Semester

I

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **Advanced Digital Communication System**	Course Code: **ECPL101**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Unit 1: Review of Signal And Systems :** Signals and Systems with focus on Random Signals, Sampling Theorem, Signal Space and Constellation Diagrams and Orthogonal Signal Sets. Base band modulation and Demodulation: Detection of binary signals in Gaussian Noise, optimum receivers for channels with ISI , AWGN, Equalization, Carrier and symbol synchronization, and Signal Design for band limited channels.	12
3	**Unit 2: Band pass Modulation and Demodulation:** All Modulation Techniques, Coherent and Non Coherent Detection, Error performance for binary system, and Symbol error performance for M-ray systems.	11
4	**Unit 3: Communication Link Analysis:** Link budget analysis, Simple link analysis, system trade-offs, and Modulation coding trade-offs.	11
5	**Unit 4: Spread Spectrum:** signal PN sequences, direct sequence spread spectrum, DS-CDMA, frequency-hopped spread spectrum, FH-CDMA, and Jamming consideration. Communication through Fading Channels.	10
	Total	**45**

Text Books:

1.Simon Haykin, "Digital Communication Systems", 2nd Edition, Wiley, 2006.
2.B. P. Lathi, "Modern Digital and Analog Communication Systems", 4th Edition, Oxford, 2011.
3.Taub and Schilling, "Principles of Communication Systems", 4th Edition, TMH, 2013.

Reference Books:

1.Sklar and Ray, "Digital Communications", 2nd Edition, Pearson, 2008.
2.Glover and Grant, "Digital Communications", 3rd Edition, Pearson, 2010.
3.John G. Proakis and MasoudSalehi, "Digital Communications", 5th Edition, Mc-Graw Hill Education, 2007.

Prerequisite:

1. Electronics Devices and Circuits

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **Advanced Digital Signal Processing**	Course Code: **ECPL102**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT-1Multirate Sampling:** Interpolation by a Factor I, Sampling Rate Conversion by a Rational Factor I/D, Filter Design and Implementation for sampling rate Conversion, Multistage Implementation of Sampling Rate Conversion, Applications of Multirate Signal Processing, Sampling Rate Conversion of Band pass Signals	8
3	**UNIT 2 Frequency Domain Analysis:** Discrete Fourier transform (DFT), Inverse DFT, Inter relationship with z-transform and Hilbert-transforms, Discrete Hilbert transform, FFT algorithms- Decimation in time and decimation in frequency. Spectral analysis using DFT, Short term DFT.	8
4	**UNIT 3 Linear Prediction And Optimum Linear Filters:** Innovations Representation of a Stationary Random Process, Forward and Backward linear prediction, Solution of the Normal Equations, Properties of linear prediction-Error Filter, AR Lattice and ARMA Lattice-Ladder Filters.	8
5	**UNIT 4 Power Spectral Estimation:** Estimation of Spectra from Finite Duration Observations of a signal, the Periodogram, Use DFT in power Spectral Estimation, Bartlett, Welch and Blackman, Tukey methods, Comparison of performance of Non-Parametric Power Spectrum Estimation Methods	10
6	**UNIT 5 Parametric Method of Power Spectrum Estimation:** Parametric Methods for power spectrum estimation, Relationship between Auto-Correlation and Model Parameters, AR (Auto-Regressive) Process and Linear Prediction, Yule-Walker, Burg and Unconstrained Least Squares Methods .	10
	Total	45

Text Books:

1. J.G. Proakis & D.G. Manolokis, “Digital Signal Processing – Principles, Algorithms Applications' ', PHI.
2. Alan V Oppenheim & Ronald W Schaffer, “Discrete Time signal processing”, PHI.

Reference Books:

1. S. M .Kay, “Modern spectral Estimation techniques' ', PHI, 1997.Emmanuel C. Ifeacher Barrie. W. Jervis, “DSP – A Practical Approach”, Pearson Education.
2. Sanjit K Mitra “Digital Signal Processing” TMH

Prerequisite:

1. Signals and Systems
2. Digital Signal Processing

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **RF and Microwave Circuit Design**	Course Code: **ECPL111**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Review** of basics of Passive and Active Circuits.	2
3	**UNIT 2 Microwave Amplifier Design:** Comparison of active devices such as BJT, MOSFET, MESFET, HEMT, and HBT; Circuit models for FETs and BJTs; Two- port power gains; Stability of transistor amplifier circuits; Amplifier design using S-parameters: Design for maximum gain, maximum stable gain, design for specified gain.	8
4	**UNIT 3 RF power amplifiers:** Introduction, class A, AB, B, and C power amplifiers, class D amplifiers, class E amplifiers, Class F amplifiers, summary of PA characteristics, RF PA design examples LNA design: Introduction, LNA topologies-power match vs. noise match, Power constrained noise optimization, Design examples, Linearity and large-signal performance, Spurious free dynamic range	10
5	**UNIT 4 Mixers:** Mixer characteristics: Image frequency, conversion loss, noise figure; Devices for mixers: p-n junctions, Schottky barrier diode, FETs; Diode mixers: Small-signal characteristics of diode, single-ended mixer, large-signal model, switching model; FET Mixers: Single-ended mixer, other FET mixers; Balanced mixers; Image reject mixers, Analysis of microwave mixers.	10
6	**UNIT 5 Oscillators and Frequency Synthesizers:** General analysis of RF oscillators, transistor oscillators, voltage-controlled oscillators, dielectric resonator oscillators, frequency synthesis methods, analysis of first and second order phase-locked loop, oscillator noise and its effect on receiver performance	8
7	**UNIT 6 Switches:** Devices for microwave switches: PIN diode, BJT, FET; Device models; Types of switches; Switch configurations; Basic theory of switches; Multi-port, broad-band and isolation switches.	6
	Total	**45**

Text Books:

1. Pozar, D.M. "Microwave and RF Design of Wireless Systems", John Wiley & Sons. 2001
2. Gonzalez, G., "Microwave Transistor Amplifiers: Analysis and Design", 2nd Ed., Prentice- Hall. 1997
3 .Bahl, I. and Bhartia, P., "Microwave Solid State Circuit Design", 2nd Ed., John Wiley & Sons. 2003
4. Chang, K., Bahl, I. and Nair, V., "RF and Microwave Circuit and Component Design for Wireless Systems", Wiley Interscience. 2002

Reference Books:

1. Rohde, U.L. and Newkirk, D.P., "RF/Microwave Circuit Design for Wireless Applications", John Wiley & Sons. 2000
2. Larson, L.E., "RF and Microwave Circuit Design for Wireless Applications", Artech House. 1996
3. Egan, W. F., "Practical RF Circuit Design", John Wiley & Sons. 1998

Prerequisite:

1. Basic circuit theory.
2. Understanding of semiconductor device principles.
3. Familiarity with electromagnetic theory and transmission line concepts.

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **MIMO systems**	Course Code: **ECPL112**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Introduction to Multi-antenna Systems:** Types of multi-antenna systems, MIMO vs. multi-antenna systems, Diversity-multiplexing trade-off, transmit diversity schemes, Delay diversity, Cyclic delay diversity, Spatial Multiplexing, Spectral efficiency and capacity, Transmitting independent streams in parallel, Mathematical notation, advantages and applications of MIMO systems	8
3	**UNIT 2 Analytical MIMO Channel Models:** Uncorrelated, fully correlated, separately correlated and keyhole MIMO fading models, parallel decomposition of MIMO channel. Power allocation in MIMO systems: Uniform, adaptive and near optimal power allocation. Channel state information, Beam forming, Beam forming principles, Increased spectrum efficiency, Interference cancellation	6
4	**UNIT 3 Space-Time Codes:** Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes. MIMO detection: ML, ZF, MMSE, ZF-SIC, MMSE-SIC, LR based detection	12
5	**UNIT 4 Channel Estimation:** Channel estimation techniques, Estimation and tracking, Training based channel estimation, Blind channel estimation, Channel estimation architectures, Iterative channel estimation, MMSE channel estimation, Correlative channel sounding, Channel estimation in single carrier systems, Channel estimation for CDMA, Channel estimation for OFDM.	12
6	**UNIT 5 Advances in MIMO Wireless Communications:** Spatial modulation, MIMO based cooperative communication and cognitive radio, multi-user MIMO, cognitive-photocells and large MIMO systems for 5G wireless.	6
	Total	45

Text Books:

1. B. Clerckx and C. Oestges, MIMO wireless networks, Elsevier Academic Press, 2nd ed., 2013.
2. N. Costa and S. Haykin, Multiple-input multiple-output channel models, John Wiley & Sons, 2010.
3. A. Chokhalingam and B. S. Rajan, Large MIMO systems, Cambridge University Press, 2014.

Reference Books:

1. T. M. Duman and A. Ghrayeb, "Coding for MIMO communication systems", John Wiley and Sons, 2007.
2. J. Choi, "Optimal Combining & Detection", Cambridge University Press, 2010.
3. Hamid Jafarkhani, "Space Time coding-Theory and Practice",Cambridge University Press, First Edition, 2005.
4. David Tse, PramodViswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
5. M. Janakiraman, "Space-time codes and MIMO systems", Artech House, 2004.
6. Upena Dalal, "Wireless Communication", Oxford University Press, 2009

Prerequisite:

1. Mathematical analysis of various modulation schemes.
2. Knowledge of antenna design and its parameters.
3. Basic Knowledge of wireless and digital communication.

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Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **Information Theory and Coding**	Course Code: **ECPL113**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Introduction to Information Theory and Coding:** Definition of Information Measure and Entropy, Relative Entropy, Extension of an Information Source and Markov Source, Adjoint of An Information Source, joint and Conditional Information Measure, Properties of Joint and Conditional Information Measures and a Markov Source, Asymptotic Properties of Entropy and Problem Solving in Entropy, Estimation of Probability Density and Probability Mass functions, Expectation-Maximization algorithm, Maximum Entropy Principle Jensen's Inequality- Fano's Inequality	8
3	**UNIT 2 Introduction to lossless Coding:**Block Code and its Properties, Instantaneous Code and Its Properties, Kraft-McMillan Equality and Compact Codes, Shannon's Source Coding Theorem, Prefix Coding, Huffman Coding and Proof of Its Optamality, Competitive Optamality of the Shannon Code, Adaptive Huffman Coding, Shannon-fano Coding, Arithmetic Coding, Lempel-ziv Algorithm	8
4	**UNIT 3 Channel Capacity and Coding :**Introduction to Discrete information Channels, Equivocation and mutual information, Properties of Different information Channels, Reduction of information Channels, Noiseless Channel, Properties of Mutual information and introduction to Channel Capacity, Calculation of Channel Capacity for Different information Channels, Shannon's Channel Coding Theorem, Bandwidth S/N Trade-off, Channel Capacity Theorem, Discussion an Error free Communication over Noisy Channel, Error free Communication over a binary Symmetric Channel and introduction to Continuous Sources and Channels, Differential Entropy and Evaluation of Mutual information for Continuous Sources and Channels, Channel Capacity of A band-limited Continuous Channel.	9
5	**UNIT 4 Linear Block and Cyclic Error:**Correction Coding, Definition of Terms - Redundancy, Code Efficiency, Systematic Codes, Hamming Distance, Hamming weight, Hamming bound- Types of Codes - Parity Check Codes, Hamming Codes, BCH Codes, Reed-Solomon Codes, Concatenated Codes- linear block Codes, generator and Parity Check Matrix, Syndrome Decoding- Cyclic Codes, generation and Detection- Coding for Reliable Communication, Coding gain, bandwidth Expansion Ratio- Comparison of Coded and Uncoded systems.	8

6	**UNIT 5 Convolution Codes:** Burst Error Detecting and Correcting Codes- Convolutional Codes- Time Domain and frequency Domain Approaches- Code Tree, Trellis and State Diagram- Decoding of Convolutional Codes, Viterbi's Algorithm, Sequential Decoding- Transfer function and Distance Properties of Convolutional Codes- bound on the bit Error Rate- Coding gain.	6
7	**UNIT 6 Coded Modulation:** Coding for bandwidth Constrained Channels - Combined Coding and Modulation, Trellis Coded Modulation (TCM), Set-partitioning, Encoder and Decoder Design for TCM, Decoding of TCM Codes using the Viterbi Algorithm.	5
	Total	**45**

Text Books:

1. Ranjan Bose, "Information Theory, Coding and Cryptography", Tata McGraw Hill, 2nd edition.
2. P.S. Satyanarayana, "Concepts of Information Theory and Coding", Dynaram Publication, 2005
3. Simon Haykin, "Digital communication," , John Wiley, 2003

Reference Books:

1. Shu Lin and Daniel Castello, "Error Control Coding – Fundamentals and Applications", second edition 2004
2. Thomas M Cover, Joy Thomas, "Elements of Information Theory", 2nd Edition, 2013.
3. HariBhat ,"Information Theory and Coding", Ganesh Rao, Cengage, 2017.

Prerequisite:

1.Random Variables and Probabilities
2. Probability Density Functions (PDFs) and Cumulative Distribution Functions (CDFs)

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **Modern Satellite Communication**	Course Code: **ECPL114**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Architecture of Satellite Communication:** Origin and History of Satellite Communication, Current State of Satellite Communication, Orbital Aspect of Satellite Communication , Orbital Mechanism , Equation of Orbit, Locating Satellite in Orbit , Orbital Elements , Orbital Perturbation.	10
3	**UNIT 2 Orbital Analysis:** Orbital equations, Kepler's laws of planetary motion, Apogee and Perigee for an elliptical orbit, evaluation of velocity, orbital period, angular velocity etc. of a satellite, concepts of Solar day and Sidereal day.	8
4	**UNIT 3 Satellite Subsystems:** Architecture and Roles of various sub-systems of a satellite system such as Telemetry, tracking, command and monitoring (TTC & M), Attitude and orbit control system (AOCS), Communication sub-system, power subsystems, antenna sub-system.	8
5	**UNIT 4 Indian Satellite Launch Vehicle:** SLV (Satellite Launch Vehicle), ASLV (Augmented Satellite Launch Vehicle), PSLV (Polar Satellite Launch Vehicle), GSLV (Geosynchronous Satellite Launch Vehicle), GSLV Mk III, Sounding Rockets.	6
6	**UNIT 5 Satellite Link Design:** Satellite Link Design, System Noise Temperature and G/T Ratio, Downlink Design, Domestic Satellite System, Uplink Design	6
7	**UNIT 6 Indian Regional Navigation Satellite System:** IRNSS System Overview, IRNSS Signal Characteristics, IRNSS Data Structure, Sub Frame Structure.	6
	Total	**45**

Text Books:

1. T. Pratt & C.W. Bostain, Satellite Communication, Wiley 2000
2. M. Richharia , "Satellite Communication Systems Design Principles", Pearson Publications 2nd edition,1999.
3. Wilbur, L. Pritchand, Robert A. Nelson and Heuri G. Suyderhoud, "Satellite Communications Engineering – 2ndEd., Pearson Publications.

Reference Books:

1. D C Agarwal, Satellite Communication, Khanna Publication,5TH Edition.
2. D. Roddy, Satellite Communication (4/e), McGraw- Hill, 2009.
3. Tri T. Ha, "Digital Satellite Communications", Tata McGraw Hill, 2009.

Prerequisite:

1.Introduction to Communication Systems
2. Need of Satellite Communication
3. Electromagnetic Waves and Antennas
4. Basics of Digital Communication

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **Terahertz Devices and Applications**	Course Code: **ECPL115**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Terahertz Overview and Principles:** Electromagnetic Radiation and Propagation Fundamentals, Terahertz Principles, Towards Terahertz communication systems, Key technological issues for Terahertz technology	7
3	**UNIT 2 Terahertz Sources :** The development of Terahertz sources, Terahertz sources based on Schottky diode frequency multipliers, Free Electron based Terahertz sources, Compact Tunable Terahertz Sources very short wave length Vacuum Electronic devices, Photo mixing Tunable Terahertz sources, Terahertz magnetic response from artificial material, Continuous wave THz radiation generation through nonlinear processes.	10
4	**UNIT 3 THz Detectors:** Pyroelectric detectors, gallium doped Germanium photoconductive detector, Bolometer detectors, composite Germanium Bolometer, unturned Indium Antimode, Go lay Cell detectors, Terahertz Electronic components, Travelling Wave Terahertz detector, Tunable Plasma Wave-HEMT THz Detector, Terahertz detector on a single chip, Quantum dot Photodetector, Multiband Terahertz detection and imaging devices, Integrated Terahertz Imager based on quantum dots, CNT based QD frequency tunable THz detector.	10
5	**UNIT 4 Low coherence THz signal sources and applications and THz chemical spectroscopy:** Introduction, Schemes for Noise generation, Characterization of noise signals, Imaging,2D imaging, Tomographic imaging, spectroscopy, amplifier characterization, Application: Terahertz spectroscopic imaging, chemical mapping of pharmaceuticals in medicine	9
6	**UNIT 5 Industrial and Wireless communications Applications of Terahertz waves :** Different kinds of Terahertz systems, Polymer Industry, Polymeric compounds, Paper Industry, Food Industry, Pharmaceuticals Industry, crops Industry, why the terahertz waves for communication, current technologies, frequency dispersion, Ray shadowing by moving persons.	8
	Total	**45**

Text Books:

1. Dimitris Pavlidis, "Fundamentals of Terahertz Devices and Applications", Wiley,August 2021 ISBN: 978-1-119-46071-8
2. Ali Rostami, Hassan Rasooli, Hamed Baghban, "Terahertz Technology: Fundamentals and applications," New York, Springer, 2011.

Reference Books:

1. RE Miles,P Harisson, D Lippens "Terahertz Sources and Systems ",Springer Science+Business media, BV 2000, ISBN 978-94-010-0824-2.
2. Kiyomi Sakai, "Terahertz Optoelectronics", Springer, 2004, ISBN 978-3-540-20013-0.
3. Ho-Jin Song,Tadao Nagatsuma, "Handbook of Terahertz Technologies, Devices and applications", Pan Stanford Publishing Pte. Ltd. 2015, ISBN: 9789814613088.

Prerequisite:

1. Semiconductor Physics
2. Wireless and Optical Communications

Name of the Programme: M.Tech. in Digital Communication	Year: I	Semester: I
Course Name: **Design of MIC's and MMIC's**	Course Code: ECPL116	Credit: 3
Max Marks: 100	CIE: 40	SEE: 60
End Term Exam Time: 3 Hrs	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1** Introduction to Microwave Integrated Circuits (MIC) and Monolithic Microwave Integrated Circuits (MMICs), their advantages over discrete circuits, MMIC fabrication techniques, Thick and Thin film technologies and materials, encapsulation and mounting of active devices in MIC and MMIC.	8
3	**UNIT 2** Hybrid MIC: Definition, characteristics, comparison with conventional circuits, fields of application and limitations and criteria for the choice of substrate material; thin film hybrid circuits, thick film hybrid circuits, artwork, mask making, photolithography, resistor stabilization, sawing, brazing process, wire bonding.	8
4	**UNIT 3** Different Types of MMIC: Advantages, disadvantages and application of MMICs, MMIC fabrication techniques, Thick and Thin film technologies and materials, Encapsulation and mounting of active devices, Introduction to MM-Wave Integrated Circuits, GaAs Fabrication Technology and various processes, Materials used for MM-wave Integrated Guides	10
5	**UNIT 4** Passive Circuit Elements: Transmission lines for Microwave Integrated Circuits, Discontinuities, Lumped elements Passive Components: Introduction, Power transfer in parallel-coupled guides, Parallel Guide Directional Couplers, Other Directional Couplers, Ring Resonator Filters.	8
6	**UNIT 5** Active Semiconductor Circuit Elements: Schottky-barrier diodes, Varactor diodes, p-i-n diodes, MESFETs, HEMTs Active Components: Introduction, Image Guide Detector Circuits, Electronic Phase Shifters, Balanced Mixers, High Frequency Devices, Low Noise MM-wave Amplifiers, Monolithic Mixers..	10
	Total	**45**

Text Book:

1. David H. Schrader, "Microstrip Circuit Analysis" Prentice Hall PTR, New Jersey
2. KC. Gupta, R. Gargand I.J. Bahl , "Microstrip lines and Slot lines"- Artech House.
3. I. D. Robertson, "MMIC Design" The Institution of Electrical Engineers, U.K., 1995

Reference Books:

1. B. Bhat, S. K. Koul, "Stripline-like Transmission lines for Microwave Integrated circuits", Wiley Eastern Ltd., New Delhi.
2. T.C.Edwards, "Foundations for Microstrip Circuit Design (2/e)", Wiley, 1992.
3. Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.

Prerequisite:

1. Microwave Theory & Technique
2. IC technology
3.EMFT

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name:**Optimization Techniques**	Course Code: **NP40.01**	Credit: 3
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme:**CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**Introduction to optimization**: Engineering applications of optimization, Mathematical Modeling and simulation, Formulation of structural optimization problems as programming problems. Graphical method.	7
3	**Linear Programming**: Theory of Simplex Method, Standard form of LPP, feasible solution and basic feasible solution, Improving BFS, Optimality condition, Unbounded solution, Alternative optimal solution, Simplex method, Big M Method, Two phase method.	9
4	**Metaheuristics in Optimization:** Genetic algorithms, Tabu search, particle swarm intelligence and their applications in Engineering	8
5	**PERT & CPM:** Objective of CPM & PERT, elements of network, network rules, constraints, error in network, Critical Path Analysis, Activity time and floats, optimization through CPM techniques, PERT and three estimates, critical path analysis of a PERT network, probability of completion of project, controlling and monitoring.	9
6	**Non-linear Programming:** Local and global minima of one and two variables, constraints optimization, Lagrange's Method, K-T conditions, Steepest descent method, Conjugate gradient method.	11
	Total	**45**

Text Books:

1. S. S. Rao, Engineering Optimization: Theory and Practice , Wiley, 2008.
2. K. Deb, Optimization for Engineering design algorithms and Examples , Prentice Hall, 2 nd edition 2012.

Reference Books:

1. Operations Research, Hira & Gupta,
2. C.J. Ray, Optimum Design of Mechanical Elements , Wiley, 2007.
3. R. Saravanan, Manufacturing Optimization through Intelligent Techniques , Taylor & Francis Publications, 2006.
4. D. E. Goldberg, Genetic algorithms in Search, Optimization, and Machine Learning , Addison-Wesley Longman Publishing, 1989.

Prerequisite:

1. Basic concepts of matrix operations, graph study, differentiation

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Course Name: **Advance Digital Communication Lab**	Course Code**: ECPP130**	Credit**: 2**
Max Marks: **100**	CIE: **60**	SEE: **40**
End Term Exam Time: **2 Hrs**	Teaching Scheme: **60 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	2
2	PCM Encoding and Decoding Use MATLAB • To simulate PCM encoding and decoding processes for an analog signal. • Observe how an analog signal is sampled, quantize, and encoded into a digital form. • To simulate PCM encoding with different quantization levels and observe the resulting quantization error.	16
3	Signal Modulation and Demodulation: • Understand different digital modulation schemes (e.g., BASK, BFSK, BPSK and QPSK). Use MATLAB • simulate and visualize the modulation and demodulation process. • Analyze the effect of noise on different modulation schemes	16
4	Digital Filters Design: Use MATLAB • Design digital filters (e.g., FIR, IIR) . • Apply the designed filters to process digital signals. • Evaluate the performance of different filter designs in terms of frequency response and filter order.	16
5	OFDM System Design: Use MATLAB • To design and simulate an OFDM system. • Analyze the performance of the OFDM system under different channel conditions.	10
	Total	**60**

Text Books:

1."Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris G. Manolakis
2."Discrete-Time Signal Processing" by Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck
3. Digital Signal Processing: A Practical Approach" by Emmanuel Ifeachor and Barrie Jervis

Reference Books:

1. "Digital Signal Processing Using MATLAB" by Vinay K. Ingle and John G. Proakis
2. "Digital Signal Processing Laboratory Using MATLAB" by E. S. Gopi

Prerequisite:

1. Understanding of Digital Modulation techniques
2. Basics of MATLAB Programming
3. Knowledge of Probability and Random Processes
4. DSP concepts such as signal sampling, quantization, Fourier analysis, and digital filtering

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I**
Course Name: **Advance Digital Signal Processing Lab**	Course Code: **ECPP131**	Credit: **2**
Max Marks: **100**	CIE: **60**	SEE: **40**
End Term Exam Time: **2 Hrs**	Teaching Scheme: **60 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	2
2	**(Use Matlab for this Lab)** Introduction to Advanced DSP ● Review of basic DSP concepts ● Complex signals and systems	4
3	Spectral Analysis ● Fourier Transform and Fourier Series ● Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT)	6
4	Advanced Filtering Techniques ● FIR filter design techniques (Windowing methods) IIR filter design techniques (Butterworth, Chebyshev, Elliptic filters) ● Design of Multirate systems (Decimation and Interpolation)	12
5	Statistical Signal Processing ● Random signals and stochastic processes ● Estimation theory (Parameter estimation, Least Squares estimation) ● Detection theory (Hypothesis testing, Signal detection)	12
6	Adaptive Signal Processing ● Adaptive filtering fundamentals ● LMS algorithm and its variants ● Applications of adaptive filters (Noise cancellation, Echo cancellation)	12
8	Advanced DSP Applications ● Image and video processing ● Biomedical signal processing	12
	Total	**60**

Text Books:

1."Digital Signal Processing: Principles, Algorithms, and Applications" by John G. Proakis and Dimitris G. Manolakis
2."Discrete-Time Signal Processing" by Alan V. Oppenheim, Ronald W. Schafer, and John R. Buck
3."Digital Signal Processing: A Practical Approach" by Emmanuel Ifeachor and Barrie Jervis

Reference Books:

1. "Digital Signal Processing Using MATLAB" by Vinay K. Ingle and John G. Proakis
2. "Digital Signal Processing Laboratory Using MATLAB" by E. S. Gopi

Prerequisite:

1.A solid understanding of mathematical concepts relevant to signal processing is essential
2.Proficiency in programming languages commonly used in DSP, such as MATLAB, Python, or C/C++, is important
3.Understanding of advanced signal processing theory beyond the basics is necessary.
4.Since DSP often intersects with digital communications, familiarity with digital modulation techniques, channel coding, and communication systems is advantageous.

Semester

II

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Fiber Optic Communications and Optical Networks**	Course Code: **ECPL201**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme:**CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Introduction to Optical fiber:** LEDs for Optical Communication:Quantum dot LEDs (QLEDs): Emission characteristics, color-tunable LEDs, and applications, Plasmonic LEDs, Nanophotonic LEDs: Photonic crystal LEDs, nanowire LEDs, and metal-insulator-metal (MIM) LEDs for improved light extraction and efficiency, Organic light-emitting diodes (OLEDs): Electroluminescent materials, device architectures, and applications in displays.	8
3	**UNIT 2 Optical sources LASER:** Quantum well lasers: Design, fabrication, and operation principles.Quantum cascade lasers (QCLs): Band structure engineering, mid-infrared (mid-IR) emission, and applications in spectroscopy and sensing. Vertical-cavity surface-emitting lasers (VCSELs): Fabrication techniques, mode control, and high-speed modulation. Widely tunable lasers, High-power diode lasers. Industrial and medical applications.	9
3	**UNIT 3 Photo Detectors and Optical Components:** PIN photodiodes, Avalanche photodiodes Optical Amplifiers: Raman amplifiers, EDFAs and semiconductor optical amplifiers (SOAs) for WDM signal amplification. Optical Modulators: Electro-optic modulators, Mach-Zehnder modulators (MZMs), Semiconductor optical modulators, Semiconductor Optical Switches. Electro-Optic Semiconductor Optical Switches, (MZI) Semiconductor Optical Switches.	9
4	**UNIT 4 Optical Networks: Optical Network Evolution and Concepts:** Optical networking terminology, Optical network node and switching elements, Wavelength division multiplexed networks, Optical network transmission modes, layers and protocols: Synchronous networks, Asynchronous transfer mode, Optical switching networks, Optical network deployment: Long-haul networks, Metropolitan area networks, Access networks, Local area networks.	9
5	**UNIT 5 Applications and Future Trends Optical Communication:** in data centers, optical networks with 5G and beyond, Deployment of dense fiber networks, fiber-to-the-antenna (FTTA) solutions, Optical communication for IoT applications, optical sensors and instrumentation in industrial applications, need for scalability, cost-effectiveness, and energy efficiency in optical networks.	9
	Total	**45**

Text Books:

1.Ghatak A and Tyagarajan K, "Introduction to Fiber optics", Cambridge University Press, 1998
2.Thyagarajan K and Ghatak A., " Fiber Optic Essentials", Wiley Interscience, 2007

Reference Books:

1.Rajiv Ramaswami: "Optical Networks: A Practical Perspective" (3rd edition, 2010); Morgan Kaufman/Elsevier
2.Keiser, Gerd: Optical Fiber Communications, 4th Ed., McGraw Hill (2009).

Prerequisite:

1. Working principle and Types of Fiber
2. Propagation losses and dispersion in optical fiber Commnuication
3.Basics of networking

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Smart Antennas**	Course Code: **ECPL202**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT I : Smart Antennas:** Introduction, Need for Smart Antennas, Overview, Smart Antenna Configurations, Switched-Beam Antennas, Adaptive Antenna Approach, Space Division Multiple Access (SDMA), Architecture of a Smart Antenna System, Receiver, Transmitter, Benefits and Drawbacks, Basic Principles, Mutual Coupling Effects.	10
3	**UNIT 2 : DOA Estimation Fundamentals:** Introduction, Array Response Vector, Received Signal Model, Subspace-Based Data Model, Signal Auto covariance, Conventional DOA Estimation Methods, Conventional Beam forming Method, Capon's Minimum Variance Method, Subspace Approach to DOA Estimation, , ESPRIT Algorithm, Uniqueness of DOA Estimates	9
4	**UNIT 3 : Beam Forming Fundamentals:** Classical Beam former, Statistically Optimum Beam forming Weight Vectors, Maximum SNR Beam former, Multiple Sidelobe Canceller and Maximum, SINR Beam former, Minimum Mean Square Error (MMSE), Direct Matrix Inversion (DMI), Linearly Constrained Minimum Variance (LCMV), Adaptive Algorithms for Beamforming.	9
5	**UNIT 4 : Integration and Simulation of Smart Antennas:** , Antenna Design, Mutual Coupling, Adaptive Signal Processing Algorithms, DOA, Adaptive Beam forming, Beam forming and Diversity Combining for Rayleigh-Fading, Channel, Trellis-Coded Modulation (TCM) for Adaptive Arrays, Smart Antenna Systems for Mobile Adhoc Networks (MANETs), Protocol, Simulations, Discussion.	9
6	**UNIT 5 : Space–Time Processing:** Introduction, Discrete Space–Time Channel and Signal Models, Space– Time Beam forming, Inter symbol and Co-Channel Suppression, Space–Time Processing for DSCDMA, Capacity, and Data Rates in MIMO Systems, Discussion.	8
	Total	**45**

Text Books:

1. Constantine A. Balanis & Panayiotis I. Ioannides, "Introduction to Smart Antennas", Morgan & Claypool Publishers' series-2007
2. Joseph C. Liberti Jr., Theodore S Rappaport, "Smart Antennas for Wireless CommunicationsIS-95 and Third Generation CDMA Applications", PTR – PH publishers, 1st Edition, 1989.

Reference Books:

1.T.S Rappaport, "Smart Antennas Adaptive Arrays Algorithms and Wireless Position Location", IEEE press 1998, PTR – PH publishers 1999.
2.Lal Chand Godara, "Smart Antennas", CRC Press, LLC-20

Prerequisite:

1. Basic understanding of electro-magnetics and antenna theory.
2. Proficiency in signal processing concepts.
3. Familiarity with wireless communication principles.

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Automation using IOT and AI**	Course Code: **ECPL211**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **3L+0T+0P**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Internet of Things (IoT):** Definition, Conceptual Framework, Architectural view, technology behind IoT, Sources of the IoT, M2M Communication, IoT Examples. Design Principles for Connected Devices: IoT/M2M systems layers and design standardization, communication technologies, data enrichment and consolidation, ease of designing and affordability	7
3	**UNIT 2 AI problems, Foundation of AI and History of AI Intelligent Agents:** Agents and Environments, the concept of rationality, the nature of environments, structure of agents, problem solving agents, problem formulation.	7
4	**UNIT 4 Introduction to Automation :** Automated manufacturing systems. Sensors and Actuators in Automation, Digital and analog sensors; Fluid power actuators; Control valves; Electrical system elements; Motors drives; Mechanical devices. Pneumatic and Hydraulic Systems position and pressure sensing	10
5	**UNIT 5 Industrial Robotics -Robot Anatomy:** Work volume – Drive systems – Sensors in robotics – Robot reference frames and coordinates and robot kinematics. End effectors: Mechanical and other types of grippers – Tools as end effectors – Robot end effectors interface. Robot kinematics. Typical applications of robots: material transfer, machine loading/unloading; processing operations; assembly and inspection.	10
6	**UNIT 6 Industry 4.0 & IoT:** Introduction. Digitization, Drivers of Industry 4.0, End-to-end digital integration within a smart factory, IOT Swarm Sensors, RF and wireless sensors module, power management module; Challenges. Cyber-Physical Systems Applications: Smart cities & smart homes, connected vehicles, Healthcare, Machine condition monitoring, Process monitoring and control.	10
	Total	45

Text Books:

1. Kamal, R.,"Internet of Things – Architecture and Design Principles," 1st Edition, Mcgraw Hill,2017.
2. S. Russel and P. Norvig, "Artificial Intelligence – A Modern Approach", SecondEdition, Pearson Education
3. Robert J. Schilling, "Fundamentals of Robotics, Analysis & Control", Prentice Hall, 2009.
4. Mikell P. Groover, "Automation, Production Systems and Computer Integrated Manufacturing", Third Edition, Pearson Education, 2009.

Reference Books:

1. David Poole, Alan Mackworth, Randy Goebel, "Computational Intelligence : a logical approach", Oxford University Press.
2. G. Luger, "Artificial Intelligence: Structures and Strategies for complex problem solving", Fourth Edition, Pearson Education.
3. J. Nilsson, "Artificial Intelligence: A new Synthesis", Elsevier Publishers.
4. Raj, Pethuru, and Anupama C. Raman.The Internet of things: Enabling technologies, platforms, and use cases. Auerbach Publications, 2017.
5. Buyya, Rajkumar, and Amir VahidDastjerdi, eds. Internet of Things: Principles and paradigms. Elsevier, 2016.
6. Antony Espossito, "Fluid power with Applications ", Pearson, Sixth Edition., 2003.
7. Nanua Singh, Tatla Dar Singh., "Systems Approach to Computer-Integrated Design and Manufacturing", John Wiley & Sons, 1995.
8. Bahga, Arshdeep, and Vijay Madisetti.Internet of Things: A hands-on approach. Vpt, 2014.

Prerequisite:

1. Basics of IoT
2. Basics of AI/ML
3. Basics of Mechanics and Kinematics

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Advanced Photonics devices and components**	Course Code: **ECPL212**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	U**NIT 1 Optical Network Components:** Components of Fiber Optic Networks, Couplers/ Splitters, Semiconductor Optical Amplifier, EDFA, Wavelength Division Multiplexers/ Demultiplexers, isolators, Circulators, switches, grating, tunable filters.	7
3	**UNIT 2 Optical Instruments for Test Purpose:** BR Meter, Optical Spectrum Analyzer, Optical power meters, OTDR, Fiber optic Sources- Fiber joints-connectors, splices, Fusion splicers-Fiber polishing-Fiber cable design and structures- Photonic Packaging-Passive and active component packaging	9
4	**UNIT 3 Photonic Crystals:** Photonic band structures-rotational symmetry and irreducible Brillouin zone-time reversal invariance- Bloch wave propagation velocity, Photonic crystals- multilayer film- physical origin of photonic band gaps- the size of the bandgap- evanescent modes in PBG Two dimensional Photonic crystals-localization of light by point defects-linear defects and waveguides, Photonic Crystals: Basics concepts, Bandgap and band structures in two and three dimensional lattices. Photonic crystal fibers (PCF).	10
5	**UNIT 4 Plasmonics:** Drude theory, Surface Plasmons, Localized Surface Plasmons, Enhancement of emission and scattering of light, Local density of states in plasmonic nanostructures, Hot-spots in plasmonic nanostructures, Raman scattering enhancement in metal–dielectric nanostructures	9
6	**UNIT 5 Optical Biosensors:** Fluorescence and energy transfer sensing, molecular beacons and optical geometries of bio-sensing, Laser activated therapy; Photodynamic therapy, photo-sensitizers for photodynamic therapy.	9
	Total	**45**

Text Books:

1. Chuang, Shun Lien, "Physics of photonic devices". John Wiley & Sons, 2012.
2. Saleh, Bahaa EA, and Malvin Carl Teich. "Fundamentals of photonics" John Wiley & sons, 2019

Reference Books:

1. Maier, Stefan A. Plasmonics: fundamentals and applications. Vol. 1. New York: springer, 2007.
2. S O Kasap, Optoelectronics and Photonics: Principles and Practices, International Edition, Pearson Prentice Hall, 2013.

Prerequisite:

1. Optical Engineering
2. Fiber Optics Communication

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Applied Machine Learning**	Course Code: **ECPL213**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Introduction: Introduction to Machine Learning:** Different types of learning, Hypothesis space and inductive bias, Evaluation. Training and test sets, cross validation, Concept of over fitting, under fitting, Bias and Variance. Linear Regression: Introduction, Linear regression, Simple and Multiple Linear regression, Polynomial regression, evaluating regression fit.	8
3	**UNIT 2 Decision Tree Learning:** Decision tree representation, appropriate problems for decision tree learning, the basic decision tree algorithm, hypothesis space search in decision tree learning, inductive bias in decision tree learning, issues in decision tree learning, Python exercise on Decision Tree. Instance based Learning: K nearest neighbour, the Curse of Dimensionality, Feature Selection: forward search, backward search, univariate, multivariate feature selection approach, Feature reduction (Principal Component Analysis), Python exercise on KNN and PCA. Recommender System: Content based system, Collaborative filtering based.	10
4	**UNIT 3 Probability and Bayes Learning:** Bayesian Learning, Naïve Bayes, Python exercise on Naïve Bayes, Logistic Regression. Support Vector Machine: Introduction, the Dual formulation, Maximum margin with noise, nonlinear SVM and Kernel function, solution to dual problem.	9
5	**UNIT 4 Artificial Neural Networks:** Biological motivation, ANN representation, appropriate problem for ANN learning, Perceptron, multilayer networks and the back propagation algorithm	9
6	**UNIT 5 Ensembles:** Introduction, Bagging and boosting, Random forest, Discussion on some research papers. Clustering: Introduction, K-mean clustering, agglomerative hierarchical clustering, Python exercise on k-mean clustering.	8
	Total	**45**

Text Books:

1. Tom Mitchell , “Machine Learning”. . First Edition, McGraw- Hill, 1997.
2. Alpaydin, Ethem. Introduction to machine learning. MIT press, 2020.
3. M.Gopal , “Applied Machine Learning”, 1st Edition, McGraw- Hill.

Reference Books:

1.Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press, 2012.
2. Yegnanarayana, B. “Artificial Neural Networks”, PHI Learning

Prerequisite:

1.Statistics, Linear Algebra,Calculus
2.Probability
3.Programming Languages

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Neural Network and Fuzzy Logic**	Course Code: **ECPL214**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 FUNDAMENTALS OF NEURAL NETWORKS:** Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and-Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Historical Developments, Potential Applications of ANN-single layer net for pattern classification- Biases and thresholds, linear separability - Hebb's Rule- algorithm - perceptron - Convergence theorem-Delta rule	9
3	**UNIT 2 BASIC NEURAL NETWORK TECHNIQUES:** Back propagation neural net:standard back propagation-architecture algorithm- derivation of learning rules number of hidden layers--associative and other neural networks- hetero associative memory neural net, auto associative net- Bidirectional associative memory-applications-Hopfield nets-Boltzman machine	9
4	**UNIT 3 COMPETITIVE NEURAL NETWORKS:** Neural network based on competition: fixed weight competitive nets- Kohonen Self organizing maps and applications-learning vector quantization-counter propagation nets and applications adaptive resonance theory: basic architecture and operation-architecture, algorithm, application and analysis of ART1 & ART2	9
5	**UNIT 4 FUNDAMENTALS OF FUZZY LOGIC:** Basic concepts: fuzzy set theory-basic concept of crisp sets and fuzzy sets- complement- union intersection- combination of operation- general aggregation operations- fuzzy relations-compatibility relations-orderings- morphisms- fuzzy relational equations-fuzzy set and systems	8
6	**UNIT 5 SPECIAL NEURAL NETWORKS:** Cognitron and Neocognitron - Architecture, training algorithm and application-fuzzy associate memories, fuzzy system architecture- comparison of fuzzy and neural systems.	9
	Total	**45**

Text Books:

1. Rajasekharan, Pai , "Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications", PHI Publications.
2. Rajesh Kumar, "Fundamental of Artificial Neural Network and Fuzzy Logic" Lakshmi publications
3. Simon Haykin , "Neural Networks and Learning Machines" Mac Millen College Pub co., New York, 2011.
4. Klier Van, "Fuzzy System & Fuzzy logic" Prentice Hall of India, First Edition.
5. Lawrence Fussett, "Fundamental of Neural network" Prentice Hall , First Edition.

Reference Books:

1. Bart Kosko, "Neural network and Fuzzy System" Prentice Hall-1994.
2. J.Klin and T.A.Folger, "Fuzzy sets - Uncertainty and information" Prentice Hall -1996.
3. Introduction to artificial neural systems by J.M.Zurada-Jaico Publication house,Delhi 1994.
4. Neural Networks by James A Freeman and Davis Skapura, Pearson Education.
5. Neural Networks: A Comprehensive Foundation by S. Haykin-Prentice- Hall India, 2nd Edition, 1999.

Prerequisite:

1. knowledge of fundamentals of set theory, control systems and networks.
2. Microcontroller based system design

Name of the Programme: M.Tech. in Digital Communication	Year: I	Semester: II
Course Name: **Cryptography and Network Security**	Course Code: **ECPL215**	Credit: 3
Max Marks: 100	CIE: 40	SEE: 60
End Term Exam Time: 3 Hrs	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1 Introduction to Network Security:** Introduction - Need for Security, Security Approaches, Principles of Security, Security services, Types of Attacks – General View - Technical View, Programs that Attack, Specific Attacks.	7
3	**UNIT 2 Basics of Cryptography and Encryption:** Introduction to Cryptography, Plain Text and Cipher Text, Symmetric Cipher Model, Cryptography, Cryptanalysis, Brute Force Attacks, Substitution Techniques - Caesar Cipher and Modified Caesar Cipher, Mono Alphabetic cipher, Poly-Alphabetic Cipher, Playfair Cipher, Transposition Techniques- Rail Fence technique, Simple Columnar transposition Technique, Encryption and Decryption-Symmetric and Asymmetric key cryptography, Steganography.	8
4	**UNIT 3 Block ciphers and Data Encryption Standards:** Stream ciphers Block ciphers, Data Encryption Standard, a DES example, AES- structure, AES transformation functions.Public key cryptography and RSA: Principles of public key cryptosystems - public key cryptosystems - applications for public key cryptosystems, RSA algorithm - algorithm and example, Deffie Hellman key exchange algorithm and example.	10
5	**UNIT 4 Cryptographic Data Integrity Algorithms** - Cryptographic Hash functions - applications, Message Authentication – Requirements and Functions. Digital signatures – Introduction, Properties, attacks and forgeries, digital signature requirements. User Authentication mechanisms- Authentication basics, Passwords- Introduction- clear text passwords, Password encryption- Problems with passwords, Authentication tokens- introduction and types, use of smart cards, biometric authentication, Kerberos- introduction and working, Remote user authentication principles, personal identity verification.	11
6	**UNIT 5 Applications of Network Security, Ethical and legal Issues:** Network and internet security -Cloud computing- Data protection on the cloud, cloud security as a service, Web/Internet security protocols- HTTPS, SSL, SSH, Wireless network security, Mobile device security, Email security -Pretty good privacy, S/MIME .Legal and Ethical issues- Introduction to Cybercrime & computer crime, Intellectual property, Privacy, Ethical issues.	8

Total	**45**

Text Books:

1. William Stallings, "Crpyptography and Network security Principles and Practices", Pearson.
2. Wade Trappe, Lawrence C Washington, "Introduction to Cryptography with coding theory", Pearson
3. William Stallings, Network Security Essentials (Applications and Standards), PearsonEducation, India.

Reference Books:

1. W. Mao, "Modern Cryptography – Theory and Practice", Pearson Education.
2. Charles P. Pfleeger, Shari Lawrence Pfleeger – Security in computing – Prentice Hall of India.
3. Robert Bragg, Mark Rhodes, Network Security: The complete reference, Tata McGrawhill, India.

Prerequisite:

1. Digital Electronics
2. Computer Networks
3. Embedded System

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Adaptive Digital Image Processing**	Course Code: **ECPL216**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT 1: Fundamental of Image Processing and Image Transformation :** Fundamental steps in DIP – Image Sampling and Quantization - Basic relationship between pixels. Image enhancement - Spatial Domain: Basic Grey level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters. Color image Processing:Models, Transformation. Image Transforms: Two dimensional Fourier Transform- Discrete cosine transform – Multi resolution analysis – Haar Transform- Discrete Wavelet Transform. Karhunen-Loeve transforms. SVD.	12
3	**UNIT-2: Image Compression, Segmentation & Restoration :I**mage Compression Techniques- Encoding- JPEG and MPEG, TIFF, GIF, PNG WebP standards. Detection of discontinuities – point, corner, edge detection- Thresholding -edge based segmentation-region based segmentation- morphological segmentation - watershed algorithm Descriptors: Boundary descriptors-Region descriptors- Texture descriptors, RANSAC. Image Restoration: Image deformation and geometric transformations, Restoration techniques, Noise characterization, Linear, Position invariant degradations	12
4	**UNIT 3: Recognition and Classification :** Patterns and pattern classes – Introduction to classification – Decision theoretic methods –structural and syntactic classifiers – Clustering techniques – similarity measures – hierarchical methods – K-Means algorithm – Cluster evaluation methods. Convolution neural networks,Region-based CNN, fully convolution networks, Multi-modal networks, Hybrid learning methods.	12
5	**UNIT 4 :Computer Vision Applications :**Face recognition application: personal photo collections – Instance recognition application :Location recognition – Machine learning applications: Deep voting, transfer learning and structured regression for image analysis and categorization.	8
	Total	**45**

Text Books:

1.Rafael C. Gonzalez & Richard E. Woods, “Digital Image Processing”, 4th Edition, 2018, Pearson, USA.
2.David A. Forsyth and Jean Ponce, “Computer Vision: A Modern Approach”, 2nd Edition, 2012, Prentice Hall, Pearson Education

Reference Books:

1.Richard Szeliski, “Computer vision: Algorithm and Applications”, Springer- Verlag, London,2010.
2. Anil K. Jain, Fundamentals of Digital Image Processing, 2015, 3rd Edition, Pearson Education, USA.
3. K.P.Soman, K.I. Ramchandran, N.G.Resmi, Insights into Wavelets, From Theory to Practice, 2013, 3rd Edition, PHI Learning Private Limited, New Delhi, India.
4. Mark Nixon & Alberto Aguado, Feature Extraction, and Image Processing, 2013, 3rd Edition, Elsevier‟s Science & Technology Publications, USA
5. William K. Pratt, Digital Image Processing, 2013, John Wiley Sons, USA.

Mode of Evaluation: Continuous Assessment Test, Quiz, Digital Assignment, Final Assessment Test.

Prerequisite:

1. Signals and Systems
2. Digital Signal Processing
3.Filter Designing

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Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name:**Antenna & Radiating System Lab**	Course Code: **ECPP230**	Credit: **2**
Max Marks: **100**	CIE: **60**	SEE: **40**
End Term Exam Time: **2 Hrs**	Teaching Scheme:**60 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	2
2	Study of antenna parameters i.e., S-parameters, VSWR, Gain, Directivity, Radiation Mechanism, Field Zones, Axial ratio, Polarization, HPBW, Impedance matching, antenna modeling	4
3	Design of half wave dipole antenna using HFSS software	6
4	Design of quarter wave, full wave antenna and comparison of their parameters using HFSS software	6
5	Design of half wave dipole antenna array (Broadside and End fire array) using HFSS software	6
6	Design of Pyramidal Horn antenna using HFSS software	6
7	Design of Parabolic reflector antenna using HFSS software	6
8	Design and Development of Rectangular Microstrip antenna with microstrip inset feed. Compare the simulated and measured parameters (Return loss, VSWR, E- and H-plane radiation Pattern, Directivity, Gain, HPBW, etc.).	6
9	Design and Development of Circular Microstrip antenna with probe feed. Compare the simulated and measured parameters (Return loss, VSWR, E- and H-plane radiation Pattern, Directivity, Gain, HPBW, etc.).	6
10	Design and Simulation of 4-element microstrip antenna array using power divider	6
11	Design a smart antenna as per latest trend and submit a report	6
	Total	**60**

Text Books:

1. J.D. Kraus, RJ. Marhefka and Ahmad S. Khan., "Antennas and Wave Propagation" TMH, New Delhi, 4th ed., (Special Indian Edition), 2010.
2. Harish AR and Sachidananda M, O, "Antenna and Wave Propagation"Oxford University Press, 2007
3. E.C. Jordan and K.G. Balmain., "Electromagnetic Waves and Radiating Systems" PHI, 2nd ed., 2000

Reference Books:

1.C.A.Balanis, Antenna Theory - Analysis and Design, John Wiley & Sons, 1998
2. J.D.Kraus and R.J.Marhefka, Antennas for all Applications, McGraw Hill, 2003
3. G.Kumar and K.P.Ray, Broadband Microstrip Antennas, Artech House, 2000

Prerequisite:

1. Basic Knowledge of Electromagnetics
2. Electronics & Electromagnetic Course
3. Experience with Simulation Tools
4. Mathematical skills

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **II**
Course Name: **Wireless and Fiber Optical Communication Lab**	Course Code: **ECPP231**	Credit: **2**
Max Marks: **100**	CIE: **60**	SEE: **40**
End Term Exam Time: **2 Hrs**	Teaching Scheme: **60 hrs. per semester**	

Module No.	Contents	Hours
1	Introduction: Objective, Scope, Outcome of the Course and Prerequisite	2
2	Design Free-Space Propagation-Path Loss model to determine the free space loss and power received.	4
3	. Realization of WLAN Multipath Channel to plot BER-SNR and Bit Rate -SNR graph for the fading environments of (i)No Fading (ii) Flat Fading	6
4	Realization of WLAN Multipath Channel to plot BER-SNR and Bit Rate -SNR graph for Dispersive Fading environment.	6
5	Implement Amplitude Modulation, Frequency Modulation and Pulse Modulation Techniques	6
6	Setting up of LTE 2x2 MIMO system for establishing two-way communication.	6
7	Observe the effect of noise and dispersion on eye pattern in a communication system .	6
8	Measure insertion loss, reflectance, total loss, attenuation coefficient and fiber break location using OTDR.	6
9	Observe the Four Wave Mixing and Nonlinear Effect in Optical Fiber	6
10	Simulate optical fibre modes with OptiSIM Software	6
11	Setup the WDM link with the given components and determine the total loss for each wavelength	6
	Total	**60**

Text Books:

1. Introduction to Fiber Optics, Ajoy Ghatak and K Thyagarajan, Cambridge University Press, 1998. Reprinted by Foundation Books, New Delhi.
2. Fundamentals of Optical Fiber Sensors, Z. Fang, K.K.Chin, R. Qu, H. Cai, Wiley,2012, New Jersy, USA
3. David Tse, PramodViswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.

Reference Books:

1. G P Agarwal, Academic Press, Boston, 2013
2. G. Keiser, McGraw Hill, 2000

Prerequisite:

1. Knowledge of Fiber Optics ,Optical Communication.
2. Knowledge of wireless communication

Name of the Programme: M.Tech. in Digital Communication	Year: **I**	Semester: **I/II**
Course Name: **Audit Courses**	Course Code: **NP99.XX**	Credit: **0**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **-**	

S. No.	Course Title	Course Code	Credits
1	English for Research Paper Writing	NP99.01	0
2	Disaster Management	NP99.02	0
3	Sanskrit for Technical Knowledge	NP99.03	0
4	Value Education	NP99.04	0
5	Constitution of India	NP99.05	0
6	Pedagogy Studies	NP99.06	0
7	Stress Management by Yoga	NP99.07	0
8	Personality Development through Life Enlightenment Skills	NP99.08	0
9	IoT and Machine Learning	NP99.09	0
10	Data Analytics using Python	NP99.10	0

Semester

III

Name of the Programme: M.Tech. in Digital Communication	Year**: II**	Semester**: III**
Course Name: **Advance 5G Technologies**	Course Code**: ECPL311**	Credit**: 3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme: **CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT-1: 5G Channel Modeling and use Cases:** Modeling requirements and scenarios, Channel model requirements, Propagation scenarios, Relaying multi-hop and cooperative communications: Principles of relaying, fundamentals of relaying, Cognitive radio: Architecture, spectrum sensing, Software Defined Radio (SDR).	10
3	**UNIT-2 :Multiple-input multiple-output (MIMO) systems:** Introduction to Multi- antenna Systems, Motivation, Types of multi-antenna systems, MIMO vs. multi-antenna systems. Diversity, Exploiting multipath diversity, Transmit diversity, Space-time codes, The Alamouti scheme, Delay diversity, Cyclic delay diversity, Space-frequency codes, Receive diversity, The rake receiver, Combining techniques, Spatial Multiplexing.	11
4	**UNIT-3: The 5G Architecture:** Introduction, NFV and SDN, Basics about RAN architecture, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional split alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment	11
5	**UNIT-4 :The 5G Radio-Access Technologies:** Access design principles for multi-user communications, Orthogonal multiple-access systems, Spread spectrum multiple access systems, Capacity limits of multiple-access methods, Sparse code multiple access (SCMA), Interleave division multiple access (IDMA), Radio access for dense deployments, OFDM numerology for small-cell deployments, Small-cell sub-frame structure, Radio access for V2X communication, Medium access control for nodes on the move, Radio access for massive machine type communication	12
	Total	**45**

Text Books:

1. Kushwaha Ritesh Kumar,Sikh Gurmeet Singh, "5G Technologies and Its Applications" JSR Publications,2024
2. Sachan VK, "Fundamentals of 5G Wireless Communications" , JDS Memorial Publications. 2021
3. Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos" , New Directions in Wireless Communication Systems from Mobile to 5G". CRC Press.2019
4. Velrajan Saro, " 5G Wireless Networks", Notion Press.2020.

Reference Books:

1. Manvi Sunilkumar S., "Wireless and Mobile Network ". Wiley Publications,2016
2. Lee Willams, "Wireless and Telecommunications". MGH Publications , 3rd Edition,2006.
3. Behera G K, "Mobile Communication", Scientec Publications, 3rd Edition,2016.
4. Wanshi Chain,Peter Gaal, Juan Montojo, Haris Zisimopoulos,"Fundamental of 5G communications".MGH, 2024.

Prerequisite:

1. Basic Understanding of Telecommunication Principles
2. Understanding of Networking Concepts

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Digital Communication	Year: **II**	Semester: **III**
Course Name: **Nano-Technologies (Devices and Applications)**	Course Code: **ECPL312**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme:**CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT-1: Introduction to Nanomaterials :** Nanotechnology, Frontier of future-an overview, Length Scales, Variation of physical properties from bulk to thin films to nanomaterials, Confinement of electron in 0D, 1D, 2D and 3D systems, Surface to Volume Ratio, Synthesis of Nanomaterials: Bottom-Up approach: Chemical Routes for Synthesis of nanomaterials-Sol-gel, Precipitation, Solution Combustion synthesis, Hydrothermal, SILAR, Chemical Bath Deposition. Top-Down approach- Ball milling technique, Sputtering, Laser Ablation.	10
3	**UNIT-2 :Characterization of Nanomaterials:** Basic principles and instrumentations of Electron Microscopy –Transmission Electron Microscope, Scanning Electron Microscope, Scanning Probes- Scanning Tunneling microscope, Atomic Force Microscope –different imaging modes, comparison of SEM and TEM, AFM and STM, AFM and SEM. Basic principles of working of X-ray diffraction, derivation of Debye- Scherrer equation, numericals on Debye Scherrer equation, Optical Spectroscopy- Instrumentation and application of IR, UV/VIS (Band gap measurement)	11
4	**UNIT-3: Nanotechnology in Energy storage and conversion Solar cells:** First generation, Second generation and third generation solar cells: Construction and working of Dye sensitized and Quantum dot sensitized solar cells. Batteries: Nanotechnology in Lithium ion battery- working, Requirements of anodic and cathodic materials, classification based on ion storage mechanisms, limitations of graphite anodes, Advances in Cathodic materials, Anodic materials, Separators Fuel Cells:Introduction, construction, working of fuel cells and nanotechnology in hydrogen storage and proton exchange membranes	12
5	**UNIT-4: Applications of Nanotechnology:** Nanotech Applications and Recent Breakthroughs: Introduction, Significant Impact of Nanotechnology and Nanomaterial, Medicine and Healthcare Applications, Biological and Biochemical Applications (Nano biotechnology), Electronic Applications (Nano electronics), Computing Applications (Nano computers), Chemical Applications (Nano chemistry), Optical Applications (Nano photonics), Agriculture and Food Applications, Recent Major Breakthroughs in Nanotechnology.	11
	Total	**45**

Text Books:

1. A.K. Bandyopadhyay, " Nano Materials". New Age Publisher, 2014.
2. Kulkarni Sulbha K., " Nano Technolorgy: Principles and Practice", CPC Publications, 2016
3. Rao MS Ramchandra, "Nano Science and Nano Technology". Willey Publications, 2013
4. Droege Peter, "Nano Structured Materials". Elsevier Publishers, 2011
5. M.A. Shah, K.A. Shah, "Nanotechnology: The Science of Small", Wiley India,2020.

Reference Books:

1. 1 C. P. Poole and F. J. Owens, " Introduction to Nanotechnology", Wiley, 2003
2. M. Ratner and D. Ratner, "Nanotechnology", Prentice Hall, 2013
3. M. Wildon, K. Kannagara, G. Smith, M. Simmons and B. Raguse, "Nanotechnology". CRC Press Boca Raton 2020

Prerequisite:

1. Basic Understanding of Electronics Devices & circuits
2. Understanding of materials behaviour.

Swami Keshvanand Institute of Technology, Management & Gramothan, Jaipur

Name of the Programme: M.Tech. in Digital Communication	Year: **II**	Semester: **III**
Course Name: **Embedded Systems**	Course Code: **ECPL313**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme:**CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT-1: Embedded system Basics:** Application domain of embedded systems, General characteristics of embedded systems, figure of merit for an embedded system, Model of an embedded system, Processor fundamentals and its Architecture, Memory for Embedded Systems- Semiconductor Memory, RAM, Dynamic RAM, ROM, Caches, Low Power Design, Pull down and Pull up Resistances, Examples of Embedded system.	10
3	**UNIT-2 :Sensors-** Temperature Sensors, Light Sensors, Proximity/Range Sensors, Encoders, Humidity Sensors, Other Sensors, Analog to Digital Converters, ADC Interfacing, Actuators- Motors, and Relays, Displays, Opto couplers/Opto isolators. Different types of Buses for Embedded systems, Protocols- I2C Protocol, SPI Bus, External Buses, USB, Firewire Port, Standard Serial Port, RS 422/RS 485, Ethernet, Automotive Buses, Controller Area Network (CAN), Wireless Communications Protocols, WLAN (IEEE 802.11), IEEE 802.15 for WPAN.	11
4	**UNIT-3:Introduction to RTOS: RTOS** importance in embedded systems, Task scheduling and management, Inter-task communication and synchronization, RTOS Programming basics.Software programming in C language, C program elements, Object oriented programming approach, Embedded Programming in C++ and Java.	12
5	**UNIT-4: Embedded Design:** A Systems Perspective- Typical Example, Product Design, The Concept of 'Need', Requirements, User's Perspective, User Research, Feasibility Study, Specifications, The Design Process, The Starting Point, Ergonomic Design, Mechanical and Interface Design, Software Design, Hardware Design, Schematic Design, PCB Layout, PCB Manufacturing and Assembly, Testing, Design for Testability (DFT), Levels of Testing, Reliability and 'Standards' Testing, Field Trials, Signature Testing, Bulk Manufacturing, Manufacturing Tests, Yield and Product packing/Delivery.	11
	Total	**45**

Text Books:

1. Lyla B. Das," Embedded Systems an Integrated Approach", Pearson Education, 2016
2. Raj Kamal, “Embedded Systems - Architecture, Programming and Design”, Tata-Mc Graw Hill, 12th Reprint, 2007
3. Kothari D P, “Embedded Systems”, New Age Publications, 2015

Reference Books:

1. Wayne Wolf “Computers as components: Principles of Embedded Computing System Design”, The Morgan Kaufmann Series in Computer Architecture and Design, 2013
2. Shibu K V," Introduction to Embedded Systems", McGraw Hill Education(India) Private Limited, 2014
3. Sriram V Iyer, Pankaj Gupta " Embedded Real Time Systems Programming", Tata McGraw- Hill, 2012.
4. Packol James K. , “Embedded Systems:A Contomprary Design Tool”,Willey Publication , 2010

Prerequisite:

1. Basic understanding of Computer Architectures.
2. Basic understanding of Number Systems.
3. Basic understanding of microprocessors and microcontrollers.
4. Basic understanding of C language.

Name of the Programme: M.Tech. in Digital Communication	Year: **II**	Semester: **III**
Course Name: **Research Methodology & IPR**	Course Code: **NP40.02**	Credit: **3**
Max Marks: **100**	CIE: **40**	SEE: **60**
End Term Exam Time: **3 Hrs**	Teaching Scheme:**CI (45) + TW & SL(45) = 90 hrs. per semester**	

Module No.	Contents	Hours
1	**Introduction:** Objective, Scope, Outcome of the Course and Prerequisite	1
2	**UNIT-1: Research Methodology**: Basic Statistics, Inferential statistics, Central tendency of data, Standard deviation, frequency distribution, level of measurement, Probability distribution, Normal distribution, Correlation, Numerical problems, Introduction to research, Need of research, Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem	9
3	**UNIT-2 :Research Approaches:** Approaches of investigation of solutions for research problems, Sample design, data collection, Regression and Z-test, t-test, ANOVA, analysis, interpretation, Necessary instrumentation's, Effective literature studies approaches, analysis. Plagiarism, Research ethics, examples	9
4	**UNIT-3:Effective Technical Writing**: Development of Research Proposal, citation of references, Report writing, Precautions for writing research reports	8
5	**UNIT-4: Nature of Intellectual Property**: Patents, Designs, Trademarks, and Copyright, Geographical Indications. Process of Patenting and Development, International Scenario, International Cooperation on Intellectual Property	9
6	**UNIT-5: Patent Rights:** Scope of Patent Rights, Licensing and transfer of technology, patent Infringement and Enforcement. New developments in IPR: IPR of Biological Systems, Computer Software, etc. Case Studies on Intellectual Properties	9
	Total	**45**

Text Books:

1. C. R. Kothari, "Research Methodology", New Age Publication, 2nd Revised Edition.2012
2. Deepak Chawla, "Research Methodology-Concept and Cases" , Vikas Publications ,2nd Edition,2020.
3. Dr. Rupinder Tewari and Ms. Mamta Bhardwaj, " Intellectual Property: A Primer for Academia" Honorary Director Publication Bureau, Panjab University Chandigarh.2016.

Reference Books:

1. Rao G Nageswara, "Research Methodology and Quantitative Methods", B S Publications.2008
2. Ganguli Prabuddha, "Intellectual Property rights - 2020". McGraw Hill Education,2020.

Prerequisite:

1. Knowledge of Basic Statistics