SEMESTER – I

21LC01 LINEAR ALGEBRA AND OPTIMIZATION
Vide Information Technology 21NN01

21LC02 RANDOM SIGNAL PROCESSING

3 1 0 4

RANDOM PROCESS: Random variables, stationary process ,nonstationary and quasi stationary process - autocovariance and autocorrelation matrices - joint distribution - conditional mean, random process as input to LTI system, Time series analysis (9+3)

BASIC PRINCIPLES OF ESTIMATION: Unbiased estimator , minimum variance criteria, Cramer Rao lower bound, Efficient estimator, Consistent estimator (9+4)

CLASSICAL PARAMETER ESTIMATION TECHNIQUES: Minimum Variance Unbiased Estimator - Best Linear Unbiased Estimator, Maximum Likelihood Estimator, Least Squares Estimator, Bayesian Estimator (13+4)

DETECTION THEORY: Bayesian, Minimax and Neyman-Pearson decision rules, likelihood ratio, receiver operating characteristics, composite hypothesis testing, locally optimum tests, detector comparison techniques, asymptotic relative efficiency, detection of random signals (14+4)

Total L: 45 + T: 15 = 60

REFERENCES:

1. D. G. Manolakis, V. K. Ingle, and S. M. Kogon, “Statistical and Adaptive Signal Processing”, Artech House, 5th Edition, 2015.
2. S. M. Kay, “Fundamentals of Statistical Signal Processing: Estimation Theory”, 2nd edition, Prentice Hall PTR, 2016.
3. S. M. Kay, “Fundamentals of Statistical Signal Processing: Detection Theory”, 2nd edition, Prentice Hall PTR, 2015.
4. H. L. Van Trees, “Detection, Estimation and Modulation Theory”, Volume 1, 2nd edition, John Wiley, 2016.

21LC03 DIGITAL COMMUNICATION SYSTEMS

3 1 0 4

DIGITAL MODULATION SCHEMES: Baseband Pulse Transmission, Review of Signal Representation, decision boundary and decision regions for AWGN model with/without equal prior probability, Exact symbol error probability for several linear modulation schemes (ASK, FSK, PSK and QAM), Error Vector Magnitude (11+4)

COMMUNICATION CHANNELS: Discrete Memoryless Channels - Self information, conditional entropy and mutual information, channel capacity theorem for DMC, Continuous Channels -Average mutual information, AWGN channel capacity. Introduction to source coding, Introduction to channel coding. Trellis Coded Modulation (11+4)

PULSE SHAPING AND EQUALIZATION: Band limited Channels - Nyquist criterion for zero ISI, Sync and Raised cosine pulse shaping, controlled ISI using duobinary signals, Distorting channels, Zero forcing equalization, Linear MMSE equalizers, Decision Feedback Equalizer, Viterbi algorithm for MLSE. (11+4)

SYNCHRONISATION: Receiver impairments – CFO, Phase offset, IQ imbalance, Harmonic distortion, Synchronization of baseband signals, early late gate methods, delay locked loop and squaring loop, carrier synchronization, PLL and Costas loop, pilot aided and decision aided approaches. (12+3)

Total L: 45 + T: 15 = 60

REFERENCES:

1. S Haykin, “Digital Communication Systems”, John Wiley & Sons, 2013.
2. Proakis J.G and Salehi M “Fundamentals of Communication Systems” Pearson,2011.
3. Bernard Sklar, “Digital Communications”, Pearson Education Asia, Sixth reprint,2005.
4. Lathi B P and Zhi Ding, “Modern Digital and Analog communication Systems", Oxford University Press, 2011.
5. Reza F M, “An Introduction to Information Theory”, McGraw Hill, 2014.

21LC04 COMMUNICATION NETWORKS

3 0 0 3

END TO END CONNECTIVITY: Network Edge and core - Protocol Layers and their service models-Principle of network applications- web and HTTP-FTP- Electronic Mail-DNS-Connectionless transport, End-to-End Issues, Connection Establishment and Termination, Transport Layer protocols. (12)

INTERNETWORKING: Switching and bridging, basic internetworking, Internet protocol IPv4, IPv6, Distance vector and link state Routing algorithms, routing in the internet, RIP, Multiprotocol Label Switching(MPLS) - routing among mobile devices (10)

CONGESTION CONTROL AND MULTIPLE ACCESS : Congestion Control - Congestion-Avoidance Mechanisms - Quality of Service- Issues in Resource Allocation - Queuing Disciplines – Little's Theorem -Link layer services –framing –Error detection – multiple access protocols – Channel partitioning –Random access protocols – Ethernet- CSMA/CD -- Virtual LANs (12)

WIRELESS NETWORKS: TCP performance over Wireless Links - Adaptive and Cross-Layer Techniques CSMA-CA-IEEE 802.11 standards – Multiple access in 802.11 -Wireless Ad Hoc and sensor Networks - Topology and Connectivity. MANETS-Wireless PAN- Bluetooth and ZigBee. (11)

Total L: 45

REFERENCES:

1. Kurose James F and Keith W Ross, "Computer Networking: A Top-Down Approach Featuring the Internet", Pearson Education, 2009.
2. Ilya Grigorik, " High Performance Browser Networking" O'REILLY ,2013.
3. Anurag Kumar,D.Manjunath,Joy Kuri," Communication Networking- An Analytical Approach," Morgan Kaufmann Publishers 2004.
4. Behrouz A Forouzan, "Data Communication and Networking", Tata McGraw Hill, 2009.
5. Vijaykumar Garg, " Wireless Communications and Networking " , Morgan Kaufmann Publishers , 2007.
6. Larry L Peterson and Bruce SDavie, "Computer networks: A system approach", Morgan Kaufmann Publishers 2010.

21LC05 RF CIRCUIT DESIGN

3 0 0 3.

RF FILTER DESIGN: Definition - properties - networks – ABCD, Z, Y, h and S parameters – Filter Design by the insertion loss method – Filter Design by the insertion loss Methods, Filter Transformations, Filter Implementation. Stepped impedance Low pass filters. (12)

MATCHING NETWORK AND PASSIVE DEVICES: Matching with lumped Elements - Design of T and p matching network-Matching by micro strip line -Stub matching. Single stub matching – Double stub matching. Basic properties of dividers and couplers – T Junction Power divider – Wilkinson Power divider – Quadrature Hybrid – Coupled line Directional Coupler. (9)

RF DEVICES AND AMPLIFIER DESIGN: The Diode Model – Two Port Design Model- The output terminals of a two port RF Device, The bipolar Transistor, The heterojunction bipolar transistor- RF Amplifier Design - Two port power Gains- Stability circles- Tests for Unconditional stability - Low Noise amplifier Design-Noise figure – Low Noise MOSFET Amplifier –Broad Band Transistor Amplifier Design – Characteristics of Power Amplifiers - Amplifier classes-Design Examples. (12)

OSCILLATORS AND MIXERS: RF Oscillators –Oscillators using BJT and FET –Dielectric Resonator Oscillators – Oscillator Phase Noise. Mixers – Mixer Characteristics – Single –Ended Diode Mixer – Single-Ended FET Mixer- Balanced Mixer – Image Reject Mixer- Differential FET Mixer and Gilbert Cell Mixer. (12)

Total L: 45

REFERENCES:

1. Les Besser and Rowan Gilmore, "Practical RF Circuit Design for Modern Wireless Systems", Vol I, Passive Circuit and Systems, Artech house, London, Reprint 2019.
2. Les Besser and Rowan Gilmore, "Practical RF Circuit Design for Modern Wireless Systems", Vol II, Active Circuit and Systems, Artech house, London, Reprint 2019
3. David M Pozar, "Microwave Engineering", John Wiley and Sons, 2019.
4. Reinhold Ludwig and Pavel Bretchko, "RF Circuit Design: Theory and Applications", Pearson Education, Reprint, Reprint 2019

21LC06 Research Methodology and IPR

vide Automotive Engineering 21AE06

21LC72 AUDIT COURSE I

vide Automotive Engineering 21AE72

21LC51 COMMUNICATION NETWORKS LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

- Networking commands (Windows and LINUX)
- Packet and protocol analysis using Wireshark
- Performance analysis of transport layer protocols using discrete event network simulator
- Performance evaluation of MAC and routing protocols using discrete event network simulator
- Construction of Layer2 and Layer3 protocol packets using traffic generator
- Configuration and realization of VLAN
- Design and simulation of MAC & Routing protocol for wireless networks

Total P: 60

REFERENCES:

1. Lab Manual prepared by ECE Department.
2. Behrouz A Forouzan, “Data Communication and Networking”, Tata McGraw Hill, Fifth Edition.

21LC52 RF CIRCUIT DESIGN LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

Designand Implementation of

- RF Passive filters
- Transmission lines
- Branch line couplers
- Microstrip Filter
- Impedance matching networks
- Amplifiers
- Measurement of S parameters using Network Analyzer

Total P: 60

REFERENCES:

1. Les Besser and Rowan Gilmore, “Practical RF Circuit Design for Modern Wireless Systems”, Vol I, Passive Circuit and Systems, Artech house, London, Reprint 2019.
2. Les Besser and Rowan Gilmore, “Practical RF Circuit Design for Modern Wireless Systems”, Vol II, Active Circuit and Systems, Artech house, London, Reprint 2019

SEMESTER – II

21LC07 WIRELESS COMMUNICATION SYSTEMS

3 0 0 3

WIRELESS CHANNEL: Physical modeling for wireless channels- Input /output model of the wireless channel- Time and frequency coherence- Statistical channel models- Detection in a Rayleigh fading channel (10)

CAPACITY OF WIRELESS CHANNELS: Capacity of Flat Fading Channels – Capacity of Frequency Selective Fading Channels– Time varying, Time Invariant Channels –Diversity Techniques - Narrowband MIMO model, Parallel Decomposition of the MIMO Channel, MIMO Channel Capacity – MIMO diversity gain – Space Time Coding. (12)

MULTICARRIER COMMUNICATIONS: OFDM based multiple access, Broadband wireless access using OFDM and OFDMA, frequency diversity and multiuser diversity, MIMO-OFDM techniques – closed loop and open loop. Introduction to MC-CDMA and FBMC (12)

CELLULAR SYSTEMS AND STANDARDS: Cellular Concept – System Design -Fundamentals, Link Design and Link Budget for noise limited channels -2G, Interference limited channels-3G, Long Term Evolution.

(11)

Total L: 45

REFERENCES:

1. David Tse and Pramod Viswanath, “Fundamentals of Wireless Communication”, Cambridge University Press, 2010.
2. Theodore S Rappaport, “Wireless Communications Principles and Practice”, Pearson Education, Asia, New Delhi, 2009.
3. Lajos L Hanzo and Thomas Keller, “OFDM and MC-CDMA – A primer”, John Wiley and Sons Ltd, 2006.
4. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2009.
5. Guizani, Mohsen(ed), “ Wireless Communications Systems and Networks”, springer 2004.

21LC08 ADVANCED DIGITAL SIGNAL PROCESSING

3 1 0 4

REVIEW OF DIGITAL SIGNAL PROCESSING: DT signals and LTI Systems – Need for frequency domain analysis - Fourier transform for continuous and discrete time signals – Z-Transform - DFT – FFT - Use of FFT for power spectral estimation - Linear phase FIR filters – Realization of FIR filters. (11+4)

MULTIRESOLUTION ANALYSIS USING WAVELETS: Need for time frequency analysis - Heisenberg's uncertainty principle - Short time Fourier transform - Need for wavelets - wavelet basis – concept of scale and its relation with frequency - Continuous time wavelet transform equation - Admissibility condition – Multi resolution analysis – Applications - Signal Denoising (11+4)

MULTIRATE SIGNAL PROCESSING: Review of Sampling Theory - Down sampling – Upsampling - Noble identities – Decimation and Interpolation with transversal filters and polyphase filters – Fractional sampling rate convertor - multistage implementation - Two channel, QMF and Perfect Reconstruction Filter banks (12+3)

ADAPTIVE SIGNAL PROCESSING: Linear MMSE based estimation - Adaptive linear combiner – Performance function – Gradient and Minimum Mean Square error – Gradient search by the method of steepest descent – LMS algorithm – Convergence of LMS algorithm – Applications. (11+4)

Total L: 45 + T: 15 = 60

REFERENCES:

1. Lonnie.C.Ludeman, "Fundamentals of Digital Signal Processing", John Wiley and sons, 2000
2. K P Soman, "Insight into Wavelets: From Theory to Practice", PHI Learning, 2013.
3. Vaidyanathan P P, "Multirate Systems and Filter banks", Prentice Hall, 2008.
4. Fliege N J, "Multirate Digital Signal Processing", John Wiley and sons, 2010.
5. Bernard Widrow and Samuel D Stearns, "Adaptive Signal Processing", Prentice Hall, 2008.

21LC82 AUDIT COURSE II

vide Automotive Engineering 21AE82

21LC61 WIRELESS COMMUNICATION SYSTEMS LABORATORY

0 0 4 2

LIST OF EXPERIMENTS:

- BER Analysis of single carrier and multicarrier modulation schemes
- Analysis of Space Time Coding Techniques
- Design and analysis of MIMO systems
- Wireless channel estimation and channel modelling
- Build an AM/FM transmitter and receiver using USRP
- Implementation of digital modulation and demodulation schemes with SDR Platform.
- Build a digital transmitter and receiver using USRP

Total P: 60

REFERENCES:

1. John.G. Proakis, Masoud salehi, Gerhard Bauch, "Contemporary Communication systems using MATLAB", Cengage learning ,2013.
2. Yong soo cho,Kim,Yang,Kang, "MIMO-OFDM wireless communications with MATLAB, John wiley & Sons ,2010.
3. Ram, Amitesh Pandey, " Practical Approach to Software Defined Radios," BUUKS Bookshelf, 2019.

21LC62 EMBEDDED SYSTEM DESIGN LABORATORY

0 0 4 2

ARCHITECTURE OF ARM CORTEX M4 MICROCONTROLLER: TIVA architecture – Memory Map - General Purpose IO – System Clock - Watchdog Timer – Low power modes – Interrupts.

PERIPHERAL INTERFACING: Timers – RTC – ADC – Analog Comparator – DAC – Motion Control peripherals – PWM – QEI – Interfacing: Display, Keyboard – Stepper motor – DC motor

IOT ENABLING TECHNOLOGIES: Sensors and Actuators – Communications- Bluetooth Low Energy – 6LowPAN – ZigBee-LoRa – Protocols.

LIST OF EXPERIMENTS:

- Interrupt programming with GPIO.

- interfacing with servo motors using on-chip PWM module
- Estimation of power consumption in various Power saving modes
- Implementation of Wired Communication Protocols – I2C, CAN, Ethernet
- Implementation of Wireless Communication Protocols – Bluetooth, WiFi
- Porting Embedded Linux
- IoT application development using LoRA
- Application development using IoT

Total P: 60

REFERENCES:

1. Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to ARM(r) Cortex -M Microcontrollers: Volume 2", CreateSpace Independent Publishing Platform; 5th edition, 2012.
2. Jonathan W. Valvano, "Embedded Systems: Real-Time Interfacing to ARM(r) Cortex -M Microcontrollers: Volume 1", CreateSpace Independent Publishing Platform; 5th edition, 2011.
3. Tiva TM4C123GH6PM Microcontroller Datasheet
4. Cirani, Simone, Gianluigi Ferrari, Marco Picone, and Luca Veltri, "Internet of Things: Architectures, Protocols and Standards" John Wiley & Sons, 2018.

21LC63 INDUSTRIAL VISIT AND TECHNICAL SEMINAR

vide Automotive Engineering 21AE63

SEMESTER – III

21LC71 PROJECT WORK – I

vide Automotive Engineering 21AE71

SEMESTER – IV

21LC81 PROJECT WORK – II

Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVES THEORY COURSES (Four to be opted)

21LC21 / 21LW36 MULTIMEDIA COMPRESSION TECHNIQUES

3 0 0 3

INTRODUCTION: Compression Techniques - Overview of information theory - lossless and lossy coding– Modeling and Coding -Taxonomy of compression techniques – Rate distortion theory - Huffman coding – Non-Binary Huffman codes – adaptive Huffman coding – Application of Huffman coding. (9)

ARITHMETIC CODING AND DICTIONARY TECHNIQUES: Introduction- coding a sequence – generating deciphering the tag –Generating a binary code – Uniqueness of arithmetic code – Algorithm, integer implementation – comparison of Huffman and arithmetic coding – Applications -Static and Adaptive dictionary – LZ77, LZ78, LZW approach – Applications - Facsimile encoding –run length coding – comparison of MH, MR, MMR and JBIG. Scalar and Vector Quantization (11)

AUDIO COMPRESSION: Audio compression techniques - frequency domain and filtering - basic sub-band coding -application tospeech coding - G.722 - application to audio coding - MPEG audio - silence suppression - speech compression techniques –Vocoders. (11)

IMAGE AND VIDEO COMPRESSION: Predictive techniques - DPCM, DM - KL transform – discrete cosine, Walsh- Hadamard transform - JPEG,Wavelet based compression: quad-trees, EZW, SPIHT, JPEG-2000. Video signal representation – Motion compensation – MPEG standards - Motion estimation techniques -H.261 family of standards - Motion video compression. (15)

Total L: 45

REFERENCES:

1. Khalid Sayood, "Introduction to Data Compression", Morgan Kaufman, 2012.
2. Salomon D, "Data Compression The Complete Reference", Springer, 2007.
3. Salomon D, "A Guide to Data Compression Methods", Springer, 2002.
4. Jan Vozer, "Video Compression for Multimedia", AP Press, New York, 1995.
5. AlistarMoffat, "Compression and Coding Algorithms", Kluwer Academic Publishers, 2002.

21LC22 ADAPTIVE SIGNAL PROCESSING

3 0 0 3

INTRODUCTION: Linear Filtering problem – Adaptive filters – Approaches to the development of adaptive filters – Wiener filter – orthoganility principle – minimum MSE – Wiener Hopf Equations – error performance surface – linearly constrained minimum variance filter. (11)

STOCHASTIC GRADIENT-BASED ALGORITHMS: Steepest descent algorithm – stability analysis - Least Mean Square algorithm – stability and convergence analysis – variants of LMS algorithm (11)

RECURSIVE LEAST SQUARE ALGORITHMS: Matrix inversion lemma - ExponentiallyWeightedRLS – Sliding Window RLS – convergence analysis – operation of RLS in nonstationary environment – comparison of RLS and LMS algorithms. (11)

KALMAN FILTER AND FILTERING APPLICATIONS: Recursive minimum mean square estimation – state space model - Innovation process - Adaptive Modeling & System Identification - Inverse Adaptive Modeling – Deconvolution – Equalization - Adaptive self tuning filter - Adaptive Line enhancer. (12)

Total L: 45

REFERENCES:

1. Haykin S, “Adaptive Filter Theory", Prentice Hall Inc, 2012.
2. Widrow B and Stearns SD, "Adaptive Signal Processing", Prentice Hall inc., 2011.
3. Cowan C F N and Grant P M, "Adaptive Filters", Prentice Hall inc., 2010
4. FarhangBoroujeny, “Adaptive Filters Theory and Applications”, John Wiley & Sons, 2010
5. Alexander ST, "Adaptive Signal Processing: Theory and Applications ", Springer – Verlag, 2010.

21LC23 DIGITAL IMAGE AND VIDEO PROCESSING

3 0 0 3

DIGITAL IMAGE AND VIDEO BASICS: Human visual system and image perception, Types of Images, Digitization of Images, Sampled Images, Quantized Images, Digital Video, Sampled video and colour vision models, 2D signals and systems; image transforms - 2D DFT, DCT, KLT, Harr transform and discrete Wavelet transform (11)

IMAGE AND VIDEO ENHANCEMENT AND RESTORATION: Linear Image Enhancement, Non-Linear Image Enhancement: Weighted median filters, Image Noise cleaning, Image Zooming, Image Sharpening, Edge Detection, Wavelet denoising, Image restoration, Video Enhancement, Filtering and restoration (11)

IMAGE AND VIDEO CLASSIFICATION AND SEGMENTATION: Statistical methods of segmentation, Texture classification and segmentation, Gradient and Laplacian type edge detection, Diffusion based edge detectors, video segmentation (9)

IMAGE AND VIDEO STORAGE, RETRIEVAL, COMMUNICATIONS AND APPLICATIONS: Image and Video Indexing and retrieval, Video browsing and retrieval, Image and video communication networks, Image watermarking and authentication Pixel-based model. Case studies : Surveillance system, Space-frequency-model , Mosaic creation, Geometrical model, Video restoration, Region-based model, object tracking (14)

Total L: 45

REFERENCES:

1. Gonzaleze and Woods, “Digital Image Processing”, 3rdedition , Prentice Hall, 2008
2. Chris Solomon, Toby Breckon, “Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab”,John Wiley & Sons,2011
3. Yao wang, JoemOstarmann and Ya–quin Zhang, ”Video processing and communication” , 1st edition , PHI, 2015
4. Alan Bovik “Handbook of Image and Video Processing” 2ndEdition , Academic Press,2005

21LC24 WAVELETS AND SUBBAND CODING

3 0 0 3

INTRODUCTION: Signal spaces - concept of Convergence - Hilbert spaces for energy signals. Fourier basis & Fourier Transform –Limitations of standard Fourier analysis – Need for Time-Frequency Analysis, Spectrogram plot –Windowed Fourier transform Tiling of the Time-Frequency Plane for STFT – Heisenberg’s Uncertainty principle – Short time Fourier transform (STFT) Analysis- short comings of STFT- Need for Wavelets. (11)

CONTINUOUS WAVELET TRANSFORMS (CWT): Introduction, Continuous Time wavelets, Definition of CWT, The CWT as a correlation, Constant Q-Factor Filtering Interpolation and time frequency resolution, the CWT as an operator, inverse CWT. (10)

DISCRETE WAVELET TRANSFORM (DWT) AND MRA: Introduction, Approximationof vectors in nested linear vector spaces, A wavelet basis for MRA, Interpreting orthonormal MRAs for Discrete time signals,example of an MRA-Bases for the approximations subspaces and Haar scaling function, Relationship between Filter banks and wavelet basis, Important wavelets: Haar, Mexican hat, Meyer, Shannon, Daubechies. (12)

ADVANCED TOPICS AND APPLICATIONS: Wavelet packets, Non - separable multidimensional wavelets, Bi-orthogonal basis-B-Splines, Lifting scheme of wavelet generation, Multiwavelets, Ridgelets, Curvelets. Applications of Wavelets: Signal Denoising - Sub-band coding of Speech and music– Image Compression using 2-D DWT- JPEG 2000 standard - Fractal Signal Analysis. (12)

Total L: 45

REFERENCES:

1. Soman K P and Ramachandran K I, "Insight into Wavelets from Theory to Practice", Prentice Hall India, 2010
2. Stéphane Mallat, "A Wavelet Tour of Signal Processing: The Sparse Way", Third Edition Academic Press, 2009
3. Jaideva C Goswami and Andrew K Chan, "Fundamentals of Wavelets – Theory, Algorithms and Applications", John Wiley and Sons, Inc., Singapore, 1999.
4. Vetterli M and Kovacevic J, "Wavelets and Subband Coding," Prentice Hall, 1995.
5. Wornell G W, "Signal Processing with Fractals: A Wavelet based Approach", Prentice Hall, 1995.

21LC25 / 21LW24 FREE SPACE OPTICS

3 0 0 3

FUNDAMENTALS OF FSO TECHNOLOGY: Introduction – Maxwell's equations- Electromagnetic Wave Propagation in free space -Alternate Bandwidth technologies - fiber Vs FSO- fiber access - Overview of FSO optical transmitters- receivers- subsystems-pointing, acquisition and tracking – line of sight analysis. (12)

FSO NETWORKS: The role of FSO in the network- factors affecting FSO line of sight- selecting transmission wave integration ofFSO in optical networks- installation of FSO systems- Moving towards edge and residential areas. (10)

FSO COMMUNICATION: The FSO model - applications- system descriptions and design- introduction to lasersatellite communications- characteristics, modulation techniques and radiation effects – laser sources. Visible light communications- VLC principle- VLC system model- system implementation-VLC applications (11)

OPTICAL COMPONENTS AND SIGNAL PROCESSING: Optical waveguides- optical filters, couplers, amplifiers, switches,antennas, interconnecting equipments- optical integrated circuits- semiconductor integrated optic devices.Analog and Discrete systems- noise and stochastic processes- filters- power spectra estimation – The ambiguity function, Wignerdistribution function and triple correlation. (12)

Total L: 45

REFERENCES:

1. Shlomi Armon, John R. Barry, Geroge K. Karagiannidis, Robert Schober, Murat Uysal "Advanced Optical Wireless Communication Systems" Cambridge university press, 2012
2. Stamatioas V. Kartalopouls "Free space optical Networks for Ultra Broadband services" John Wiley & Sons, 2011.
3. Heinz and Willebrand, "Free Space Optics", Sams, 2002.
4. Pankaj K Das, "Optical Signal Processing", Narosa Publishing House, 2012
5. William H Mott and Robert B Sheldo, "Laser Satellite Communication- The Third Generation", Green Wood Publishing, 2000.

21LC26 / 21LW25 COOPERATIVE COMMUNICATION

3 0 0 3

COOPERATIVE COMMUNICATIONS: Introduction; Definitions and Terminology; Types of relaying protocol; One-way and two-way MIMO relaying protocols; System model and its terminologies; Pros and Cons of cooperation; Cooperative performance bounds; Application Scenarios (12)

WIRELESS RELAY CHANNEL AND TRANSMISSION SCHEMES: Propagation Modeling; Channel Modeling; Regenerative relay channels; Transparent relay channels; Distributed MIMO channel; Fundamental limits of Cooperative and Relay Networks; Gaussian Relay channels; Single and multi-relay fading channels. Cooperative transmission schemes (12)

COOPERATIVE RELAYING IN MIMO-OFDM SYSTEMS AND MAC: Overview of OFDM systems; Cooperative OFDM systems; Cooperative OFDM systems with multiple relays; Distributed space frequency codes; MAC control based cooperative networks; Networking and Cross layer issues in Cooperative Networks (10)

APPLICATIONS OF COOPERATIVE COMMUNICATION: Cooperative Relaying in multihop cellular networks; Peer-to-Peer- and Mobile AdHoc networks; Wireless Mesh Networks; Wireless Sensor and Actor Networks; Coordinated Multipoint Systems (CoMP); Cooperation for Nest Generation Wireless Networks (11)

Total L: 45

REFERENCES:

1. Jonathan Rodriguez, "Fundamentals of 5G Mobile Networks", John Wiley & Sons, 2015.

2. Ming Ding and Hanwen Luo, “Multi-point Cooperative Communication Systems: Theory and Applications”, Springer-Verlag, 2013.
3. Misha Dohler and Yonghui Li, “Cooperative Communications: Hardware, Channel and PHY.” John Wiley & Sons, 2010.
4. Peter Hong Y W, Huang Wan-Jen and Jay Kuo C C, “Cooperative Communications and Networking: Technologies and System Design”, Springer, Newyork, 2010.
5. Yan Zhang, Chen H H, Mohsen and Guizani, “Cooperative Wireless Communications”, CRC Press, 2009.

21LC27 COGNITIVE RADIO

3 0 0 3

COGNITIVE RADIO TECHNOLOGY: Introduction to Cognitive Radios: Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, SDR as a platform for Cognitive Radio – Hardware and Software Architectures (10)

SPECTRUM SENSING AND SPECTRUM SHARING:Spectrum sensing-detection of spectrum holes (TVWS), Primary user detection techniques –Fundamental Tradeoffs in spectrum sensing.Unlicensed and Licensed Spectrum Sharing,Secondary Spectrum Access -Non-Real-Time SSA -Real-Time SSA-Models of Dynamic Spectrum Access – Fundamental Limits of Cognitive Radio- spectrum trading (13)

COGNITIVE RADIO NETWORK ARCHITECTURES AND PROTOCOLS: Cognitive Radio Network Architectures-Topology-Aware CRN Architecture-Cognitive radio for broadband wireless access in TV bands- IEEE 802.22 Standard-IEEE 1900 standards (10)

RESEARCH CHALLENGES AND APPLICATIONS: Optimization Techniques of Dynamic Spectrum Allocation, Security issues in cognitive radio, Game theory in Cognitive radio, crosslayer designissues in cognitive radio networks, public safety and cognitive radioapplications: cognitive radio for Internet of Things-Vehicular communication-satellite communication (12)

Total L: 45

REFERENCES:

1. Alexander M. Wyglinski, Maziar Nekovee and Y. Thomas Hou, “Cognitive Radio Communications and Networks Principles and Practice”,Elsevier Inc. 2010.
2. Jeffrey H Reed, “Software Radio: A Modern Approach to Radio Engineering”, PEA Publication, 2002.
3. Bruce A Fette, “Cognitive Radio Technology”, Elsevier publication, Burlington, 2009.
4. Joseph Mitola III, “Cognitive Radio Architecture: The Engineering Foundations of Radio XML”, Wiley Interscience Publication, New Jersey, 2006.
5. Kwang-Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks”, John Wiley & Sons, 2009.
6. EkramHossain, Dusit Niyato, Zhu Han, “Dynamic Spectrum Access and Management in Cognitive Radio Networks”, Cambridge University Press, 2009.

21LC28 EMI AND EMC

3 0 0 3

NATURE AND ORIGINS OF ELECTROMAGNETIC COMPATIBILITY: Introduction – Visualising the EMI problem – Source of EMI – EMI coupling to victim equipments – Intersystem and Intrasystem EMI – Historical background –Technical disciplines and Knowledge areas within EMC – Electrical engineering – Physics –Mathematical modeling – Limited chemical knowledge – System engineering – Legal aspects of EMC. (13)

EMC STANDARDS AND SPECIFICATIONS: The need for standards and specifications – The need to meet EMC standards – Derivation of military standards – Derivation of commercial standards– Outline of EMC testing – Types of EMC testing – Preconformance test measurements – Implication of repeatability of EMC measurements – Introduction to EMC test sensor – Conduction and Induction couplers – Radiative coupling – EMC antennas. (12)

MEASUREMENT DEVICES FOR CONDUCTED EMI: Introduction – Measurement by direct connection –Inductively coupled devices – EMC antennas – Basic antenna parameters – Antennas for radiated emission testing –Wideband antennas – Magnetic field antennas – Use of antennas for radiated susceptibility testing – Type of antennas used in susceptibility testing – Standards requiring immunity tests. (10)

DESIGNING TO AVOID EMC PROBLEMS: Intrasystem and Intersystem EMC – Design for formal EMC compliance – Achieving product EMC :checklists for product development and testing – Introduction – Developing an approach to EMC design – Process flow chart, EMC strategy – Self certification. (10)

Total L: 45

REFERENCES:

1. Tim Williams, “EMC for Product Designers”, 5th Edition, Newnes Elsevier, 2017.
2. Clayton R. Paul “Introduction to Electromagnetic Compatibility”, Wiley Press, 2014.
3. David Morgan, “A Handbook for EMC Testing and Measurement”, IET Electrical Measurement, 2012.
4. Henry W.Ott, “Electromagnetic compatibility engineering”, Wiley Press 2009.

21LC29 / 21LW32 RADIATING SYSTEMS

3 0 0 3

RADIATING SYSTEM PARAMETERS: Parameters of radiating systems- Radiation integrals -Radiation from surface and line current distributions – dipole-monopole- loop antenna- Mobile phone antenna- base station- Broadband antennas -matching techniques-Balance to unbalance transformer-Radiation Hazards-Introduction to numerical techniques. (10)

RADIATION FROM APERTURES AND MICROSTRIP ANTENNAS : Field equivalence principle, Radiation from Rectangular and Circular apertures, Uniform aperture distribution on an infinite ground plane- Slot antenna-Horn antenna;-Reflector antenna- design considerations-Radiation Mechanism and Excitation techniques –analysis of Microstrip (12)

ARRAY ANTENNA: Linear array –uniform array, end fire and broad side array, gain, beam width, side lobe level; Two dimensional uniform array; Phased array, beam scanning, grating lobe, feed network -Binomial and Chebyshev distributions-design and analysis of log periodic dipole array-. Yagi-uda dipole (12)

EMC ANTENNA AND ANTENNA MEASUREMENTS: Concept of EMC measuring antenna; Tx and Rx antenna factors; Antenna measurement and instrumentation – Gain, Impedance and antenna factor measurement; Antenna test range Design. (11)

Total L: 45

REFERENCES:

1. Balanis A, “Antenna Theory Analysis and Design”, John Wiley and Sons, Fourth Edition,New York, Reprint 2019.
2. Krauss J D, “Antennas”, John Wiley and sons, New York, Reprint 2019.
3. Bahl I J and Bhartia P,“Microstrip Antennas”,Artech House,Inc.,1980
4. Stutzman W L andThiele G A, “Antenna Theory and Design”,John Wiley and Sons Inc., 1998.

21LC30 / 21LW31 COMPUTATIONAL ELECTROMAGNETICS

3 0 0 3

ADVANCED CONCEPTS IN ELECTROMAGNETICS: uniqueness theorem - volume/surface equivalence theorems - Introduction to integral equations methods by using the Huygen’s principle and the extinction theorem - Introduction to Green’s functions in one and two dimensions. (13)

METHOD OF MOMENTS AND FINITE ELEMENT METHOD: Solving surface integral equations using the method of moments-singularities, and use of quadrature rules -Solving volume integral equations using the Method of moments -Introduction to the Finite Element Method (FEM), basis functions in 1 and 2 dimensions - FEM formulations in 1 and 2 dimensions (12)

INTRODUCTION TO FINITE DIFFERENCE TIME DOMAIN METHODS: Yee cells, update equations – stability – Finite Differnce Time Domain (FDTD) – Accuracy, Analysis, Dispersion, Material specifications and Dispersive media -FDTD - Boundary conditions and their implementation (11)

APPLICATION OF COMPUTATIONAL ELECTROMAGNETICS: Antenna problems - Phased array and Wireless System problems - Scattering problems. (9)

Total L: 45

REFERENCES:

1.Advanced Engineering Electromagnetics - C A Balanis, Wiley India, Second Edition, 2012.
2.Andrew F Peterson, Scott L Ray and Raj Mittra, “Computational Methods for Electromagnetics”, IEEE Press Series on Electromagnetic Wave Theory,1998.
3. Waves and Fields in Inhomogeneous Media : Electromagnetic Waves - W.C. Chew, IEEE Press, 1995.
4. Finite Element Method for Electromagnetics: Antennas, Microwave Circuits, and Scattering Applications - Volakis, Chatterjee, and Kempel, Wiley, 2010.

21LC31 WIRELESS NETWORK SECURITY

3 0 0 3

INTRODUCTION: Overview of security in WLAN, WMAN and Cellular Networks - Kinds of security breaches – Eavesdropping-Communication Jamming -DOS attack – Spoofing-Wireless security Standards. (13)

SECURITY IN CELLULAR NETWORKS AND COMMUNICATION: Security architecture of cellular communication networks - Security techniques in GSM networks, 3G networks, LTE networks and 5G - Security issues of mobile devices. (8)

SECURITY IN WIRELESS LOCAL AREA NETWORKS: Current State of WLAN Security - WLAN Communication Security - WLAN Access Point Security-Security Risks-WEP (Wired Equivalence Privacy) - Countermeasures –WPA (Wi- Fi Protected Access) - IEEE 802.11x-Standards-Bluetooth security. (12)

SECURITY IN WIRELESS DATA NETWORKS: Wireless Device security issues- GPRS security (General Packet Radio

Service)-IP-security-Secure SocketLayer-Wireless Transport Layer Security (WTLS)- WAP Security Architecture – Security architecture in WSN – Cryptographic approaches (12)

Total L: 45

REFERENCES:

1. Vijay K Garg, "Wireless Communication and Networking", Morgan Kaufmann Publishers, 2010.
2. Lei Chen, Jiahuang Ji and Zihong Zhang, "Wireless Network Security - Theories and Applications", Springer, 2013
3. Nichols and Lekka, "Wireless Security-Models, Threats and Solutions", McGraw Hill, 2002.
4. Hakima Chaouchi, Maryline Laurent, Maknavicius," Wireless and Mobile Network security", Wiley, 2015.
5. Merritt Maxim and David Pollino, "Wireless Security",RSA press series Osborne/McGraw Hill, 2002.

21LC32 / 21LW43 VEHICULAR SYSTEMS AND NETWORKS

3 0 0 3

INTRODUCTION: Vehicular network definition, special characteristics, technical challenges, Evolution and progress, Vehicular network application and services, public safety application, vehicular traffic coordination, road traffic management. (9)

MAC PROTOCOLS & HETEROGENEOUS WIRELESS COMMUNICATION: DSRC spectrum and applications for vehicular networks, IEEE standards for MAC protocols - A cluster based, A distributed MAC protocol, Priority based secure MAC protocol, Introduction to heterogeneous wireless communications, enabling technologies for vehicular communication networks, platform for design and simulation. (10)

ROUTING IN VEHICULAR NETWORKS: Challenges and requirements for routing protocols, classification, basic solutions, Map based solutions, based on trajectories, based on traffic information. Adhoc IP address auto configuration problem, IP address auto configuration solution requirements, Analysis of solution space, IP address auto configuration in vehicular networks (10)

MESSAGE SCHEDULING AND NETWORK MOBILITY: Context and motivations, congestion control approaches, dynamic message scheduling, Analysis and validation, The network mobility problem, NEMO basic support protocol, NEMO route optimization, NEMO in vehicular scenario, Mobile Adhoc NEMO. (16)

Total L: 45

REFERENCES:

1. Hassnaa Moustafa and Yan Zhang, " Vehicular networks – Techniques, Standards and applications" CRC Press, New York, 2009.
2. Stephen Olariu and Michele C Weigle, " Vehicular networks – From theory to Practice", CRC Press, New York, 2009.
3. Claudia Campolo, Antonella Molinaro, Riccardo Scopigno (Ed), "Vehicular ad hoc Networks-Standards, Solutions, and Research" ,Springer ,2015.
4. Mohamed Watfa,"Advances in Vehicular Ad-hoc Networks: Developments and Challenges", Information Science Reference ,2010.

21LC33 / 21LW44 OPTICAL NETWORKS

3 0 0 3

OPTICAL SYSTEM COMPONENTS: Light propagation in optical fibers-Loss& Bandwidth, System limitations, Non-Linear effect, Solitons, Optical Network \ Components- Couplers, Isolators & Circulators, Multiplexers & Filters Optical Amplifiers, Switches Wavelength Converters. (12)

OPTICAL NETWORK ARCHITECTURES Introduction to Optical Networks; WDM networks , SONET / SDH, Metropolitan-Area Networks, Layered Architecture; Broadcast and Select Networks- Topologies for Broadcast Networks, Media Access Control Protocols, Wavelength Routing Architecture. WOBAN and OTDM networks. Introduction to ASON. (11)

WDM AND OPTICAL NETWORKS: WDM-DWDM-operations, components. Network topologies, protection schemes, robustness, diversity, 1: N protection channel sharing, BLSR, PONs and Metro Optical networking. MPLS and optical networks, Label switching, Lambda switching, Traffic Engineering. OTN - Architecture, Digital wrappers, Control Planes, Layered model (11)

OPTICAL INTERNETS: Optical Routers - switching, preferences, LMP messages, connectivity, Fault management, ATM vs. IP in optical internets: IP over ATM & SONET, OSI internet layered model, Encapsulation & its methods, PPP packet, ATM vs. IP debate. Optical Internets: Evolution to 3G architecture, Migration to IP networking, IP subnets, non-optical nodes, routing tables. (11)

Total L: 45

REFERENCES:

1. Uyless Black, "Optical Networks-Third Generation Transport Systems", Pearson Education, 2012.

2. Rajiv Ramasami Kumar and Sivarajan N, “Optical Networks : A Practical Perspective”, Morgan Kaufmann Publishers, 2011
3. Siva Ram Murthy and Mohan Gurusamy, “WDM Optical Networks-Concept, Design and Algorithms”, Prentice-Hall of India Private Limited, New Delhi, 2011.
4. Vivek Alwayn, “Optical Network Design and Implementation”, Pearson Education, 2004.
5. Stamatious V Kartalopoulos, “Understanding SONET/SDH and ATM-communications networks for the next millennium”, PHI India, 1999.

21LC34 COMMUNICATION PROTOCOLS FOR IOT

3 0 0 3

IOT DATA LINK PROTOCOL: IEEE 802.15.4 – IEEE 802,11 – WirelessHART – Z-Wave – Bluetooth Low Energy – Zigbee Smart Energy – Long Term Evaluation – A – LORAWAN (12)

NETWORK LAYER LINK PROTOCOL: Routing Protocol for Low power Lossy Networks(RPL) – CORPL - 6LoWPAN - Dynamic Host Configuration Protocol(DHCP) - IPv6 (10)

SESSION LAYER PROTOCOLS: Message Queuing Telemetry Transport (MQTT), Advanced Message Queuing Protocol (AMQP), Constrained Application Protocol (CoAP), Extensible Messaging and Presence Protocol(XMPP) Security in IoT Protocols: MAC 802.15.4 – 6LoWPAN – Application Layer (13)

BUILDING IOT SOLUTIONS: Setting up web services and publishing to web services using Raspberry PI Case Studies: Smart Grid, Industrial Automation and Building automation, Connected Car, Connected Home, Digital Health, Smart city (10)

Total : 45

REFERENCES:

1. Tsiatsis, Vlasios, Stamatis Karnouskos, Jan Holler, David Boyle, and Catherine Mulligan “Internet of Things: Technologies and applications for a new age of intelligence”, Academic Press, 2019
2. Lea, Perry,” Internet of Things for Architects: Architecting IoT solutions by implementing sensors, communication infrastructure, edge computing, analytics, and security”, Packt Publishing Ltd, 2018.
3. Minoli, Daniel, “ Building the internet of things with IPv6 and MIPv6: The evolving world of M2M communications”, John Wiley & Sons, 2013
4. Cirani, Simone, Gianluigi Ferrari, Marco Picone, and Luca Veltri, “Internet of Things: Architectures, Protocols and Standards”, John Wiley & Sons, 2018.
5. Peter Waher “Learning Internet of Things” Packt Publishing, 2015.
6. Dow, Colin,”Internet of things programming projects: build modern IoT solutions with the Raspberry Pi 3 and Python”, Packt Publishing Ltd, 2018.

21LC35 / 21LW38 / 21LV27 SYSTEM ON CHIP DESIGN

3 0 0 3

INTRODUCTION: Components of SoC - Design flow - Driving factors for hardware-software codesign, design space, system specification and modeling- Hardware Software tradeoffs- Co-Design Approaches, System Design Methodologies - Models of Computation- Platform based SoC design - Processor Selection -Concepts in Processor Architecture: Instruction set architecture (ISA) - Soft and Firm processors, Custom-Designed processors- on-chip memory - Prototyping and emulation. (11)

COMMUNICATION ARCHITECTURES: On-chip Buses: Characteristics - Data Transfer Modes - Bus Topology Types - Standard on-chip bus-based communication architectures: AMBA, CoreConnect, STBus, SMART Interconnect, Wishbone, and Avalon - Socket-based on-chip bus interface standards: Open Core Protocol, virtual component interface, and device transaction level - Network-on-chip - Network Topology - Switching Strategies - Routing Algorithms - Flow Control - NoC Architectures - Off-chip bus architecture standards. (12)

IMPLEMENTATION AND TESTING: System synthesis - Transaction Level Modeling (TLM) based design - Software synthesis - Hardware synthesis - IP based system design: Types of IP, IP Generation - HDL based IPs, Model based IPs and High Level Language based IPs - IP Sources - Built-in IPs, Custom IPs and Third Party IPs. - Real-time operating system (RTOS) - Peripheral Interfacing and Programming - SOC TESTING: Manufacturing test of SoC: Core layer, system layer, application layer-P1500 Wrapper Standardization-SoC Test Automation (STAT). (12)

APPLICATIONS: Automotive - Communications - Defense and Aerospace - Robotics, Control and Instrumentation - Image and Video Processing - Artificial Intelligence - Medical - High Performance Computing - Dynamic System-on-chip. (10)

Total L: 45

REFERENCES:

1. Patrick Schaumont “A Practical Introduction to Hardware/Software Co-design”, Patrick Schaumont, 2nd Edition, Springer, 2012.
2. Michael J Flynn and Wayne Luk, “Computer system Design: System-on-Chip”, Wiley-India, 2012.
3. SudeepPasricha and NikilDutt, “On Chip Communication Architectures: System on Chip Interconnect”, Morghan Kaufmann Publishers, 2008.
4. Wang, Wu and Wen, “VLSI Test Principles and Architectures”, Morgan Kaufmann, 2006.

5. Daniel D. Gajski, Samar Abdi, Andreas Gerstlauer and GunarSchirner, "Embedded System Design : Modeling, Synthesis and Verification", Springer, 2009.

21LC36 COMMUNICATION ALGORITHMS ON FPGA

3 0 0 3

VERILOG HDL: HDL overview - Modules and ports - compiler directives - data types - operands and operators - gate level modeling - data flow modeling - behavioral modeling - structural modeling – primitives-Tasks and functions - Writing test bench – Timing issues. (11)

FIELD PROGRAMMABLE GATE ARRAYS: Introduction – FPGA Technology – DSP Technology Requirement – Design Implementation – FPGA Architectures – Xilinx – Altera Flex – FPGA implementation issues. (11)

DSP ALGORITHMS ON FPGA: Fixed and Floating point arithmetic - Design of Binary Adder, Multiplier, Divider - Design of FIR Filters – Design of IIR Filters – DFT and FFT Algorithms (12)

DIGITAL COMMUNICATION MODULES ON FPGA: Error Control coders and decoders, encryption, scrambling, LMS Algorithm for channel estimation/equalization, pulse shaping, Digital PLL, CORDIC implementations, Numerically controlled oscillator and SDR. (11)

Total L: 45

REFERENCES:

1. Samir Palnitkar, “Verilog HDL: A Guide to Digital Design and Synthesis”, Prentice Hall, 2003.
2. Uwe Meyer Baese, “Digital Signal Processing with Field Programmable Gate Arrays”, Springer, 2004.
3. Jeffrey H Reed, “Software Radio: A Modern Approach to Radio Engineering”, Pearson Education Asia, 2002.
4. James Tsui, “Digital Techniques for Wideband Receivers”, Prentice-Hall of India, 2005.
5. Roger Woods, John Mc Allister, Gaye Lightbody and Ying yi, “FPGA Based Implementation of Signal Processing Systems”, Wiley, 2008.
6. Keshab K Parhi, “VLSI Digital Signal Processing Systems: Design and Implementation”, John Wiley and Sons, 1999.

21LC37 / 21LW45 MACHINE LEARNING AND DEEP LEARNING

3 0 0 3

MACHINE LEARNING BASICS: Learning Algorithms - Capacity, Overfitting and Underfitting – Hyper parameters and Validation Sets - Estimators, Bias and Variance - Maximum Likelihood Estimation - Bayesian Statistics - Supervised Learning Algorithms - Unsupervised Learning Algorithms - Stochastic Gradient Descent - Building a Machine Learning Algorithm - Challenges Motivating Deep Learning . (12)

LINEAR MODELS FOR CLASSIFICATION: Linear Models for Classification – Linear Discriminant Analysis - Two class and Multiple class - Probabilistic Generative Models – Maximum Likelihood solution - Probabilistic Discriminative Models – Logistic regression (10)

DEEP FEED FORWARD NETWORKS: Learning XOR - Gradient-Based Learning -Hidden Units - Architecture Design - Back-Propagation and Other Differentiation Algorithms - Regularization for Deep Learning - Regularization and Under-Constrained Problems - Dataset Augmentation - Noise Robustness - Optimization for training deep models (10)

CONVOLUTIONAL AND RECURRENT NETWORKS: The Convolution Operation – Pooling - Variants of the Basic Convolution Function - Structured Outputs - Efficient Convolution Algorithms - Random or Unsupervised Features - Recurrent Nets - Unfolding Computational - Recurrent Neural Networks - Bidirectional RNNs - Encoder-Decoder Sequence-to-Sequence Architectures - Deep Recurrent Networks (13)

Total L: 45

REFERENCES:

1. Christopher Bishop, “Pattern Recognition and Machine Learning”, Springer-Verlag New York, 2013.
2. Tom M. Mitchell, “Machine Learning”, First Edition reprint, McGraw Hill Education, 2017.
3. Ian Goodfellow, Yoshua Bengio, Aaron Courville, “Deep Learning”, MIT Press, 2016.
4. John D. Kelleher, "Deep Learning (The MIT Press Essential Knowledge series)", MIT Press, 2019.
5. François Chollet, “Deep Learning with Python”, Manning Publications, 2017.

21LC38 / 21LW46 DATA STRUCTURES AND ALGORITHMS

3 0 0 3

INTRODUCTION: Software Development process – Data structures - Abstract Data Types - Analysis of algorithms - Best, worst and average case time complexities – notations. ARRAYS: Operations - Implementation of one, two, three and multi dimensioned arrays – Sparse and dense matrices - Applications. SORTING: Insertion sort - Selection sort - Bubble sort - Radix

sort –Quick Sort- Linear Search- Binary Search Algorithms and their time complexities. (12)

STACK AND QUEUE: Stack operations - implementations - Applications: Function handling - Recursion – Expression Evaluation. Queue - operations - implementations - Priority Queues - Dequeues - Applications: Job scheduling. (11)

LISTS: Linked List Vs Arrays: Memory allocation and deal location for liked list**-** Operations - Singly linked lists, doubly linked lists, Circular lists - Linked Stacks - Linked queues- Applications of Linked List- Polynomial addition. (10)

TREES AND GRAPHS: Tree Terminologies - Implementation - Binary Tree: Properties –representation of trees, operations- Traversals- Expression trees - Infix, Postfix and Prefix expressions – Dijkstra's Algorithms-Floyd's Algorithm. Graph Terminologies-representations-graph search methods: Breadth first search, Depth first search, Minimum spanning trees- Multistage graph. (12)

Total L: 45

REFERENCES:

1. Robert L Kruse, Bruce P Leung and Clovin L Tondo, "Data Structures and Program Design in C", Pearson Education, New Delhi, 2009.
2. Vijayalakshmi Pai G A, "Data Structures and Algorithms: Concepts Techniques and Applications", McGraw-Hill, 2017.
3. A. Chitra P T Rajan "Data Structures", Tata McGraw Hill Education, 2016.
4. Ellis Horowitz ,Sartaj Sahni and Sanguthevar Rajasekaran, 'Computer Algorithms/C++', Orient Black Swan, 2019.
5. Mark Allen Weiss, "Data Structures and Algorithm Analysis in C", Pearson Education, New Delhi, 2012.
6. Sahni Sartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2016.

21LC39 / 21LW47 PYTHON PROGRAMMING

3 0 0 3

BASICS OF PYTHON PROGRAMMING: Variables - Keywords - Strings and Numeric Data Types - Lists – Tuples - Sets - Dictionaries - Control Statements**:** if Statement, Relational Operators, Logical Operators, Bit Wise Operators, while Loop, break and continue, for Loop – Functions: Scope - Passing Functions to a Function - Mapping Functions in a Dictionary – Lambda – Modules - Standard Functions. (12)

OBJECT ORIENTED FEATURES AND I/O HANDLING: Classes - Principles of Object Orientation - Creating Classes – Instance Methods – Special Methods - Class Variables – Inheritance – Polymorphism - Type Identification – Data Streams - Files- Access Modes - Writing Data to a File - Reading Data from a File - Additional File Methods - Using Pipes as Data Streams (10)

ERROR HANDLING AND REGULAR EXPRESSIONS: Run Time Errors - Exception Model - Exception Hierarchy - Handling Multiple Exceptions - Handling IO Exceptions **-** Regular Expressions**:** Simple Character Matches - Special Characters – Character Classes – Quantifiers - Dot Character - Greedy Matches – Grouping - Matching at Beginning or End - Match Objects – Substituting - Splitting a String – Compiling Regular Expressions. (11)

APPLICATIONS USING PYTHON: Network programming-Sending e-mail using SMTP Library- -Database Access- Multithreading- Web application development: opening an URL-creating a simple web page- Overview of Flask- GUI Libraries introduction. (12)

Total L: 45

REFERENCES:

1. Sumit Gupta "Building Web Applications with Python and Neo4j",Packt publishers, 2015.
2. Ron DuPlain, " Instant Flask Web Development ",Packt publishers ,Second Edition, 2013.
3. Wesley J Chun, "Core Python Applications Programming", Prentice Hall, 2012.
4. Martin C. Brown , " The complete Reference- Python", McGrawHill Education, Second Edition, 2018.
5. Mark Summerfield. "Programming in Python 3: A Complete introduction to the Python Language", Addison-Wesley Professional,2010.
6. Brandon Rhodes, John Goerzen, " Foundations of Python Network Programming", Apress, Third Edition, 2014

21LC40 / 21LW21 SPACE TIME WIRELESS COMMUNICATION

3 0 0 3

MULTIPLE ANTENNA PROPAGATION AND ST CHANNEL CHARACTERIZATION: Wireless channel, Channel as a ST random field, Scattering functions, Polarization and field diverse channels, Antenna array topology, Degenerate channels, reciprocity and its implications, Channel definitions, Channel measurements, sampled signal model, ST multiuser and ST interference channels, ST channel estimation (10)

CAPACITY AND SPATIAL DIVERSITY OF MULTIPLE ANTENNA CHANNELS : Capacity of frequency flat deterministic MIMO channel: Channel unknown to the transmitter, Channel known to the transmitter, capacity of random MIMO channels, Capacity of frequency selective MIMO channels - Receive antenna diversity - Transmit antenna diversity - Combined space and path diversity, Indirect transmit diversity, Diversity of a space-time-frequency selective fading channel . (15)

MULTIPLE ANTENNA CODING AND RECEIVERS: Coding and interleaving architecture, ST coding for frequency flat channels, ST coding for frequency selective channels, Receivers(SISO,SIMO,MIMO),Iterative MIMO receivers, Exploiting channel knowledge at the transmitter: linear pre-filtering, optimal pre-filtering for maximum rate, optimal pre-filtering for error rate minimization, selection at the transmitter, Exploiting imperfect channel knowledge. (10)

ST OFDM, SPREAD SPECTRUM AND MIMO MULTIUSER DETECTION: SISO-OFDM modulation, MIMO-OFDM modulation, Signaling and receivers for MIMO- OFDM,SISO-SS modulation, MIMO-SS modulation, Signaling and receivers for MIMO-S.MIMO-MAC,MIMO-BC, Outage performance for MIMO-MU,MIMO-MU with OFDM,CDMA and multiple antennas. (10)

Total L: 45

REFERENCES:

1. David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
2. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.
3. Paulraj A, Rohit Nabar and Dhananjay Gore, "Introduction to Space Time Wireless Communication Systems", Cambridge University Press, 2003.
4. Sergio Verdu, "Multi User Detection", Cambridge University Press, 2003.
5. Andre Viterbi, "Principles of Spread Spectrum Techniques", Pearson, 1995.

21LC41 / 21LW22 5G WIRELESS TECHNOLOGIES

3 0 0 3

INTRODUCTION AND ROADMAP TO 5G: Historical trend and evolution of LTE technology to beyond 4G – Key building blocks of 5G – 5G use cases and System Concepts – The 5G Architecture – IoT: relation to 5G. (10)

5G WAVEFORMS AND CHANNEL MODELS: 5G Radio Access Technologies: Design principles - Multi-carrier with filtering - Non-orthogonal Multiple Access - Radio access for dense deployments – Radio Access for V2X Communication - Radio access for massive machine-type communication - 5G wireless propagation channel models: Modeling requirements and scenarios - The METIS channel models. (10)

NETWORKING IN 5G: Coordinated multi-point transmission in 5G: Joint Transmission CoMP enablers - Distributed cooperative transmission - JT CoMP with advanced receivers - Relaying and network coding in 5G: Multi-flow wireless backhauling - Buffer-aided relaying. (12)

EVALUATION OF 5G AND 5G APPLICATIONS: Machine-type communications: Fundamental techniques for MTC - Massive MTC - Ultra-reliable low-latency MTC - Device-to-device (D2D) communications - Multi-hop D2D communications - Multi-operator D2D communication - Simulation methodology: Evaluation methodology – Calibration - New challenges in the 5G modeling. (13)

Total L: 45

REFERENCES:

1. Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, - 5G Mobile Communications, Springer, 2017.
2. Afif Osseiran, Jose F. Monserrat and Patrick Marsch, - 5G Mobile and Wireless Communications Technology, Cambridge University Press, 2016.
3. Jonathan Rodriguez, - Fundamentals of 5G mobile networks, John Wiley and Sons, Ltd, 2015.

OPEN ELECTIVES THEORY COURSES

21LC91 / 21LW91 / 21LV91 / 21LN91 SMART CITIES

3 0 0 3

SMART CITIES: Ideal Smart City loop, Socio-economic and environmental issues, Implications of Urbanization, Urbanization models and global trends, Urbanization in India, Criteria for smart cities, Smartness - Citizens, Living, Environment, Mobility, Economy, Governance Pillars of Smart cities, Buildings, Utilities, Smart Energy,Transportation and road Infrastructure, Health Care, Stakeholders' perceptions, Sustainability issues (12)

FUNDAMENTAL TECHNOLOGIES AND OPPORTUNITIES: Ubiquitous computing, Big Data, Networking, Internet of Things, Cloud computing, Service-oriented architectures, Cyber security architectures. Opportunities: Smart street lighting, Smart Parking, Environmental pollution monitoring, Vehicular tracking, Smart Traffic Control, Waste Management, Smart Grid, Amenity availability, Heritage Information portal, Mobile application design, development and Visualization. (12)

ICT FOR SMART CITIES: Complex Urban systems ICT Infrastructure modeling, Typical Edge Environment, Smart Cities as Systems of Systems, IoT Centric approach, IoT Protocols: WiFi, 6LowPAN, Cellular, NFC, LoRa, NBIOT (11)

CASE STUDIES OF SMART CITIES: European Smart cities, Singapore, Taipei and Surabaya, Mumbai and New Delhi. Smart Village Clusters and Urbanization: Application of smart city Concepts (10)

Total L: 45

REFERENCES:

1. Carlo Ratti and Matthew Claudel, “The City of Tomorrow: Sensors, Networks, Hackers, andthe Future of Urban Life (The Future Series)”, Yale University Press 2016.
2. Stephen Goldsmith, Susan Crawford, “The Responsive City: Engaging CommunitiesThrough Data-Smart Governance”, 1st Edition Jossey Bass – Wiley, 2014.
3. Anilkumar ,”Introduction to Smart Cities”,Pearson India Education series Pvt Ltd, 2020.
4. Sameer Sharma ,”Smart cities Unbounded - Ideas and Practices of Smart cities in India”,BloomsburyPublishing India Pvt Ltd, 2018.

21LC92 / 21LW92 / 21LV92 / 21LN92 RADIATION HAZARDS

3 0 0 3

BIOLOGICAL EFECTS OF RADIATION AND PROTECTION: Production and properties - interaction mechanism of RF and mircrowaves with biological systems: Thermal and non-thermal effects on whole body, lens and cardiovascular systems -tissue characterization and Hyperthermia and other applications-Biomagnetism - Effects - applications. (9)

NON IONIZONG RADIATION: Historical context- Extent of the problem-Understanding non-ionising EMR- Units of measurement –The impact of non-ionising EMR on the body- Legislation- Extra Low Frequency Radiation- Definition and use- Health effects- Risk management- Radio Frequency Radiation- Infra Red Radiation- Visible Light-Ultraviolet -Legislation - Implications for practice. (12)

RF AND MICROWAVE RADIATION: Introduction - Sources of radio frequency radiation- Effects of radio frequency radiation- The development of standards for human safety- The calculation of RF field quantities- Microwave antenna calculations and safety with moving microwave beams - Other antenna system calculations -Simultaneous irradiations and peak pulse power limits -Mobile communications systems. (12)

RF RADIATION MEASUREMENTS AND METHODS: Radiation measurements and methods- X-rays and X-ray measuring instruments - Planning surveys and measurements - Conducting radiation measurements and surveys Leakage surveys - Exposure measurements -Designing to reduce radiation hazards - Radio frequency radiation safety management and training. (12)

Total L : 45

REFERENCES :

1. Ronald Kitchen,”RF Microwave Radiation Safety Handbook”, Newness, Second Edition, 2001.
2. Thomas S. Curry, James E. Dowdey and Robert E. Murry, “Christensen's Physics of Diagnostic Radiology”, Lea & Febiger,U.S.Fourth Edition, Reprint 2010.
3. Harry Moseley, Hospital Physicists' Association, Non-ionising radiation: microwaves, ultraviolet, and laser radiation, A. Hilger, in collaboration with the Hospital Physicists' Association, 1988.