SEMESTER – III

21LW71 PROJECT WORK – I
vide Automotive Engineering 21AE71

SEMESTER – IV

21LW81 PROJECT WORK – II
Vide Automotive Engineering 21AE81

PROFESSIONAL ELECTIVES THEORY COURSES (Four to be opted)

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.

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.

21LW23 SOFTWARE DEFINED RADIO ARCHITECTURE

3 0 0 3

INTRODUCTION: Software Defined Radio- SDR concepts and history,- Characteristics and Benefits of Software Radio – Design Principles of a Software Radio, Ideal SDR architecture--SDR Based End-to-End Communication. (10)

RF SYSTEM DESIGN: Introduction- Principal Challenge of Receiver Design - Enhanced Flexibility of the RF Chain with Software Radios - Noise and Channel Capacity , State-of-the-Art SDR Components - SDR Using Test Equipment, SDR Using COTS Components. (12)

ARCHITECTURE AND STANDARDISATION OF SDR: Signal Processing Architectures - GPP-Based SDR, FPGA-Based SDR, Architecture for FPGA-Based SDR, SDR Standardization - Software Communications Architecture – JTRS, STRS, Physical Layer Description and Data Formats. (12)

HARDWARE AND SOFTWARE CENTRIC SDR PLATFORMS AND APPLICATIONS: Hardware platforms for SDR – Universal Software Radio Peripheral, Wireless open Access Research platform, RTL SDR receiver. Software platforms for SDR- GNU Radio, Open-Source SCA Implementation: Embedded, Other All-Software Radio Frameworks and Front End for Software (11)

Total L: 45

REFERENCES:

1. Eugene Grayver, “Implementing Software Defined Radio”, Springer, 2013.
2. Alexander M. Wyglinski, Di Pu, “Digital Communication Systems Engineering with Software-Defined Radio”, Artech House, 2013.
3. Jeffrey H Reed, “Software Radio: A Modern Approach to Radio Engineering”, PEA Publication, 2002.
4. Walter Tuttle bee, “Software Defined Radio: Enabling Technologies”, Wiley Publications, 2002.

21LW24 / 21LC25 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.

21LW25 / 21LC26 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 and 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 and 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.

21LW26 LONG TERM EVOLUTION

3 0 0 3

LONG TERM EVOLUTION: Architecture – Standardization process in 3GPP – Technologies for LTE -The Core Network , The Access Network . Roaming Architecture – Protocol Architecture – S1 and X2 E-UTRAN Network Interfaces. (10)

CONTROL PLANE AND USER PLANE PROTOCOLS: Radio Resource Control – PLMN and Cell Selection – Paging – User Plane Protocol Stack – Packet Data Convergence Protocol – Radio Link Control – Medium Access Control. (10)

PHYSICAL LAYER FOR DOWNLINK AND UPLINK: OFDMA – Parameter dimensioning – Downlink physical layer design – Synchronization and Cell Search – Reference Signals and Channel Estimation – Downlink Physical Data and Control Channels – Link Adaptation and Channel Coding. Uplink Physical Layer Design – Uplink reference signals – Uplink Physical channel structure Random Access – Uplink transmission procedures. (15)

LTE ADVANCED: Self Optimizing Networks – Architecture and services-LTE- Advanced - Carrier Aggregation- Multiple Antenna Techniques for Advanced Voice Over LTE. (10)

Total L: 45

REFERENCES:

1. Stefania Sesia, Issam Toufik and Matthew Baker, “LTE – The UMTS Long Term Evolution: From Theory to Practice”, John Wiley and Sons, 2011.
2. Christopher Cox, “An introduction to LTE – LTE, LTE-Advanced, SAE and 4G Mobile Communications”, John Wiley and Sons, 2012.

21LW27 ERROR CONTROL AND CODING TECHNIQUES

3 0 0 3

BLOCK AND CONVOLUTIONAL CODES: Galois fields. Linear block codes; encoding and decoding. Cyclic codes. Convolutional codes. Generator sequences. Structural properties. ML decoding. Viterbi decoding. Sequential decoding. (12)

MODULATION CODES: Trellis coded modulation. Lattice type Trellis codes. Geometrically uniform trellis codes. Decoding of modulation codes. (11)

TURBO CODES: Turbo decoder. Interleaver. Turbo decoder. MAP and log MAP decoders. Iterative turbo decoding. Optimum decoding of turbo codes. Space-Time codes- Space-Time Block Codes (STBC) – decoding of STBC (12)

LDPC AND POLAR CODES: Construction of Low Density Partiy Check Codes (LDPC). Probabilistic decoding of LDPC codes. Introduction to Polar codes. (10)

Total L: 45

REFERENCES:

1. S.Lin and D.J.Costello, “Error Control Coding (2/e)”, Pearson, 2005.
2. B.Vucetic and J.Yuan, “Turbo codes”, Kluwer, 2000.
3. C.B.Schlegel and L.C.Perez, “Trellis and Turbo Coding”, Wiley,2004.
4. B.Vucetic and J.yuan, “Space-Time Coding”, Wiley, 2003.
5. Orhan Gazi , “Polar Codes: A Non-Trivial Approach to Channel Coding” Springer, 2018.

21LW28 RF INTEGRATED CIRCUIT DESIGN

3 0 0 3

ISSUES IN RFIC DESIGN, NOISE, LINEARITY AND FILTERING: LF analog design and microwave design versus RFIC design - Impedance levels for microwave and low-frequency analog design- noise - linearity and distortion in RF Circuits - dynamic range - filtering issue-review of technology – small signal model- HF effects and noise source model (12)

DESIGN OF PASSIVE CIRCUIT ELEMENTS IN IC TECHNOLOGIES: Technology backend and metallization in IC technologies - sheet resistance and skin effect -parasitic capacitance and inductance -current handling in metal lines-design of inductors and transformers - characterization of inductor-layout of spiral inductors - on-chip transmission lines - high frequency measurements of on-chip passives and common De-Embedding techniques-packaging. (12)

LNA AND POWER AMPLIFIER: Basic amplifiers - amplifiers with feed back - noise in amplifiers - linearity in amplifiers - differential pair and other differential amplifiers-low-voltage topologies for LNAs and the use of on-chip transformers - DC bias networks - temperature effects - broad band LNA design. Power amplifier: power capability - efficiency calculations - matching considerations - Class A,B,C.D.E.F,G,H and S amplifiers -summary of amplifier classes for RF Integrated circuits - AC load line - matching to achieve desired power - packaging -effects and implications of non linearity - linearization techniques - CMOS power amplifier example. (12)

MIXERS: Mixing with nonlinearity - basic mixer operation – controlled transconductance mixer - double- balanced mixer - mixer with switching of upper quad - analysis of switching modulator-mixer noise - linearity - improving isolation - image reject and single -sideband mixers-alternative mixer designs - general design comments- CMOS mixers. (9)

Total L: 45

REFERENCES:

1. John Rogers and Calvin Plett, “Radio Frequency Integrated Circuit Design”, Artech House, Reprint 2018.
2. Stephan A Mass, “Non-Linear Microwave and RF circuits”, Artech House.Second Edition, Reprint 2018.
3. Ferri Losee, “RF Systems, Components and Circuits Handbook”, Artech House, 2002.
4. Larson L E, “RF and Microwave Circuit for Wireless Applications”, Artech House, 1997.

21LW29 RF MEMS

3 0 0 3

MICROELECTROMECHANICAL SYSTEMS AND RADIO FREQUENCY MEMS: Introduction –Microfabrication for Micro Electro Mechanical SystemsMEMS – Electromechanical transducers – Microsensing for MEMS – Materials for MEMS-MEMS Materials and Fabrication Techniques-Metals – Semiconductors – Thin films for MEMS and their deposition techniques – Bulk micromachining for silicon-based MEMS – Silicon surface micromaching – Microstereolithography for polymer MEMS. (12)

RF MEMS SWITCHES: Introduction – Switch parameters – Basics of switching – Switches for RF and microwave applications – Electrostatic switching – Approaches for low-actuation –voltage switches – thermal switching –MEMS switch design, modeling and evaluation –MEMS switch design considerations. MEMS Inductors and Capacitors (12)

MICROMACHINED RF FILTERS AND PHASE SHIFTERS: Introduction – Modeling of mechanical filters - Micromechanical filters –Micromachined phase shifters: Introduction – Types of phase shifters and their limitations – MEMS phase shifters. (12)

MICROMACHINED TRANSMISSION LINES AND ANTENNA: Introduction – Micromachined transmission lines and components – Design, fabrication and measurements- Overview of microstrip antenna – Micromachining techniques to improve antenna performance – Micromaching as a fabrication process for small antenna – Micromachined reconfigurable antenna (9)

Total L: 45

REFERENCES:

1. Vijay K Varadan, Vinoy K J and Jose K A, "RF MEMS and Their Applications“, John Wiley and Sons Ltd., England, 2003.
2. Gabriel M Rebeiz, “RF MEMS Theory, Design and Technology “, John Wiley and Sons Ltd., New Jersey, 2004.
3. Hector J De Los Santos, “RF MEMS Circuit Design for Wireless communications”, Artech House, 2002.
4. Tai-Ran Hsu, “MEMS And Microsystems: Design And Manufacture”, Tata McGraw Hill, NewDelhi ,2003.

21LW30 EMC TESTING AND MEASUREMENTS

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

21LW31/21LC30 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.

21LW32 / 21LC29 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 and Thiele G A, "Antenna Theory and Design", John Wiley and Sons Inc., 1998.

21LW33 WIRELESS TECHNOLOGIES AND MEASURING TOOLS

3 0 0 3

MODERN WIRELESS COMMUNICATION SYSTEMS: Second Generation, Third Generation mobile Cellular networks – 4G, 5G, LTE, LTE A- Cognitive Radio Technology. (10)

RF SIGNAL GENERATION AND SYSTEM FUNDAMENTALS: Basics of RF and Microwaves - Scattering parameters – Microwave passive devices –Mixers – Switches – Attenuators – Connectors and adaptors – Oscillator Circuits – Direct Digital synthesis – PLL Based Synthesizers – Arbitrary waveform generator – Vector Signal Generator - Phase frequency detector.(15)

POWER AND SCATTERING MEASUREMENTS: Power detectors and instrumentation – Primary power standards – power measurement techniques – History of vector network analyzers – Measurement types in VNA – Two port network analyzer calibration. (10)

RF MODULAR INSTRUMENTS: Introduction – Understanding software designed systems – Multichannel measurements – Customized measurement systems – Instruments: Spectrum/Signal Analyser – Digital storage Oscilloscope - Mixed signal Oscilloscopes. (10)

Total L: 45

REFERENCES:

1. Ananjan Basu "An Introduction to Microwave Measurements", CRC Press, 2015.
2. Valeria Teppati**,** Andrea Ferrero**,** Mohammed Sayed " Modern RF and Microwave Measurement Techniques", Cambridge University Press,2013.
3. Gordon L Stuber, "Principles of Mobile Communication", Artech House, 2011.
4. Matthew M Radmanesh "RF and Microwave Design Essentials", Author House, 2007.
5. Hsiao-Hwa Chen and Mohsen Guizani, "Next Generation Wireless Systems and Networks", John Wiley and Sons, 2006.

21LW34 SMART ANTENNAS

3 0 0 3

INTRODUCTION: Antenna gain, Phased array antenna, power pattern, beam steering, degree of freedom, optimal antenna, adaptive antennas, smart antenna - key benefits of smart antenna technology, wide band smart antennas, Digital radio receiver techniques and software radio for smart antennas. (12)

NARROW BAND AND BROADBAND PROCESSING: Signal model conventional beamformer, null steering beamformer, optimal beamformer, Optimization using reference signal, beam space processing. Tapped delay line structure, Partitioned realization, Derivative constrained processor, Digital beam forming, Broad band processing using DFT method (12)

ADAPTIVE PROCESSING: Sample matrix inversion algorithm, unconstrained LMS algorithm, normalized LMS algorithm, Constrained LMS algorithm, Perturbation algorithms, Neural network approach, Adaptive beam space processing, Implementation issues. (12)

DIRECTION OF ARRIVAL ESTIMATION METHODS: Spectral estimation methods, linear prediction method, Maximum entropy method, Maximum likelihood method, Eigen structure methods, Music algorithm – root music and cyclic music algorithm, the ESPRIT algorithm. Diversity combining- Spatial diversity selection combiner, switched diversity combiner, equal gain combiner, maximum ratio combiner, optical combiner. (9)

Total L: 45

REFERENCES:

1. Lal Chand Godara, "Smart Antennas" CRC press, 2004.
2. Balanis, "Antenna Theory: Analysis and Design", John Wiley and Sons, Fourth Edition ,2019.
3. Joseph C Liberti.Jr and Theodore S Rappaport, "Smart Antennas for Wireless Communication: IS-95 and Third Generation CDMA Applications", Prentice Hall, 1999.

4. Robert A Monzingo, Haupt R L and Miller T W, “Introduction to Adaptive Arrays”, Yesdee Publishing Pvt. Ltd., 2012.

21LW35 OPTIMAL SIGNAL PROCESSING

3 0 0 3

LMS ALGORITHM AND OPTIMAL ESTIMATION: Need for adaptive filtering - FIR adaptive filters – Wienner Filter-Normal Equations- Newton’s method - Steepest descent method –Convergence analysis - Performance surface – Least Mean Square (LMS) adaption algorithms – Convergence – Excess mean square error -Optimal Estimation-Classical and Bayesian Estimation-MMSE Estimation-Estimation of Signals (12)

LEAST SQUARES ALGORITHM: Recursive Least Squares (RLS) algorithm for adaptive filtering of stationary process- Matrix inversion – Comparison with LMS – RLS for quasi-stationary signals- Exponentially weighted RLS- Sliding window RLS – RLS algorithm for array processing – Adaptive beam forming –Other applications of adaptive filters – Echo cancellation – Channel Equalization (12)

LINEAR PREDICTION: Introduction-Lattice Filter-Lattice Recursions-Lattice as Optimal Filter Linear Prediction and Autoregressive Modeling-Gradient Adaptive Lattice (10)

KALMAN FILTERING: Statistical filtering for non-stationary signals – Kalman filtering- Principles -Initialization and tracking – Scalar and vector Kalman filter – Applications in signal processing – Time varying channel estimation – Radar tracking (11)

Total L: 45

REFERENCES:

1. Simon O. Haykin, Adaptive Filter Theory, Fifth Edition, Pearson Education Ltd, 2014.
2. Bernard Widrow, Samuel D Stearns, Adaptive Signal Processing, Pearson Education; 2002
3. Monson H. Hayes, Statistical Digital Signal Processing And Modeling, First Edition, Wiley India, Pvt Ltd, 2008.
4. S. J. Orfanidis, Optimum Signal Processing, Second ed., McGrawHill, 2007.

21LW36 / 21LC21 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. (8)

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 (10)

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. (10)

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. (17)

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.

21LW37 IMAGE PROCESSING

3 0 0 3

DIGITAL IMAGE BASICS AND IMAGE TRANSFORMS: Mathematical preliminaries, Digitization of Images, Sampling and Quantization, 2D signals and systems; image transforms - 2D DFT, DCT, KLT, Harr transform and discrete Wavelet transform. (10)

IMAGE ENHANCEMENT AND RESTORATION: Linear and Non-Linear Image Enhancement, Weighted median filters, Image Noise cleaning, Image Zooming, Image Sharpening, Edge Detection, Wavelet denoising, Image restoration: Degradation model - Inverse Filtering - Wiener Filter. (12)

IMAGE COMPRESSION: Walsh- Hadamard transform , JPEG, Wavelet based compression: quad-trees, EZW, SPIHT, JPEG-2000.Case study: Medical Image compression, SAR image compression (11)

IMAGE SEGMENTATION AND REPRESENTATION: Statistical methods of segmentation, Texture classification and segmentation, Gradient and Laplacian type edge detection, Diffusion based edge detectors, Representation schemes: chain codes - Polygon approximation - Boundary descriptors: Simple descriptors - Shape, Fourier descriptors. Case study: Visual Inspection of objects, Surveillance, Vehicle Guidance in Agriculture, Region-based model. (12)

Total L: 45

REFERENCES:

1. Gonzaleze and Woods, “Digital Image Processing”, Third Edition , Prentice Hall, 2008.
2. Chris Solomon, Toby Breckon ,"Fundamentals of Digital Image Processing A Practical Approach with Examples in Matlab",John Wiley and Sons,2011.
3. Jayaraman S, Esakkirajan S and Veerakumar T, “Digital Image Processing”, Tata McGraw Hill, New Delhi, 2009.
4. Kenneth R Castleman, “Digital Image Processing”, Prentice Hall, New Delhi, 2008.

21LW38 /21LC35/21LV27 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.

21LW39/21LC36 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.

21LW40 / 21LV33 VLSI FOR WIRELESS COMMUNICATION

3 0 0 3

OVERVIEW OF MODULATION SCHEMES: Classical Channel - Wireless Channel Description - Path Loss - Channel Model and Envelope Fading - Multipath Fading: Frequency Selective and Fast Fading - Summary of Standard Translation. (10)

RECEIVER FRONT END: Filter Design - Rest of Receiver Front End: Non idealities and Design Parameters - Nonlinearity – Noise - Noise Figure. AMPLIFIER DESIGN: Low Noise Amplifier Design - Wideband LNA - Narrowband LNA - Impedance Matching - Automatic Gain Control Amplifiers – Power Amplifiers. (13)

MIXERS: Balancing Mixer : Qualitative Description of the Gilbert Mixer - Conversion Gain – Distortion -Noise -Analysis of Gilbert Mixer: Low Frequency Case and High-Frequency Case – A Complete Active Mixer. Unbalanced Switching Mixer - Conversion Gain-Distortion - Noise - A Practical Unbalanced Switching Mixer. Single ended Sampling Mixer - Conversion Gain - Distortion - Intrinsic Noise - Extrinsic Noise - Demodulators. (11)

FREQUENCY SYNTHESIZERS: Phase Locked Loops - Phase Detector – Analog Phase Detectors – Digital Phase Detectors - Voltage Controlled Oscillators - Frequency Dividers - LC Oscillators - Ring Oscillators - Phase Noise - A Complete Synthesizer Design Example (DECT Application). Loop filter: Voltage Controlled Oscillators - Design Approaches. (11)

Total L: 45

REFERENCES:

1. Bosco H Leung "VLSI for Wireless Communication", Pearson Education, 2002.
2. Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI Wireless Design - Circuits and Systems", Kluwer Academic Publishers, 2000.
3. laskar J, Matinpourand B and Charaborty S, "Modern receiver front ends: Systems, Circuits and integration", Wiley 2004
4. Leenearts D, Vander J Tang and Vaucher C S, "Circuit design for RF transceivers", Springer 2002.
5. Luzzatto A and Shirazi G, "Wireless Transceiver Design: Mastering the Design of Modern Wireless Equipment and Systems", Wiley 2007.

21LW41 WIRELESS SENSOR NETWORKS

3 0 0 3

INTRODUCTION: 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, Design principles. (10)

SENSOR LOCALIZATION AND TIME SYNCHRONIZATION: Localization and positioning: Possible approaches, single hop localization, positioning in multihop environments. Time synchronization: Time synchronization problem, protocols based on sender to receiver and receiver to receiver synchronization in WSN. (11)

MAC AND ROUTING PROTOCOLS: Fundamentals of wireless MAC protocols, low duty cycle protocols and wakeup concepts, contention-based protocols, Schedule-based protocols. ROUTING PROTOCOLS - Gossiping and agent-based unicast forwarding, Energy-efficient unicast, Broadcast and multicast, geographic routing, Data centric routing, Data aggregation. (12)

SENSOR NETWORK PROGRAMMING: Programming Challenges in Wireless Sensor Networks, Tiny Operating System, Contiki OS, Event-Driven Programming, Techniques for Protocol Programming. Simulators: GloMosim, Sensor Sim, ToSSIM and Power TOSSIM. (12)

Total L: 45

REFERENCES:

1. Sitharama Iyengar S, Nandan Parmeshwaran, Balakrishnan N and Chuka D, "Fundaments of Sensor Network Programming,

Applications and Technology", John Wiley and Sons, 2011.
2. Fei Hu and Xiaojun Cao, "Wireless Sensor Networks Principles and Practice", CRC Press, 2010.
3. Jean Philippe Vasseur and Adam Dunkels, "Interconnecting Smart Objects with IP, The Next Internet", Morgan Kaufmann, Elsevier, 2010.
4. Holger Karl and Andreas Willig, "Protocol and Architecture for Wireless Sensor Networks", John Willey Publication, Oct 2007.
5. Feng Zhao and Leonidas Guibas, "Wireless Sensor Networks: an Information Processing Approach", Elsevier Publication, 2004.

21LW42 WIRELESS SECURITY

3 0 0 3

WIRELESS THREATS: 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. (12)

CRYPTOGRAPHY: Encryption and Decryption - Product ciphers-AES (advanced Encryption Standard) - Stream ciphers, Pseudorandom number Generator, A5, RC4 - Public key cryptography-ECC (Elliptic Curve Cryptography) - Cryptography in Embedded Hardware. (12)

WIRELESS LOCAL AREA NETWORK : Introduction to IEEE 802.11 Standard-Security Risks-WEP (Wired Equivalence Privacy) - Countermeasures –WPA (Wi- Fi Protected Access) - IEEE 802.11x-Standards-Bluetooth security. (10)

CASE STUDIES: Wireless Device security–IP-security-Secure Socket Layer-Wireless Transport Layer Security - Mobile Security Solutions-5G security- Wireless sensor network security. (11)

Total L: 45

REFERENCES:

1. William Stallings, "Cryptography and Network Security, Principles and Practices", Pearson; Seventh Edition, 2017.
2. Behrouz A Forouzan, "Cryptography and Network Security", McGraw Hill, 2015.
3. Nichols and Lekka, "Wireless Security-Models, Threats and Solutions", McGraw Hill, 2002.
4. HakimaChaouchi, 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.

21LW43/21LC32 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.

21LW44 / 21LC33 OPTICAL NETWORKS

3 0 0 3

OPTICAL SYSTEM COMPONENTS : Light propagation in optical fibers-Loss and Bandwidth, System limitations, Non-Linear effect, Solitons, Optical Network / Components- Couplers, Isolators, Circulators, Multiplexers and 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 and SONET, OSI internet layered model, Encapsulation and 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 Pvt., Ltd, 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.

21LW45 / 21LC37 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.

21LW46 / 21LC38 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.GraphTerminologies-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. VijayalakshmiPai 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 ,SartajSahni 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. SahniSartaj, "Data Structures, Algorithms and Applications in C++", Universities Press, Hyderabad, 2016.

21LW47 /21LC39 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.

OPENL 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.