 Hrs**

FIR adaptive filters -adaptive filter based on steepest descent method- LMS adaptive algorithm, Normalized LMS. Adaptive channel equalization-Adaptive echo cancellation-Adaptive noise cancellation- Adaptive recursive filters (IIR). RLS adaptive filters-Exponentially weighted RLS-sliding window RLS.

MULTIRATE DIGITAL SIGNAL PROCESSING **09 Hrs**

Mathematical description of change of sampling rate - Interpolation and Decimation, Decimation by an integer factor - Interpolation by an integer factor, Sampling rate conversion by a rational factor, Multistage implementation of multirate system, Direct form FIR filter structures, Polyphase filter structures, Subband Coding, Quadrature Mirror Filters – Condition for perfect reconstruction, Applications of Multirate systems.

Theory: 45	**Tutorial: 0**	**Practical: 0**	**Project: 0**	**Total: 45 Hours**

REFERENCES:

1. Monson H.Hayes, **"Statistical Digital Signal Processing and Modeling"**, John Wiley and Sons, Inc., 2009
2. John G. Proakis, Dimitris G. Manolakis, **" Digital Signal Processing"** Pearson Education**,** 4th Edition, 2007
3. John G. Proakiset.al., **"Algorithms for Statistical Signal Processing**", Prentice Hall, 2002.
4. Dimitris G. Manolakiset.al., **"Statistical and adaptive signal Processing",** McGraw Hill, New York, 2005.

List of Experiments:

1. Statistical parameter estimation of signals.
2. Frequency response of anti-aliasing and anti-Imaging filter
3. Implementation of Adaptive Filters.
4. Simulation of power spectral estimation methods.
5. Simulation of QMF.

Theory: 0	**Tutorial: 0**	**Practical: 30**	**Project: 0**	**Total: 30 Hours**

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P18COI1203 ADVANCED DIGITAL COMMUNICATION TECHNIQUES

L	T	P	J	C
3	0	2	0	4

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Apply appropriate channel model for design and analysis of digital communication system (K3).
CO2: Design, analyze and implement channel encoder and decoder for the given specification by applying channel coding algorithms (K4)
CO3: Analyze signaling schemes and equalizers for band limited channels (K4)
CO4: Develop and analyze Mathematical model for pass band signals (K4)
CO5: Design Coherent and non-coherent receiver for digital modulation schemes using modern tools (K3).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S	M	M		S						M
CO2	S	M	M		S						M
CO3	S	M	M		S						M
CO4	S	M	M		S						M
CO5	S	M	M		S						M

Course Assessment Methods:

Direct
1.Mid Term Examination (Theory component) 2.Research Assignment, Presentation (Theory component) 3. Pre/Post- Experiment Test/ Viva, Experiment Report for each experiment(Lab Component) 4. Model Examination 5. End Semester Examination(Theory and lab component)
Indirect
1. Course-end survey

COMMUNICATION CHANNEL MODELS **09 Hrs**

Review of Detailed block diagram of Digital Communication Systems –AWGN Channel Models: Discrete Memoryless Channel - Waveform and vector AWGN Channel, Channel Capacity. Wireless channel models: Large scale channel models-Small scale channel models - Time and Frequency coherence – Capacity of wireless Channel: Capacity of Flat Fading Channel.

CHANNEL CODING **09 Hrs**

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Linear block codes: Hamming – Golay – Cyclic - BCH - Reed – Solomon codes - Convolutional Codes: Representation of codes using Polynomial, State diagram, Tree diagram, and Trellis diagram – Decoding techniques using Maximum likelihood, Viterbi algorithm, Sequential and Threshold methods –Turbo Coding.

BAND LIMITED CHANNELS AND EQUALIZATION TECHNIQUES **09 Hrs**

Line Coding Techniques - Band Limited Channels- ISI – Nyquist Criterion- Controlled ISI-Partial Response signals- Equalization algorithms – Viterbi Algorithm – Linear equalizer – Decision feedback equalization – Adaptive Equalization algorithms.

DIGITAL MODULATION TECHNIQUES **09 Hrs**

Representation of Digitally Modulated signals, Memory less Modulation Methods, Signaling Schemes with Memory – CPFSK, CPM, Power Spectrum of Digitally Modulated Signals-PSD of a digitally modulated signal with memory, PSD of a linear modulated signal, PSD of a digitally modulated signal with Finite memory, PSD of a digitally modulation scheme with a Markov Structure

COHERENT AND NON COHERENT RECEIVERS **09 Hrs**

Optimal Detection and Error Probability for band limited Signaling, Optimal Detection and Error Probability for power limited signaling. Non-coherent detection of carrier modulated signals, Optimal Noncoherent detection of FSK modulated signals, Error probability of Orthogonal signaling with Noncoherent detection, Differential PSK (DPSK).

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. John G. Proakis., and Masoud Salehi. **"Digital Communication"** , McGraw- Hill, International Edition 2008.
2. M.K.Simon, S.M.Hinedi and W.C.Lindsey, **"Digital communication techniques; Signaling and detection"**, Prentice Hall India, New Delhi.1995
3. Simon Haykin, **"Digital communications"**, John Wiley and Sons, 2006
4. B.P.Lathi**"Modern digital and analog communication systems"**, Oxford University press,3rd Edition 1998
5. Bernard Sklar, "**Digital Communications"**, Pearson Education, 2nd Edition 2001.
6. Theodore S.Rappaport, "**Wireless Communications**", Pearson Education, 2nd Edition 2002.

List of Experiments:

1. Design and Implementation of Block channel coding techniques
2. Design and implementation of Convolution encoder
3. BER analysis of channel coding techniques over AWGN and fading channel
4. Performance analysis of channel equalizers
5. BER performance of pass band modulation techniques over AWGN channel
6. BER performance of pass band modulation techniques over fading channel

Theory: 0	Tutorial: 0	Practical: 30	Project: 0	Total: 30 Hours

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P18COT0004 **HIGH PERFORMANCE NETWORKS**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Compare the switching architectures (K3).
CO2: Analyze high performance networking schemes (K4).
CO3: Examine High speed optical network standards (K3).
CO4: Classify different wireless networking standards (K3).
CO5: Analyze 3G/4G networking standards (K3).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S										
CO2	S										
CO3	S										
CO4	S	M		M							
CO5	S	M		M							

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

SWITCHING NETWORKS **09 Hrs**

ATM – Features, Addressing Signalling & Routing, Header Structure, ATM Adaptation layer, Management control, switching and transmission, IP over ATM, Research Areas in ATM.

ADVANCED NETWORK ARCHITECTURE **09 Hrs**

IP forwarding architectures, overlay models, multi-protocol label switching, integrated services, Resource Reservation Protocol (RSVP), differentiated services

SONET /SDH NETWORKS **09 Hrs**

Integration of TDM signals, Framing, Transport Overhead, Multiplexing, Topologies, Protection Architectures, Ring Architectures

HIGH PERFORMANCE WIRELESS NETWORKS **09 Hrs**

Introduction to broadband wireless networks, evolution, fixed broadband wireless networks, mobile broadband wireless networks, overview of IEEE 802.16 and WiMax standards, Physical and MAC layer of WiMax, research areas in high performance wireless networks

3G AND 4G WIRELESS STANDARDS **09 Hrs**

Overview of GSM, WCDMA, Protocols like UMTS, HSPA family: HSDPA and HSUPA RPM architecture, HSPDA protocol Stack, LTE(Long Term Evolution).

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Jean Walrand and Parvin varaiya, "**High Performance Communication Networks**", 2nd Edition, Harcourt and Morgan Kauffman, 2000.
2. Leon Gracia,Widjaja, "**Communication Networks**", Tata McGraw-Hill, New Delhi,2000
3. Rajiv Ramaswami and Kumar sivarajan, "**Optical Networks: A practical Perspective**", Morgan Kauffman, 3rd edition,2010
4. Jeffrey G. Andrews, Anuradha Ghosh, Rias Muhamed ,"**Fundamentals of WiMAX understanding Broadband Wireless Networking**", Prentice Hall, 1st Edition, 2007.
5. Kevin Roebuck, "**4G Standards: High Impact Emerging Technology**", Tebbo, 2011.

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SEMESTER II

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P18MAT0101 **APPLIED MATHEMATICS**

L	T	P	J	C
3	1	0	0	4

Course Outcomes (COs):

Upon completion of the course, the student should be able to:

CO1: Apply matrix operations and properties of determinants (K3)
CO2: Understand and apply the concepts of vector space, linear independence, basis and dimension; evaluate eigenvalues, eigenvectors and diagonalise symmetric matrices (K3)
CO3: Apply the concepts of inner product, length, orthogonality of vector spaces to image processing (K4).
CO4: Construct probabilistic models for observed phenomena through distributions which play an important role in many engineering applications (K3).
CO5: Understand and apply the concepts of graphs and trees

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
CO1	S	S	M								
CO2	S	S	M								
CO3	S	S	M	M							
CO4	S	S	M	M							
CO5	S	S	M								

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Written Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

MATRIX ALGEBRA **6+1 Hrs**

Matrix operations - Inverse of a matrix - Characteristics of invertible matrices - Partitioned matrices - Matrix factorizations- Introduction to determinants - Properties of determinants - Cramer's rule

VECTOR SPACES **9+3 Hrs**

Vector spaces and subspaces - Null spaces, column spaces and linear transformations - Linearly independent sets; Bases - Coordinate systems - Dimension of a vector space – Rank - Change of basis- Eigenvalues and Eigenvectors - Characteristic equation –Diagonalization of symmetric matrices - Eigenvectors and linear transformations

ORTHOGONALITY AND LEAST SQUARES **9+3 Hrs**

Inner product, length and orthogonality - Orthogonal sets - Orthogonal projections –Gram - Schmidt process - Inner product spaces-Applications of inner product spaces - Quadratic forms - Singular value decomposition-Applications to image processing

RANDOM VARIABLES **12+5 Hrs**

One-dimensional Random Variables – Moments and MGF – Binomial, Poisson, Geometric, Exponential and Normal distributions – Two-dimensional Random Variables – Marginal and Conditional distribution – Covariance and Correlation coefficient.

GRAPH THEORY **9+3 Hrs**

Basic definitions – Adjacency matrix and incidence matrix – Isomorphism of graphs – Walk, Path and Circuit - Path matrix and Circuit matrix- Connected graphs- Euler path and circuit - Hamiltonian path and circuit - Trees – Properties - Distance and centers in a tree - Rooted and binary tree - Spanning tree – Minimal spanning tree.

Theory: 45	**Tutorial: 15**	**Practical: 0**	**Project: 0**	**Total: 60 Hours**

REFERENCES:

1. Howard A. Anton , “**Elementary Linear Algebra**”, John Wiley & Sons, Singapore, Eleventh edition, 2013.
2. Richard Bronson, “ **Matrix Operations**”, Schaum's Outline, McGraw-Hill Education; 2nd edition, 2011
3. David C. Lay, “**Linear Algebra and its Applications**”, Pearson Education Asia, New Delhi, Fifth edition, 2016
4. Gilbert Strang, “**Linear Algebra and its Applications**”, Brooks/Cole Ltd., New Delhi, Fourth Edition
5. Seymour Lipschutz , Marc Lipson, “**Linear Algebra**”, Schaum's Outline , McGraw Hill Trade; New Delhi, Sixth Edition, 2017.
6. Veerarajan. T., “**Probability, Statistics and Random Process**”, Tata McGraw Hill, Third edition, 2008.
7. Narsingh Deo, “**Graph Theory with Applications to Engineering and Computer Science**”, Dover Publication, 2016.
8. J.A. Bondy , U.S.R. Murty, “**Graph Theory With Applications**” , North Holland, New York, 1976

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P18COT2001 **WIRELESS SENSOR NETWORKS**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):

Upon completion of the course, the student should be able to:

CO1: Interpret the basics concepts of Wireless Sensor Network architecture and its principles (K2).
CO2: Classify and examine the various communication protocols in WSN stack (K3).
CO3: Illustrate the concepts of localization and time synchronization (K3).
CO4: Analyze the design challenges in various Sensor Networks (K4).
CO5: Implementation of WSN using open source tools (K4).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
CO1	M										
CO2	S		M								
CO3	S	M									
CO4	S	M	M	S							
CO5	S		M	M	S		M	M	M		

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

INTRODUCTION **09 Hrs**

Challenges for wireless sensor networks, Comparison of sensor network with ad hoc network, Single node architecture, Hardware components, Energy consumption of sensor nodes, Network architecture, Sensor network scenarios, Optimization Goals and Design principles.

COMMUNICATION PROTOCOL **09 Hrs**

Physical layer and transceiver design consideration in wireless sensor networks, MAC protocols –fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, Schedule-based protocols, IEEE802.15.4 MAC protocol. Address and Name Management. Routing Protocols- Energy-efficient unicast, Broadcast and multicast, geographic routing, mobile nodes, Data centric and content-based networking, Data aggregation

SENSOR LOCALIZATION AND TIME SYNCHRONIZATION **09 Hrs**

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Introduction, Elements of Localization, Sensor Localization with multidimensional scaling, Localization in wireless sensor networks, On the security of WSN Localization, Time synchronization in wireless sensor network.

OPEN ISSUES AND DESIGN CHALLENGES **09 Hrs**

Internet of Things, Wireless sensor and Actor networks, underwater sensor networks, Video Sensor networks, Wireless Body Area Networks (WBAN) for health-monitoring, indoor surveillance.

SENSOR NETWORK PROGRAMMING **09 Hrs**

Programming Challenges in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming.

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Holger Karl and Andreas willig, “**Protocol and Architecture for Wireless Sensor Networks**”, John Willey Publication, 2007.
2. Fei Hu and Xiaojun Cao, “**Wireless Sensor Networks Principles and Practice**”, CRC Press,2010.
3. Feng zhao and Leonidas guibas, “**Wireless Sensor Networks: an Information Processing Approach**”, Elsevier Publication, 2004.
4. Sitharama Iyengar S, Nandan Parmeshwaran, Balkrishnan N and Chuka D, “**Fundaments of Sensor Network Programming, Applications and Technology**”, John Wiley & Sons, 2011.
5. Jean Philippe Vasseur and Adam Dunkels, “**Interconnecting Smart Objects with IP, The Next Internet**”, Morgan Kaufmann, Elsevier, 2010.

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P18COI2202 **ADVANCED RADIATION SYSTEMS**

L	T	P	J	C
3	0	2	0	4

Course Outcomes (COs):

Upon completion of the course, the student should be able to:

CO1: Analyze radiation fields of alternating current element and half wave dipole antennas. (K4).
CO2: Design and analyze antenna arrays for the given specification (K4).
CO3: Compare different types of aperture antennas.(K3)
CO4: Analyze various types of microwave antennas (K4).
CO5: Select appropriate antenna for a given applications (K4).
CO6: Design, operate and analyze the characteristics of various antennas (K4).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S		M	M	S						
CO2	S		M	M	S						
CO3	S			M	S						
CO4	S		M	M	S						
CO5	S			M	S	M					M
CO6	S			M	S	M		M			

Course Assessment Methods:

Direct
1.Mid Term Examination (Theory component)
2.Research Assignment, Presentation (Theory component)
3. Pre/Post- Experiment Test/ Viva, Experiment Report for each experiment(Lab Component)
4. Model Examination
5. End Semester Examination(Theory and lab component)
Indirect
1. Course-end survey

CONCEPTS OF RADIATION **09 Hrs**

Review of Antenna Types and Antenna parameters- Retarded vector potentials – Heuristic approach and Maxwell's equation approach. The Lorentz gauge condition. Vector potential in Phasor form. Radiation from alternating current element and Half wave dipole. Electric vector potential for a magnetic current source. Far zone fields due to magnetic source.

ANTENNA ARRAYS **09 Hrs**

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Linear array. Phased array, MEMS technology in phased arrays, Dolph-Tchebycheff arrays. Circular array. Antenna Synthesis - Line source and Discretization of continuous sources. Schelkunoff polynomial method. Fourier Transform method. Comparison of analog beam forming and digital beam forming.

APERTURE ANTENNAS **09 Hrs**

Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane; Slot antenna; Horn antenna -E Plane, H Plane and Pyramidal Horns; Reflector antenna.

MICRO STRIP ANTENNA **09 Hrs**

Radiation mechanism from patch; Excitation techniques; Rectangular patch, Circular patch, and Ring antenna – radiation analysis from transmission line model, cavity model; input impedance of rectangular and circular patch antenna; Microstrip array and feed network; Applications of microstrip array antenna.

SPECIAL ANTENNAS **09 Hrs**

Mobile phone antenna-Base station, Hand set antenna, UWB antenna, PIFA, Vivaldi antenna, Antenna for automobiles, MIMO antenna, Wearable Antenna.

Theory: 45	**Tutorial: 0**	**Practical: 0**	**Project: 0**	**Total: 45 Hours**

REFERENCES:

1. E.C. Jordan & K.G. Balmain, **“Electromagnetic waves and Radiating systems”,** Second Edition, Prentice Hall of India, 2011.
2. Balanis, C.A, **“Antenna Theory”,** Third Edition,Wiley and Sons,2005
3 Krauss, J.D, **“Radio Astronomy”,** McGraw-Hill 1966
4. Kraus, J.D. and Fleisch, D.A. “**Electromagnetics with Applications**”, Fifth Edition .New York, McGraw-Hill, 1999.
5 Fran K. B. Gross, “**Frontiers in Antennas**”, Mc Graw Hill, 2011.
6 S. Drabowitch, A. Papiernik, H.D.Griffiths, J.Encinas, B.L.Smith, “**Modern Antennas**”, Second Edition, Springer Publications, 2007.
7 I.J. Bahl and P. Bhartia,” **Microstrip Antennas**”, Artech House,Inc.,1980
8 W.L.Stutzman and G.A.Thiele, “**Antenna Theory and Design**”, Second Edition, John Wiley &Sons Inc.,1998
9 Jim R. James,P.S.Hall ,"**Handbook of Microstrip Antennas**" IEE Electromagnetic wave series 28, Volume 2,1989.

LIST OF EXPERIMENTS

Use network analyzer for the following experiments:

1. Measurement of transmission line parameters.

2. S-parameter estimation of Microstrip line Components.

Use appropriate simulation tools for the design and analysis of :

3. Microstrip components

4. Microstrip Antennas

5. Microstrip line Filters

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Use microwave test bench setup for the following experiment:

6. Radiation pattern analysis of Microwave/ Microstrip Antennas.

Theory:0	Tutorial: 0	Practical: 30	Project: 0	Total: 30 Hours

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P18COI2203 **WIRELESS COMMUNICATION SYSTEMS**

L	T	P	J	C
3	0	2	0	4

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Apply and analyze wireless channel models (K3).
CO2: Analyze the performance of digital modulation schemes and diversity techniques over fading channel (K4).
CO3: Design and operate Multi Carrier and Multiuser communication techniques (K4).
CO4: Classify MIMO communication techniques (K4).
CO5: Explain Massive MIMO concepts (K3).

Pre-requisites: Advanced Digital Communication Techniques

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S	M	M		S						M
CO2	S	M	M		S						M
CO3	S	M	M		S						M
CO4	S	M	M		S						M
CO5	S	M	M		S						M

Course Assessment Methods:

Direct
1.Mid Term Examination (Theory component)
2.Research Assignment, Presentation (Theory component)
3. Pre/Post- Experiment Test/ Viva, Experiment Report for each experiment(Lab Component)
4. Model Examination
5. End Semester Examination(Theory and lab component)
Indirect
1. Course-end survey

WIRELESS COMMUNICATION CHANNEL MODELS **09 Hrs**

Review of fading channel models - Capacity of Flat Fading Channel, Channel Distribution Information known,Channel Side Information at Receiver, Channel Side Information known at Transmitter and Receiver – Capacity with Receiver diversity – Capacity comparisons – Capacity of Frequency Selective Fading channels. MIMO Channel models: Frequency selective and correlated channels models, Capacity of MIMO channels, Ergodic and outage capacity, capacity bounds and influence of channel properties on the capacity.

DIGITAL MODULATION AND DIVERSITY TECHNIQUES **09 Hrs**

Performance of Digital Modulation over Wireless Channel-Fading– Outage Probability– Average Probability of Error — Combined Outage and Average Error Probability. Realization of Independent Fading Paths – Receiver Diversity

– Selection Combining – Threshold Combining – Maximal-Ratio Combining – Equal - Gain Combining – Transmitter Diversity – Channel known at Transmitter – Channel unknown at Transmitter – The Alamouti Scheme

MULTICARRIER AND MULTIUSER COMMUNICATION **09 Hrs**

Data Transmission using Multiple Carriers – Multicarrier Modulation with Overlapping Subchannels – Mitigation of Subcarrier Fading – Discrete Implementation of Multicarrier Modulation – Peak to average Power Ratio- Frequency and Timing offset – Introduction to CDMA systems, multiuser detection in CDMA systems – optimum multiuser receiver, suboptimum detectors, successive interference cancellation.

MIMO COMMUNICATIONS **09 Hrs**

Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO Diversity Gain:Beamforming, Diversity-Multiplexing trade-offs, Space Time Modulation and coding, Spatial Multiplexing and BLAST Architectures.

MASSIVE MIMO SYSTEM **09 Hrs**

Introduction - MIMO for LTE, capacity of massive MIMO, Pilot contamination, Resource allocation and transceivers design, Base band and RF implementation, Channel Models

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Andrea Goldsmith, "**Wireless Communications**", Cambridge University Press, 2005.
2. Aditya K Jagannatham, " **Principles of Modern Wireless Communication Systems: Theory and Practice**", McGraw- Hill Education (India) Private Limited, 2016.
3. A. Chockalingam, B. Sundar Rajan, "**Large MIMO Systems**", Cambridge University Press, 2014.
4. John G. Proakis., and MasoudSalehi. **"Digital Communication"**, McGraw- Hill, International Edition 2008.
5. MohinderJanakiraman, "**Space - Time Codes and MIMO Systems**", ArtechHousePublishers, 2004.
6. Andrew J. Viterbi, "**CDMA: Principles of Spread Spectrum Communications,**"Prentice Hall, USA, 1995
7. Theodore S.Rappaport, "**Wireless Communications**", Pearson Education, 2nd edition,2002

List of Experiments:

Performance analysis of the following techniques over SISO and MIMO channel using simulation tools

1. Channel coding techniques
2. Channel equalizers algorithms
3. Pass band modulation techniques
4. Diversity techniques
5. OFDM
6. Spread Spectrum Techniques

Theory: 0	Tutorial: 0	Practical: 30	Project: 0	Total: 30Hours

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PROGRAMME ELECTIVES

P18COE0001 ADVANCED DIGITAL IMAGE PROCESSING

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):

After successful completion of this course, the student should be able to:

CO1: Apply appropriate image enhancement techniques and Image Transforms (K3)
CO2: Compare Image Segmentation algorithms. (K3)
CO3: Analyze different features of an image (K4).
CO4: Choose appropriate Image registration and fusion algorithms (K4).
CO5: Apply suitable image processing algorithms for various applications (K3).

Pre-requisites: Advanced Signal Processing

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S	M	M			M					
CO2	S	M	M			M					
CO3	S	M	M			M					
CO4	S	M	M			M					
CO5	S	M	M			M					S

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

FUNDAMENTALS OF DIGITAL IMAGE PROCESSING **10 Hrs**

Elements of visual perception, brightness, contrast, hue, saturation, mach band effect, 2D image transforms-DFT, DCT, KLT, SVD. Image enhancement in spatial and frequency domain, Review of Morphological image processing.

IMAGE SEGMENTATION **10 Hrs**

Edge detection, Thresholding, Region growing, Fuzzy clustering, Watershed algorithm, Active contour models, Texture feature based segmentation, Graph based segmentation, Wavelet based Segmentation - Applications of image segmentation.

FEATURE EXTRACTION **10 Hrs**

First and second order edge detection operators, Phase congruency, Localized feature extraction - detecting image curvature, shape features, Hough transform, shape skeletonization, Boundary descriptors, Moments, Texture descriptors- Autocorrelation, Co-occurrence features, Runlength features, Fractal model based features, Gabor filter, wavelet features.

REGISTRATION AND IMAGE FUSION **10 Hrs**

Registration - Preprocessing, Feature selection - points, lines, regions and templates Feature correspondence - Point pattern matching, Line matching, Region matching, Template matching. Transformation functions - Similarity transformation and Affine Transformation. Resampling – Nearest Neighbour and Cubic Splines. Image Fusion - Overview of image fusion, pixel fusion, wavelet based fusion -region based fusion.

IMAGE PROCESSING APPLICATIONS **05 Hrs**

Image compression standards - Watermarking – Steganography, Medical/Biological image processing, Industrial applications.

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES

1. Rafael C. Gonzalez, **"Digital Image Processing",** Pearson Education, Inc., 4th Edition, 2017.
2. Anil K. Jain, "**Fundamentals of Digital Image Processing**", Pearson Education, Inc., 2002.
3. Mark Nixon, Alberto Aguado, "**Feature Extraction and Image Processing**", Academic Press,2008
4. Rick S.Blum, Zheng Liu, "**Multisensor image fusion and its Applications**", Taylor& Francis,2006
5. ArdeshirGoshtasby, "**2D and 3D Image registration for Medical, Remote Sensing and Industrial Applications**",John Wiley and Sons,2005.
6. John C.Russ, "**The Image Processing Handbook**", CRC Press,2007
7. Khalid Sayood, **"Data Compression",** Morgan Kaufmann Publishers (Elsevier)., 3rd Edition, 2006.

P18COE0002 COMMUNICATION NETWORK SECURITY

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Classify the symmetric encryption techniques (K2).
CO2: Illustrate various Public key cryptographic techniques (K3)
CO3: Elaborate the network security and web security techniques(K2)
CO4: Outline the various wireless threats(K2).
CO5: Discuss the security in various wireless data networks (K2)

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S	M	S	M							
CO2	S	M	S	M							
CO3	S	M		M							
CO4	S			S							
CO5	S			M							

Course Assessment Methods:

Direct
1. Mid Term Examination
2. Research Assignment, Presentation
3. End Semester Examination
Indirect
1. Course-end survey

SYMMETRIC CIPHERS **09 Hrs**
Design Principles - Data Encryption Standard- Strength of DES, AES Cipher- Multiple Encryption-Triple DES- Block Cipher Modes of Operation -Stream Ciphers and RC4, Confidentiality using Symmetric Encryption-Placement of Encryption Function, Traffic Confidentiality, Key Distribution and Random Number Generation.

PUBLIC-KEY ENCRYPTION AND HASH FUNCTIONS **09 Hrs**
Public Key Cryptography and RSA- Principles of Public Key Cryptosystems, RSA Algorithm, Key Management – Diffie -Hellman Key Exchange, Elliptic Curve arithmetic, Elliptic Curve Cryptography

NETWORK SECURITY AND WEB SECURITY **09 Hrs**
IP Security- IP Security Overview - IP Security Architecture - Authentication Header - Encapsulating Security Payload, Web Security for Wired Networks- Web Security Considerations

WIRELESS THREATS **09 Hrs**

Introduction to wireless technologies-Wireless data networks-Personal Area Networks --Kinds of security breaches- Eavesdropping-Communication Jamming - RF interference -Covert wireless channels –DOS attack - Spoofing-Theft of services-Traffic Analysis-Cryptographic threats-Wireless security Standards.

SECURITY IN WIREELSS DATA NETWORKS **09 Hrs**

Secure Sockets Layer -Wireless Transport Layer Security- WAP Security Architecture-WAP Gateway. Wireless Device security issues- Bluetooth security, CDPD security (Cellular Digital Packet Data)- GPRS security (General Packet Radio Service)-GSM (Global System for Mobile Communication) security

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1 William Stallings, **“Cryptography and Network Security”**, fourth edition, Prentice Hall of India,New Delhi ,2011

2 Behrouz A. Forouzan , DebdeepMukhopadhyay **,“ Cryptography and Network security” ,** 2nd edition, Tata McGraw- Hill,2010

3 William Stallings, **“Network Security Essentials”,** 5th edition. Pearson Education, New Delhi, 2013

4 Merritt Maxim and David Pollino, “**Wireless Security**”, Osborne/McGraw Hill, 2002.

5 Nichols and Lekka, “**Wireless Security-Models, Threats and Solutions**”, McGraw – Hill, 2002.

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P18COE0003 **SATELLITE COMMUNICATION**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Explain orbital mechanics (K2)..
CO2: Analyze various earth station equipment & spacecraft subsystems (K3).
CO3: Design the satellite links for a specified carrier to noise ratio(K4).
CO4: Compare various multiple access techniques and networking in satellite communication (K3).
CO5: Investigate various satellite services and applications (K3).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S										
CO2	S										
CO3	S		M								
CO4	S		M								
CO5	S			M							**S**

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

ORBITAL MECHANICS **09 Hrs**
Introduction-Spectrum allocations for satellite systems Kepler's laws of motion, Orbits, Orbit Equations, Orbit Description, Locating the Satellite in the Orbit and with Respect to Earth, Orbital Elements-Look angle Determination and Visibility - Orbital Perturbations, Orbit Determination. Orbital Effects in Communication System - Satellite launch vehicles.

SPACECRAFT SUB SYSTEMS AND EARTH STATION **09 Hrs**
Spacecraft Subsystems, Attitude and Orbit Control, Telemetry and Tracking, Power Systems, Communication Subsystems, Transponders, Antennas, Equipment Reliability, Earth Stations.

SPACE LINKS **09 Hrs**

The Space Link, Satellite Link Design - Satellite uplink -down link power Budget, Basic Transmission Theory, System Noise Temp, G/T Ratio, Noise Figure. Overall link C/ N ratio. Design of Satellite Links for Specified C/N - Microwave Propagation on Satellite-Earth Paths. Interference between satellite circuits, Energy Dispersal.

MULTIPLE ACCESS TECHNIQUES AND NETWORK ASPECTS **09 Hrs**

Single access vs. multiple access (MA). Classical MA techniques: FDMA, TDMA, CDMA. Demand assignment techniques. Examples of MA techniques for existing and planned systems (e.g. the satellite component of UMTS).Mobile satellite network design, ATM via satellite. TCP/IP via satellite - Call control, handover and call set up procedures, Hybrid satellite-terrestrial networks

SERVICES AND APPLICATIONS **09 Hrs**

INTELSAT series - INSAT, VSAT, Remote Sensing.Mobile satellite services: GSM,GPS, INMARSAT, Navigation System. Direct Broadcast satellites (DBS)- Direct to home Broadcast (DTH)..Special services- E-mail, Video conferencing and Internet.

Theory: 45	**Tutorial: 0**	**Practical: 0**	**Project: 0**	**Total: 45 Hours**

REFERENCES:

1. Dennis Roddy, **“Satellite Communications”,** Fourth Edition, McGraw Hill International Editions, 2006.
2. Bruce R.Elbert, **"The Satellite Communication Applications Hand Book”,** Second Edition, Artech House Boston,2004.
3. Wilbur L. Pritchard, Hendri G. Suyderhoud, Robert A.Nelson, **"Satellite Communication Systems Engineering",** Second Edition, Prentice Hall, New Jersey,1993.
4. Tri T.Ha, **"Digital Satellite Communication",** Second Edition, McGraw Hill, New York, 2008.
5. Timothy Pratt and Charles W Bostian, **"Satellite Communications",** Second Edition, John Wiley and Sons, 2008.
6. Emauel Fthenakis, **" Manual of Satellite Communications",** McGraw Hill , 1984.
7. Robert M.Gagliardi ,**"Satellite Communication",**First Edition,CBS Publishers, 2004.

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P18COE0004 **MIMO COMMUNICATION**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course the student should be able to:

CO1: Choose appropriate MIMO channel models based on different propagation environments (K3)
CO2: Analyze the performance of diversity techniques along with multiplexing (K4).
CO3: Apply equalization and pre-coding techniques(K3).
CO4: Identify the suitable beamforming technique for MIMO communication(K3)
CO5: Estimate the channel properties of a various communication links (K4)

Pre-requisites: Wireless Communication Systems

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S	M		M	S						M
CO2	S	S		M	S						M
CO3	S	S		M	S						M
CO4	S	M		M	S						M
CO5	S	M		M	S						M

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

INTRODUCTION **03 Hrs**
History of MIMO, Smart antennas vs MIMO, Open- and closed-loop MIMO, MIMO channel models- MIMO channels in LOS geometry, General channel model with correlation, Kronecker channel model, Impact of antenna correlation on MIMO capacity, Dependence of Rt and Rr on antenna spacing and scattering angle, Pinhole scattering, Line-of-sight channel model, Multiple Antenna Systems.

SPACE TIME DIVERSITY AND MULTIPLEXING **09 Hrs**
Diversity, Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel.

EQUALIZATION AND PRECODING **09 Hrs**
The generic MIMO problem, Singular Value Decomposition, Eigenvalues and eigenvectors, Equalising MIMO systems, Disadvantages of equalising MIMO systems, Predistortion in MIMO systems, Disadvantages of pre-

distortion in MIMO systems, Pre-coding and combining in MIMO systems, Advantages of pre-coding and combining, Disadvantages of precoding and combining, Channel state information.

MIMO BEAMFORMING **09 Hrs**

Codebooks for MIMO, Beamforming, Beamforming principles, Increased spectrum efficiency, Interference cancellation, Switched beamformer, Adaptive beamformer, Narrowband beamformer, Wideband beamformer.

CHANNEL ESTIMATION **09 Hrs**

Channel Estimation, Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.

CASE STUDY **06 Hrs**

MIMO in LTE, 4G and 5G technologies

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Jerry R. Hampton , “**Introduction to MIMO Communications**” by Cambridge University Press 2014
2. Andrea Goldsmith, “**Wireless Communications**”, Cambridge University Press, 2005.
3. Wei Liu and Stephen Weiss, “**Wideband Beamforming-concepts and techniques**”, John Wiley and Sons, 2010
4. Claude Oestges, Bruno Clerckx , “**MIMO Wireless Communications: From Propagation to Space-time Code Design**",Academic Press, 1st edition, 2010.
5. Mohinder Janakiraman, “**Space - Time Codes and MIMO Systems**”, Artech House Publishers, 2004

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P18COE0005 **OPTICAL NETWORKS**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Interpret functions of various optical network components. (K2)
CO2: Analyze broadcast-and-select and wavelength routing networks (K3)
CO3: Compare different optical network architectures. (K3)
CO4: Explain photonic packet switching concepts and access networks (K2).
CO5: Analyze different network management functions (K3)
CO6 Analyze the characteristics of various optical components and the transmission link (K3).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S										
CO2	S	M	M								
CO3	S										
CO4	M										
CO5	M	M	M								
CO6	S	M	M	M	S						

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

OPTICAL SYSTEM COMPONENTS **09 Hrs**
Optical Network Components – Couplers, Isolators & Circulators, Multiplexers & Filters, Optical Amplifiers, Switches, Wavelength Converters

OPTICAL NETWORK ARCHITECTURES **09 Hrs**
Introduction to Optical Networks, Metropolitan-Area Networks, Broadcast and Select Networks– Topologies for Broadcast Networks, Media-Access Control Protocols, Test beds for Broadcast & Select WDM.

WAVELENGTH ROUTING NETWORKS **09 Hrs**
Wavelength Routing Architecture, The optical layer, Node Designs, Optical layer cost tradeoff, Routing and wavelength assignment, Virtual topology design, Wavelength Routing Test beds, Architectural variations.

PACKET SWITCHING AND ACCESS NETWORKS **09 Hrs**

Photonic Packet Switching – OTDM, Multiplexing and De-multiplexing, Synchronization, Broadcast OTDM networks, Switch-based networks; Access Networks – Network Architecture overview, Future Access Networks, Optical Access Network Architectures; and OTDM networks.

NETWORK DESIGN AND MANAGEMENT **09 Hrs**

Transmission System Engineering – System model, Power penalty - transmitter, receiver, Optical amplifiers; Overall design considerations; Control and Management – Network management functions, Configuration management, Performance management, Fault management, Optical safety.

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Rajiv Ramaswami and Kumar N. Sivarajan, **"Optical Networks : A Practical Perspective"**, Harcourt Asia Pte Ltd., Second Edition 2004.
2. C. Siva Ram Moorthy and Mohan Gurusamy, **"WDM Optical Networks : Concept, Design and Algorithms"**, Prentice Hall of India, Ist Edition, 2002.
3. Vivek Alwayn, **"Optical Network Design and Implementation",** Pearson Education,2004.
4. Hussein T.Mouftab and Pin-Han Ho, **"Optical Networks: Architecture and Survivability",** Kluwer Academic Publishers, 2002.
5. Biswanath Mukherjee, **"Optical Communication Networks",** McGraw Hill, 1997.
6. P.E. Green, Jr., **"Fiber Optic Networks",** Prentice Hall, NJ, 1993

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P18COE0306 **LORA TECHNOLOGY**

L	T	P	J	C
2	0	0	2	3

Course Outcomes (COs):
Upon completion of the course the student should be able to:

CO1: Explain the impact of the LPWAN design on the Internet of Things (K2).
CO2: Examine and critique some of the most important message formats and interaction patterns being used on the World Wide Web and the IoT (K3).
CO3: Explore several standards that play a significant role in the Internet of Things (K4)
CO4: Develop and build LPWAN (K5).

Pre-requisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S										
CO2		S	M	M							
CO3	S										
CO4			S	M	S	M					

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

INTRODUCTION **06 Hrs**
Communication technology: Wired and wireless- Internet of Things: Different wireless technologies-Low Power Wide Area Network (LPWAN)- LoRa® (Radio Modulation)- LoRa characteristics- Radio propagation- LoRa modulation-Frequency bands

ARCHITEURE AND HARDWARE **06 Hrs**
Overview- LoRaWAN network server- Device classes- Scalability- Uplink and downlink messages HARDWARE- Gateways-Nodes-Prototyping and what hardware to choose - Production - Power consumption - Antennas.

INTRODUCTION TO MODELING PROTOTYPING AND PROCESSING **08 Hrs**
Building a solution and prototyping - Case studies and examples-Sketch on the node libraries-Payload functions-Setting up end-to-end application-Protocols: MQTT, HTTP integration, Data modeling and processing - Data storage and visualization-Cloud platforms and integrations- Tools: Grafana, InfluxDB, NodeRed.

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LOCALIZATION AND SECURITY **08 Hrs**

GPS - WiFi - Beacons- Geolocation - OTAA/ABP Frame counters, Secure elements-Encryption and decryptionLarge-scale deployments- Placing gateways and site surveys- Enabling ADR (scalability)- NOC, alerting, updates- Mass commissioning, OTA updates-Security: setting up own handler- Using HTTP for scaling.

CAPSTONE PROJECT **02 Hrs**

LoRaWAN ecosystem - Challenges ahead - Interoperability, roaming CAPSTONE PROJECT

Theory: 30	Tutorial: 0	Practical: 0	Project: 30	Total: 60 Hours

REFERENCE

1. https://www.lora-alliance.org/lorawan-white-papers
2. David Hanes, Gonzalo Salgueiro , Patrick Grossetete , Robert Barton "**IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things**". Cisco Press, June 2017
3. Guinard and Trifa, "**Building the Web of Things With examples in Node.js and Raspberry Pi**" Manning Publications Co. Greenwich, CT, USA ©2016.
4. Pethuru Raj and Anupama C. Raman "**The Internet of Things: Enabling Technologies, Platforms, and Use Cases**", 1st Edition Auerbach Publications, 2017
5. https://www.thethingsnetwork.org/docs/lorawan/

P18COE0007 **VLSI DESIGN TECHNIQUES**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Analyze the characteristics of MOS transistor. (K3)
CO2: Differentiate various CMOS fabrication techniques.(K2)
CO3: Design and verify different types of static and dynamic CMOS circuits. (K4)
CO4: Estimate the performance of CMOS circuits using its characteristics.(K3)
CO5: Design and verify system level components. (K4)

Prerequisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
CO1	S										M
CO2	S										M
CO3	M		S		S						M
CO4	M		S	M							M
CO5	M		S	S	S						M

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

MOS TRANSISTOR THEORY **09 Hrs**
NMOS and PMOS transistors, CMOS logic, MOS transistor theory – Introduction, Enhancement mode transistor action, Ideal I-V characteristics, DC transfer characteristics, Threshold voltage- Body effect- Design equations- Second order effects. MOS models and small signal AC characteristics, Simple MOS capacitance Models, Detailed MOS gate capacitance model, Detailed MOS Diffusion capacitance model.

CMOS TECHNOLOGY AND DESIGN RULE **09 Hrs**
CMOS fabrication and Layout, CMOS technologies, P -Well process, N -Well process, twin -tub process, SOI, MOS layers stick diagrams and Layout diagram, Layout design rules, Latch up in CMOS circuits, CMOS process enhancements, Technology – related CAD issues, Fabrication and packaging.

CMOS LOGIC DESIGN **09 Hrs**
NMOS and CMOS Inverters, Inverter ratio, DC and transient characteristics , switching times, Super buffers, Driving large capacitance loads, CMOS logic structures , Transmission gates, Static CMOS design, dynamic CMOS design.

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CIRCUIT CHARACTERISATION AND PERFORMANCE ESTIMATION 09 Hrs

Resistance estimation, Capacitance estimation, Inductance, switching characteristics, transistor sizing, power dissipation and design margining. Charge sharing, Scaling.

VLSI SYSTEM LEVEL COMPONENTS AND PHYSICAL DESIGN 09 Hrs

Multiplexers, Decoders, comparators, priority encoders, Shift registers. Arithmetic circuits – Ripple carry adders, Carry look ahead adders, High-speed adders, Multipliers. Physical design – Delay modelling, cross talk, floor planning, power distribution. Clock distribution. Basics of CMOS testing.

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Neil H.E. Weste and Kamran Eshraghian, **"Principles of CMOS VLSI Design",** Pearson Education ASIA, 2nd edition, 2010.
2. John P. Uyemura, **"Introduction to VLSI Circuits and Systems",** John Wiley & Sons, Inc., 2002.
3. Eugene D. Fabricius, **"Introduction to VLSI Design",** McGraw Hill International Editions, 1990.
4. Pucknell, **"Basic VLSI Design"**, Prentice Hall of India Publication, 1995.
5. Wayne Wolf, **"Modern VLSI Design System on chip**", Pearson Education.2002.

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P18COE0008 **ADVANCED EMBEDDED SYSTEMS**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
Upon completion of the course, the student should be able to:

CO1: Explain the architecture and instruction set of ARM Processor (K2).
CO2: Revise computing platform and design analysis (K2)
CO3: Demonstrate multiple tasks and multi processes (K2)
CO4: Demonstrate the application of networking protocols in embedded systems (K3)
CO5: Discuss hardware and software co-design (K3)
CO6: Explain case studies related to embedded systems (K4).

Prerequisites: -

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S				M						
CO2	S		M		M						
CO3	M				M						M
CO4	M	M									
CO5	M										
CO6	S	M									

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

INTRODUCTION TO ARM PROCESSORS **09 Hrs**

ARM Embedded System,Fundamentals of ARM Processor, ARM Instruction set, Thumb Instruction set, ARM assembly language programming, Digital Signal Processing in ARM, Exceptions & Interrupt Handling.

COMPUTING PLATFORM AND DESIGN ANALYSIS **09 Hrs**

CPU buses – Memory devices – I/O devices – Memory Protection Units – Memory Management Units – Component interfacing – Design with microprocessors – Development and Debugging – Program design – Model of programs – Assembly and Linking – Basic compilation techniques – Analysis and optimization of execution time, power, energy, program size – Program validation and testing.

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PROCESS AND OPERATING SYSTEMS **09 Hrs**

Multitasks and multiprocesses – Processes – Context Switching – Scheduling policies - Multiprocessor – Inter Process Communication mechanisms – Evaluating operating system performance – Power optimization strategies for processes – Firmware and Operating Systems for ARM processor.

HARDWARE ACCELERATORS & NETWORKS **09 Hrs**

Accelerators – Accelerated system design – Distributed Embedded Architecture – Networks for Embedded Systems – I^2C, CAN Bus, SHARC link ports, Ethernet, Myrinet, Internet, Network-Based design- Communication Analysis, system performance Analysis, Hardware platform design – Internet enabled systems.

CASE STUDY **09 Hrs**

Hardware and software co-design - Data Compressor - Software Modem – Personal Digital Assistants – Set–Top–Box. – System-on-Silicon – FOSS Tools for embedded system development.

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. Andrew N Sloss, Dominic Symes and Chris Wright, "**ARM system developer' s guide – Designing and Optimizing System Software**", Morgan Kaufmann publishers, 2004.
2. David E-Simon, "**An Embedded Software Primer**", Pearson Education, 2007.
3. K.V.K.K.Prasad, "**Embedded Real-Time Systems: Concepts, Design & Programming**", Dream Tech press, 2005.
4. Tim Wilmshurst, "**An Introduction to the Design of Small Scale Embedded Systems**", Pal grave Publisher, 2004.
5. Wayne Wolf, "**Computers as Components - Principles of Embedded Computer System Design**", Morgan Kaufmann Publisher, 2006.

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P18COE0009 **COMPUTER VISION**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
After successful completion of this course, the students should be able to

CO1: Perform shape analysis using boundary tracking and region descriptors(K3).
CO2: Apply Hough transform for various applications (K4).
CO3: Apply 3D vision techniques (K3).
CO4: Develop applications using computer vision techniques (K4).

Prerequisites: Digital Image Processing

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11
CO1	S	M	M	M		M					
CO2	S	M	M	M		M					
CO3	S	M	M	M		M					
CO4	S	S	S	M		S					

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

IMAGE PROCESSING FOUNDATIONS **09 Hrs**

Review of image processing techniques – classical filtering operations – thresholding techniques- edge detection techniques – corner and interest point detection – mathematical morphology – texture.

SHAPES AND REGIONS **09 Hrs**

Binary shape analysis – connectedness – object labeling and counting – size filtering – distance functions – skeletons and thinning – deformable shape analysis – boundary tracking procedures – active contours – shape models and shape recognition – centroidal profiles – handling occlusion – boundary length measures – boundary descriptors – chain codes – Fourier descriptors – region descriptors – moments.

HOUGH TRANSFORM **09 Hrs**

Line detection – Hough Transform (HT) for line detection – foot-of-normal method – line localization – line fitting – RANSAC for straight line detection – HT based circular object detection-accurate center location – speed problem –

ellipse detection – Case study: Human Iris location-hole detection – generalized Hough Transform (GHT) – spatial matched filtering – GHT for ellipse detection – object location – GHT for feature collation.

3D VISION AND MOTION **09 Hrs**

Methods for 3D vision – projection schemes – shape from shading – photometric stereo – shape from texture – shape from focus – active range finding – surface representations – point-based representation – volumetric representations – 3D object recognition – 3D reconstruction – introduction to motion – triangulation – bundle adjustment – translational alignment – parametric motion – spline-based motion – optical flow – layered motion.

APPLICATIONS **09 Hrs**

Application: Photo album – Face detection – Face recognition – Eigen faces – Active appearance and 3D shape models of faces Application: Surveillance – foreground-background separation – particle filters – Chamfer matching, tracking, and occlusion – combining views from multiple cameras – human gait analysis Application: In-vehicle vision system: locating roadway – road markings – identifying road signs – locating pedestrians.

Theory: 45	Tutorial: 0	Practical: 0	Project: 0	Total: 45 Hours

REFERENCES:

1. D. L. Baggio et al., "**Mastering Open CV with Practical Computer Vision Projects**", Packt Publishing, 2012.
2. E. R. Davies, "**Computer & Machine Vision**", Fourth Edition, Academic Press, 2012.
3. Jan Erik Solem, "**Programming Computer Vision with Python: Tools and algorithms for analyzing images**", O'Reilly Media, 2012.

4 Mark Nixon and Alberto S. Aquado, "**Feature Extraction & Image Processing for Computer Vision**", T Edition, Academic Press, 2012.

5 R. Szeliski, "**Computer Vision: Algorithms and Applications**", Springer 2011.
Simon J. D. Prince, "**Computer Vision: Models, Learning, and Inference**", Cambridge University Press, 2012.

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P18AET2001 **MACHINE LEARNING TECHNIQUES**

L	T	P	J	C
3	0	0	0	3

Course Outcomes (COs):
After successful completion of this course, the students should be able to

CO1: Discuss the various learning methods (K2)
CO2: Apply appropriate linear model for a given application (K3)
CO3: Solve a given problem using probabilistic model (K3)
CO4: Use appropriate graphical models for specific application (K3)
CO5: Review and Employ the neural network-based learning algorithm (K3)

Pre-requisites:-

CO/PO Mapping:
(S/M/W indicates strength of correlation) S-Strong, M-Medium, W-Weak

COs	Programme Outcomes										
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**
CO1	S	S									
CO2		S	S	M	M			M			M
CO3		S	S	M	M			M			M
CO4	S	S	S	M	M			M			M
CO5		S	S	M	M			M			M

Course Assessment Methods:

Direct
1. Mid Term Examination 2. Research Assignment, Presentation 3. End Semester Examination
Indirect
1. Course-end survey

FUNDAMENTALS OF MACHINE LEARNING **09 Hrs**
Learning - brain and neuron - types of learning: supervised, unsupervised and reinforcement learning. Perspectives and issues in machine learning. Concept learning task - concept-learning as search - finding a maximally specific hypothesis version space and candidate elimination algorithm.

LINEAR MODEL **09 Hrs**
Linear models for regression: linear basis function models, bias variance decomposition, Bayesian linear regression. Linear models for classification: discriminant functions – least squares for classification, Fisher's linear discriminant - two classes and multiple classes. Probabilistic generative models. Maximum margin classifiers - support vector machine.

PROBABILISTIC MODEL AND DIMENSIONALITY REDUCTION **09 Hrs**

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Probability and learning - K-means clustering and vector quantization, Gaussian mixture model, k-nearest-neighbor method. The curse of dimensionality, dimensionality reduction, factor analysis, Principal Component Analysis, Probabilistic PCA, Independent Component Analysis.

GRAPHICAL MODEL **09 Hrs**

Directed graphical models - Bayesian network, Markov Random fields-inference in graphical models - Markov m - Hidden Markov Models (HMMs). Decision trees – Classification and regression tree. Combining models - Ense learning: boosting and bagging.

NEURAL NETWORK **09 Hrs**

Models of a neuron - Feed-forward neural networks – Network training- Error Propogation-, Multi-layer perceptron, Back propagation algorithm - network pruning, limitations and convergence of back- propagation learning. Generalized radial-basis function networks, Auto encoder networks - auto-association neural network - convolutional neural network.

Theory: 45	**Tutorial: 0**	**Practical: 0**	**Project: 0**	**Total: 45 Hours**

REFERENCES:

1. C.M.Bishop, "**Pattern Recognition and Machine Learning**", Springer, 2016
2. LaureneFausett, "**Fundamentals of Neural Networks**", Prentice Hall India, New Delhi, 2006.
3. Stephen Marsland, "**Machine learning - an algorithmic perspective**", 2nd Edition, CRC Press, 2015
4 Simon Haykin, "**Neural Networks**", 2nd Edition, Pearson Education- 2008.
5 Ryszard S. Michalski, Jaime G. Carbonell, Tom M. Mitchell, "**Machine Learning: An Artificial Intelligence Approach**", Volume 1, 1st Edition, McGraw Hill education, 2013

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