Aliah University
DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING
IIA/27, New Town, Rajarhat, Kolkata- 700 160

ALIAH UNIVERSITY

Curriculum and Syllabi of Master of Technology

Programme

In

ELECTRONICS AND COMMUNICATION ENGINEERING

(Specialization in Communication Engineering)
Effective from Academic Session 2021-22 & onwards
(As per CBCS based scheme)

ALIAH UNIVERSITY

Course Structure of 2 year M.Tech Programme
in Electronics and Communication Engineering
(Departmental Code: ECE)

Note: For subjects, if any, with codes initiated by CSE/EEN/MEN/CEN, the concerned departments (CSE/EEN/MEN/CEN) will have to organize the course. The detailed courses in such cases have to be recommended by the concerned departments.

Subject Coding followed

A	B	C	E	F	G	H	X	X

1. **ABC: Three Character Department Code. Where it does not represent any dept. then it is UCE (University Core Elective)**
2. **EF : EF represents PG**
3. **GH: It represents either PC/PE/OE/AU/MC/PR**
4. **XX: 01 to 50 for theoretical subjects and 51 to 99 for labs.**

Credit Summary

1st Semester	2nd Semester	3rd Semester	4th Semester	Total
14	19	15	16	64

First Semester Structure						
SL. No.	**Course Code**	**Course Category**	**Course Name**	**Contacts (periods/week)**	**Credits**	**Remark**
01	ECEPGPC01	Professional Core I	Advanced Digital Signal Processing	3L-0T-0P	3	
02	ECEPGPC02	Professional Core II	Optical Communication and Network	3L-0T-0P	3	
03	*	Professional Elective I		3L-0T-0P	3	
04	**	Professional Elective II		3L-0T-0P	3	
05	UCEPGAU01	Audit Course I	Elementary Arabic and Islamic Studies	4L-0T-0P	0	
06	#	Audit Course II		2L-0T-0P	0	To be selected from list in **Appendix-A**
07	ECEPGPC51	Laboratory I	Optical Communication and Signal Processing Lab	0L-0T-4P	2	
Total credits					**14**	

*** Professional Elective-I:**

1. ECEPGPE01 Theory of Statistical Communication
2. ECEPGPE02 Radar Signal Processing
3. ECEPGPE03 Software Defined Radio and Cognitive Radio

**** Professional Elective II:**

1. ECEPGPE04 Microwave Devices, Circuits and Antenna
2. ECEPGPE05 Phased Array Antenna System
3. ECEPGPE06 Satellite Communication and Remote Sensing

Second Semester Structure						
SL. No.	**Course Code**	**Course Category**	**Course Name**	**Contacts (periods/week)**	**Credits**	**Remark**
01	ECEPGPC03	Professional Core III	Advanced Communication and Networks	3L-0T-0P	3	
02	ECEPGPC04	Professional Core IV	VLSI Architecture for DSP	3L-0T-0P	3	
03	***	Professional Elective III		3L-0T-0P	3	
04	****	Professional Elective IV		3L-0T-0P	3	
05	# #	Open Elective		3L-0T-0P	3	To be selected from list in **Appendix - B**
06	ECEPGPC52	Laboratory II	Advanced Communication and VLSI Architecture for DSP Laboratory	0L-0T-4P	2	
07	ECEPGPR01	Minor Project		0L-0T-4P	2	
Total Credits					**19**	

*** **Professional Elective III:**

1. ECEPGPE07 IoT and Wireless Sensor Networks
2. ECEPGPE08 Advanced Sensor Design
3. ECEPGPE09 Artificial Intelligence

**** **Professional Elective IV:**

1. ECEPGPE10 Microwave Integrated Circuits
2. ECEPGPE11 Smart Antennas
3. ECEPGPE12 Computational Electromagnetics

Third Semester Structure						
SL. No.	**Course Code**	**Course Category**	**Course Name**	**Contacts (periods/week)**	**Credits**	**Remark**
01	*****	Professional Elective V		3L-0T-0P	3	
02	ECEPGPR02	Research Methodology & IPR		2L-0T-0P	2	
03	ECEPGPR03	Dissertation I		0L-0T-20P	10	
Total credits					**15**	

*******Professional Elective V**

1. ECEPGPE13 Mobile Networks and Computing
2. ECEPGPE14 Multimedia Communication
3. ECEPGPE15 Security in Mobile Networks

Fourth Semester Structure						
SL. No.	**Course Code**	**Course Category**	**Course Name**	**Contacts (periods/week)**	**Credits**	**Remark**
01	ECEPGPR04	Dissertation II		0L-0T-20P	16	01
Total credits					**16**	

Appendix-A

List of Audit Course II

Sl No.	Course Code	Course Name
1	UCEPGMC01	Pedagogy Studies
2	UCEPGMC02	English for Research Paper Writing
3	UCEPGMC03	Disaster Management
4	UCEPGMC04	Sanskrit for Technical Knowledge
5	UCEPGMC05	Value Education
6	UCEPGMC06	Constitution of India
7	UCEPGMC07	Stress Management by Yoga
8	UCEPGMC08	Personality Development through Life Enlightenment Skills

Appendix-B

List of Open Elective Course

SL No	Code	Course	Offering Department
1	CSEPGOE01	Image Processing	Computer Science and Engineering
2	CSEPGOE02	Data Analytics	
3	CSEPGOE03	Internet of Things	
4	CENPGOE01	Operations Research	Civil Engineering
5	CENPGOE02	Waste to Energy	
6	CENPGOE03	Remote Sensing & GIS	
7	EENPGOE01	Optimization in Engineering	Electrical Engineering
8	EENPGOE02	Essentials of Renewable Energy System	
9	EENPGOE03	Industrial Automation & Control	
10	**ECEPGOE01**	**Laser Systems and Applications**	**Electronics and Communication Engineering**
11	**ECEPGOE01**	**Cyber Physical Systems**	
12	**ECEPGOE01**	**Signal and Image Processing**	
13	MENPGOE01	Materials Engineering	Mechanical Engineering
14	MENPGOE02	Finite Elements Analysis	
15	MENPGOE03	Non Conventional Energy Sources	

N.B: Courses given in the SL. No. 10-12 cannot be opted by the students of ECE department.

Detailed Syllabus
(Professional Core and Professional Electives)

Outcomes (POs) and Programme Specific Outcomes (PSOs) :

Departmental programs are well organized to provide the following outcomes. **Programme Outcomes(PO)** are general outcomes but there are some specific outcomes known as **Programme Specific Outcomes(PSO).**

PO-1: Engineering Knowledge: Apply the knowledge of mathematics, science, Electronics and Communication engineering fundamentals to the solution of complex engineering problems.
PO-2: Problem Analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO-3: Design/Development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO-4: Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO-5: Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO-6: The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO-7: Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO-8: Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO-9: Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO-10:**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and
write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO-11:Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO-12: Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

PSO-1:
An ability to understand the advanced concepts of Electronics & Communication Engineering and to apply them to study, investigate, design and develop solutions on different areas such as Communication Systems , Analog and Digital Electronics Devices and Circuits , Microprocessor and Embedded systems , Signals and Image processing, VLSI etc.

PSO-2: To develop a centre of excellence for learning and research in the field of RF , microwave , mmWave and photonics communication system and relevant emerging areas.

PSO-3: To make the department a seat for learning and research of new innovative ideas in the field sustainable technological development in Electronics and communication engineering. Thus creation of innovation and entrepreneurship.

PC	ECEPGPE01	Advanced Digital Signal Processing	3L-0T-0P	3 Credits

Course Outcomes (CO's):

After the successful completion of the course, students will be able to:

1. **Learn** the analysis of discrete time signal processing.
2. **Understand** and apply the modern digital signal processing algorithms in various applications.
3. **Understand** different adaptive algorithms and filters like Wiener Filter, Steepest descent algorithms, LMS, NLMS, Recursive filter, Frequency domain adaptive filters etc. Hence **Recognize** situations where adaptive systems may provide a good solution
4. **Implement** Multirate signal processing techniques and apply them in real world data.

Module	Content	Lecture
Module I	Introduction to Multi-rate Digital Signal Processing – Sample rate reduction – decimation by integer factors- sampling rate increase – interpolation by integer factor – Design of practical sampling rate converters Filter Specification- filter requirement for individual stages – Determining the number of stages and decimation factors – Sampling rate conversion using poly-phase filter structure – poly-phase implementation of interpolators.	**8**
Module II	**Introduction to Adaptive Systems: Adaptive Systems:** Definitions, Characteristics, Applications, Example of an Adaptive System. The Adaptive Linear Combiner - Description, Weight Vectors, Desired Response Performance function - Gradient & Mean Square Error	**7**
Module III	**Development of Adaptive Filter Theory & Searching the Performance surface:** Introduction to Filtering - Smoothing and Prediction – Linear Optimum Filtering, Problem statement, Principle of Orthogonality - Minimum Mean Square Error, Wiener- Hopf equations, Error Performance - Minimum Mean Square Error. **Searching the Performance Surface** – Methods & Ideas of Gradient Search methods -Gradient Searching Algorithm & its 3zSolution - Stability & Rate of convergence - Learning Curves.	**10**

Module IV	**Steepest Descent Algorithms:** Gradient Search by Newton's Method, Method of Steepest Descent, Comparison of Learning Curves. **LMS Algorithm & Applications:** Overview - LMS Adaptation algorithms, Stability &Performance analysis of LMS Algorithms - LMS Gradient & Stochastic algorithms - Convergence of LMS algorithm-Normalized LMS algorithm-Advantages of NLMS over LMS. **Applications:** Noise cancellation – Cancellation of Echoes in long distance telephone circuits, Adaptive Beam forming.	**10**
Module V	Frequency domain algorithms, Least Squares Estimation, Recursive Least Squares algorithm.	**5**

Text/Reference Books:

1. Digital Sinal Processing: A Computer Based approach, Sanjit K. Mitra, McGraw Hill Education
2. Adaptive Filter Theory Fourth Edition by Simon Haykin
3. Digital Signal Processing Emmanuel C Ifeachor, Barrie W Jrevis, Pearson Education
4. Adaptive Signal Processing, Bernie Widrow and Stearns, Prentice Hall,
5. Fundamentals of Adaptive Filtering, Ali Sayed, Wiley, 2003
6. Theory and Applications of DSP L.R Rabiner and B gold
7. Electronic filter Design Hand Book A .B Williams and FT Taylor, McGraw Hill
8. Wavelets and Subband Coding Valterli &Kovaceric, PHI.
9. Analog Devices & Texas Instruments Users Manuel of TMS320C4X and ADSP 2106x.
10. Fundamentals of Statistical Signal Processing: Estimation Theory by Steven Kay, Prentice Hall, 1993
11. Kernel Adaptive Filtering, Liu, Principe and Haykin, Wiley 2010

PC	ECEPGPC02	**Optical Communication and Network**	**3L-0T-0P**	**3 Credits**

Course Outcomes(CO):

At the end of this course the students will be able to

CO1: Understand the fundamental concepts of optical communication systems

CO2: Design and analyze optical communication systems

CO3: Know operations and applications of optical networks

Module	Content	Lecture
Module 1	**Overview of Optical Fiber Communication** Introduction, Evolution of Light wave Systems, Basic concepts of analog & digital signal, modulation types & formats, multiplexing, data hierarchies	**4**
Module 2	**Optical Fiber** Review of fiber types and transmission characteristics, Wave equation for step index fiber, Bessel equation and its solution, Eigen value equation and concept of Modes, LP modes, fiber	**6**

	birefringence, spot size, confinement factor, Dispersion characteristics and management, Nonlinear optical effects-SBS, SRS and Nonlinear Phase Modulation-SPM, XPM, FWM	
Module 3	**Optical Sources and Optical Modulators** Tunable laser sources, Optical Phase/Intensity Modulators	**4**
Module 4	**Optical Receiver Noise and Receiver Sensitivity** Noises for P-I-N and APD type receiver, Receiver Sensitivity, BER, Q-parameter, Sensitivity degradation	**4**
Module 5	**Lightwave Systems** System Architectures-point to point links, distribution networks and local area networks, Design Guidelines-loss limited & dispersion limited lightwave systems, link budgeting & rise time budgeting calculation	**4**
Module 6	**WDM Concepts and Components** High capacity WDM lightwave systems, Optical Amplifiers, WDM Components-Star Couplers, Circulators, Fiber Bragg grating, Tunable Optical Filters, Add/Drop Mux/DeMux, Optical Cross Connects, Optical MEMS, Wavelength Router, Wavelength Converters	**6**
Module 7	**Integrated Optics and Photonic Circuits** Integrated Optics Technology-material and process, Wave guiding-couple mode theory, IO Devices, Applications, Photonic Switching	**4**
Module 8	**Optical Networks** Network Concepts, Topologies, SONET/SDH, Multiple Access WDM Networks, Passive Optical Networks, IP over DWDM, Optical Ethernet	**8**

Text/Reference Books:

1. G Keiser, *'Optical Fiber Communications'*, McGraw Hill Education, India
2. D K Mynbaev and L L Scheiner, *'Fiber Optic Communication Technology'*, Pearson
3. John Gowar, *'Optical Communication Systems'*, PHI
4. John M Senior, *'Optical Fiber Communications: Principles and Practice'*, PHI
5. R Ramaswamy and K N Sivarajan, 'Optical Networks: A Practical Perspective', Elsevier Morgan Kaufmann Publishers

PECI	**ECEPGPE01**	**Theory of Statistical Communication**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO):

At the end of this course the students will be able to

1. To learn principles of advanced engineering mathematics through linear algebra
2. Learn the idea of random variables (discrete/continuous) and probability distributions in analyzing the probability models arising in electronic communication system.
3. Analyze random process through parameter-dependent variables in various random processes
4. Design optimal filters for application in communication system.

Module	Content	Lecture
Module 1	**LINEAR ALGEBRA AND NUMERICAL ANALYSIS**:	**6**

	Vectors, Linear independence, vector spaces and basis vectors, Matrices, Linear equations, solutions of simultaneous linear and non-linear equations, Special matrix forms – diagonal matrix, exchange matrix,triangular matrix, Toeplitz matrix, Hankel matrix, symmetric matrix, parametric matrix, centro symmetric matrix, Quadratic and Hermitian forms, solution of matrix eigen value and eigen vectors and optimization theory.	
Module 2	**DISCRETE-TIME RANDOM PROCESSES:** Definition and description of random processes with practical examples. Time average, ensemble average, covariance, autocorrelation, cross correlation. Stationary process, ergodic process, WSS process, power spectrum of random processes. Filtering of random processes – filtering of white noise, spectral shaping filter, spectral factorization. Special random processes – Autoregressive moving average process (ARMA model), autoregressive process (AR model), moving average process, harmonic process (MA model).	**8**
Module 3	**SIGNAL MODELING**: Least squares method, Padé approximation method, filter design using Padé approximation, Prony's method of signal modeling, filter design using Prony's method, FIR least square inverse filter, iterative prefilters, Stochastic models – ARMA model, AR model, MA model.	**4**
Module 4	**OPTIMUM FILTERS:** The FIR Wiener filter, linear prediction, noise cancellation, Lattice representation for the FIR Wiener filter, The IIR Wiener filter, The noncausal and causal IIR Wiener filter, causal Wiener filtering, causal Wiener prediction Wiener deconvolution and discrete Kalman filter.	**6**
Module 5	**THEORIES AND HYPOTHESIS OF PROBABILITY AND STATISTICS**: Definition and postulates of probability, Field of probability, mutually exclusive events, Decision theory, Bay's likelihood ratio, ideal observer strategy, Neyman-Pearson strategy, Bay's strategy for single and multiple sample values, optimum linear estimation composite hypothesis testing, optimum detection with incomplete knowledge of the signal, adaptive detection and estimation. Bernoulli trial, Discrete Distributions, Continuous distributions, Probable errors, Linear regression, Introduction to non-linear regression, Correlation, Analysis of variance.	**8**

Text/Reference Books:

1. An Introduction to Statistical Communication Theory- John B. Thomas, Wiley.
2. Statistical digital signal processing and modelling, - Monson N. Hays – Wiley
3. Detection, Estimation and Modulation theory– Part I/ Edition 2,- Harry L. Van Trees, John Wiley & Sons, NY, USA, 2013.
4. Numerical Mathematical Analysis- J. B. Scarborough, Oxford University Press

5. Elementary Numerical Analysis- S. D. Cone, Mc. Graw Hill.
6. Introduction to Mathematical Probability- J. V. Uspensky, Tata Mc. Graw Hill
7.Digital communication, 4th ed. - J. G. Proakis, MGH International edition

PEC I	**ECEPGPE02**	**RADAR SIGNAL PROCESSING**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO):

At the end of this course the students will be able to

1. Understand the basic principles of Radar communication
2. Apply the concepts gained form Doppler and MTI radar signal processing for target identifications.
3. Apply the concepts of SAR for different applications like remote imaging and sensing
4. Conceptualize the computational aspects of beam forming and space time adaptive signal processing (STAP)

Module	Content	Lecture
Module 1	A Preview of Basic Radar Signal Processing, Radar range equation, Signal Models, components of a Radar Signal, Amplitude Models, clutter, Noise Model and Signal -to -Noise Ratio, Jamming, Frequency Models-The Doppler Shift, Spatial Models, Spectral Model	**6**
Module 2	Sampling and Quantization of Pulsed Radar Signals, Domains and Criteria for Sampling Radar Signals, Sampling in the Fast Time Dimension, Sampling in Slow Time – Selecting the Pulse Repetition Interval, Sampling the Doppler Spectrum, Sampling in the Spatial and Angle Dimensions, Quantization, I/Q Imbalance and Digital I/Q	**8**
Module 3	Doppler Processing, Alternate Forms of the Doppler Spectrum, Moving Target Indication (MTI), Pulse Doppler Processing, Pulse Pair Processing, Additional Doppler Processing Issues, Clutter Mapping and the Moving Target Detector, MTI for moving platforms	**6**
Module 4	Introduction to Synthetic Aperture Imaging, Introduction to SAR Fundamentals, Stripmap SAR Data Characteristics, Stripmap SAR Image Formation Algorithms, Spotlight SAR Data Characteristics, the Polar Format Image Formation Algorithm for Spotlight SAR, Interferometric SAR	**8**
Module 5	Introduction to Beamforming and Space-Time Adaptive Processing- Spatial Filtering, Space-Time Signal Environment, Space Time Signal Modeling, Processing the Space Time Signal, Computational issues in STAP, Reduce – Dimension STAP, Advanced STAP Algorithms and Analysis, Limitations to STAP.	**8**

Text/Reference Books:

1. M.I. Skolnik, *Introduction to Radar Systems*, 3rd Edition, 2001, TMH.
2. Mark A. Richards, *Fundamentals of Radar Signal Processing*, McGraw Hill
3. A Hein, *Processing of SAR Data: Fundamentals, Signal Processing, Interferometry*, 2010,Springer
4. Fred E. Nathanson, *Radar Design Principles: Signal Processing and The Environment*, 2nd Edition, 1999, PHI.
5. Peyton Z. Peebles, Jr., *Radar Principles*, 2004, John Wiley.
6. R. Nitzberg, *Radar Signal Processing and Adaptive Systems*, 1999, Artech House.
7. F.E. Nathanson, *Radar Design Principles*, 1st Edition, 1969, McGraw Hill.
8. Bassem Mahafza, *Radar Signal Processing and Analysis using Matlab*, 2010,CRC Press

PECI	**ECEPGPE03**	**SOFTWARE DEFINED RADIO AND COGNITIVE RADIO**	**3L-0T-0P**	**3Credits**

Course Outcomes (CO):

At the end of this course the students will be able to

1. Understand the concept of cognitive radio.
2. Implement RF issues related to cognitive radio system
3. Work with various digital system for software defined radio and cognitive radio
4. Research on techniques related to cognitive radio

Module	Content	Lecture
Module 1	**INTRODUCTION TO SOFTWARE RADIO CONCEPTS :** The need for software radios, what is a software radio, characteristics and benefits of a software radio, Design principles of a software radio.	**6**
Module 2	**RADIO FREQUENCY IMPLEMENTATION ISSUES :** The purpose of the RF front-end, Dynamic range: The principal Challenge of receiver design, RF receiver front-end topologies, Enhanced flexibility of the RF chain with software radios, Importance of the components of overall performance, transmitter architectures and their issues, noise and distortion in the RF chain, ADC and DAC distortion.	**8**
Module 3	**DIGITAL HARDWARE CHOICES :** Introduction, Key Hardware Elements, DSP Processors, FPGA, Tradeoffs in using DSPs FPGAs and ASICs, Power Management Issues , Combinations of DSPs , FPGAs and ASICs.	**6**
Module 4	**INTRODUCTION TO COGNITIVE RADIOS:** Digital dividend, cognitive radio (CR) architecture, functions of cognitive radio, dynamic spectrum access (DSA), components of cognitive radio, spectrum sensing, spectrum analysis and decision, potential applications of cognitive radio.	**8**
Module 5	**SIGNAL PROCESING :** Spectrum sensing, detection of spectrum holes (TVWS), collaborative sensing, geo-location	**8**

	database and spectrum sharing business models (spectrum of commons, real time.	
Module 6	**DYNAMIC SPECTRUM ACCESS AND MANAGEMENT:** Spectrum broker, cognitive radio architectures, centralized dynamic spectrum access, distributed dynamic spectrum access, learning algorithms and protocols.	

Text/Reference Books:

1. Software Radio: A Modern Approach to Radio Engineering By Jeffrey H. Reed Pearson Education Low Price Edition
2. Dynamic Spectrum Access and Management in Cognitive Radio Networks, Ekram Hossain, Dusit Niyato, Zhu Han, Cambridge University Press.
3. Cognitive radio networks, Kwang-Cheng Chen, Ramjee Prasad, John Wiley & Sons Ltd.
4. Cognitive Radio, Software Defined Radio, and Adaptive Wireless Systems, Huseyin Arslan, Springer.

PEC II	**ECEPGPE04**	**Microwave Devices, Circuits and Antenna**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO's):

At the end of this course the students will be able to

1. To know and understand different microwave devices.
2. To know the concept of VNA and other microwave circuits.
3. To know different types of feed, DRA and Meta material antennas.
4. To understand microwave e propagation, link budget etc.
5. To know and apply different microwave measuring techniques.

Module	Content	Lecture
Module1	**Microwave wave Devices:** Overview of Gunn devices, oscillator using Gunn diode, PIN diode, IMPATT devices, Klystron, and microwave and mm wave performance of IMPATT, Tunnel diode, BARITT and TRAPAT.	**8**
Module2	**Microwave Circuits:** Review of scattering matrix concept in the light of vector network analyzer, impedance matching network, couplers, power dividers, resonators and filters, Detectors, mixers, attenuators	**8**
Module3	**Antennas:** Different Types of feed Technology: Probe feed, Slot coupled microstrip feed, coplanar feed. Different Types of CPW feed: Inductive, capacitive, square and circular feed. Advance antennas for communication system: Dielectric resonator antenna (DRA), Meta-material in antenna, Microstrip antenna, Smart antenna, Conformal antenna.	**10**
Module4	**Microwave propagation:** Overview of basic radio wave propagation mechanisms, Friis transmission formula, plane earth propagation model, microwave radio link and calculation of link budget. Effect on radio wave propagation due to rain, fog, snow, ice, atmospheric gases, Earth's magnetic field.	**8**
Module 5	**Microwave Measurements:** Measurement of Wavelength, Frequency and Impedance-Introduction,	**6**

	Equivalent circuit of Cavity wave meters, Typical wave meters, resonant cavities, Methods of frequency measurements-direct method - Interpolation method, Standard wave reflectors, Measurement of reflection coefficient, Low, Medium, High VSWR measurements, Standing wave pattern, Slotted Line section and its limitation, Impedance measurement techniques, Reflectometer.	

Text/Reference Books

1. David M Pozar, Microwave Engineering, John Wiley & Sons
2. R E Collin, Antenna & Radio wave Propagation, McGraw Hill Book Co.
3. Jordan & Balman, Electromagnetic waves & Radiating System
4. R E Collin, Microwave Engineering, McGraw Hill CO.

PECII	ECEPGPE05	Phased Array Antenna System	3L-0T-0P	3Credits

Course Outcomes (CO):

At the end of this course the students will be able to

CO 1. To know and understand basic of phase array radar and its architecture.
CO2. To get the knowledge of cell, grid, grating lobes and array.
CO3. To know and understand different feed networks for phase arrays.
CO4. To know frequency scanned array designs.

Module	Content	Lecture
Module1	**Phased Arrays in Radar and Communication Systems:** Introduction, System Requirements for Radar and Communication Antennas, Array Characterization for Radar and Communication Systems, Array Architecture and Control Technology	**8**
Module2	**Array Theory:** Linear and Planar arrays, various grid configurations, Concept of cell and grid, Calculation of minimum number of elements, Radiation pattern, Grating lobe formation, Rectangular and triangular grid design of arrays.	**8**
Module3	**Feed Networks for phased Arrays:** Corporate Feed, Lens and Reflect feed Techniques, Optimum f/d ratio, basic building block for corporate feed network, Series, Parallel feed networks, Comparison of various feeding techniques, Antenna Array Architecture, Brick/ Tile Type construction.	**8**
Module4	**Frequency Scanned Array Design:** Snake feed, Frequency-phase scanning, Phase scanning, Digital phase shifter PIN diode and Ferrite phase shifters for phased arrays, Beam pointing errors due to digitization, Beam pointing accuracy.	**8**
Module 5	**Search Patterns:** Calculation of search frame time, airborne phased array design, electronic scanning radar, parameter calculation, Application of phased arrays, Phased Array Radar Systems, Active Phased Array, TR/ATR Modules.	**8**

Text/Reference Books:

1. Robert J. Mailloux, "Phased Array Antenna Hand Book", Artech House, Boston, London, 1994
2. Olliner, A.A, and G.H. Knittel, "Phased Array Antennas", Artech House, 1972.
3. Kahrilas. PJ, "Electronic Scanning Radar Systems Design Handbook", Artech House, 1976.
4. Skolnik. MI, "Radar Handbook", Mc Graw Hill, NY, Mc Graw Hills-2007
5. Galati,G-(editor), "Advanced Radar Technique and Systems", Peter Peregrinus Ltd, London, 1993

PECII	ECEPGPE06	SATELLITE COMMUNICATIONS AND REMOTE SENSING	3L-0T-0P	3Credits

Course Outcomes (CO):

At the end of this course the students will be able to
CO1: Able to understand the communication satellite design.
CO2: Able to understand how analog and digital technologies are used for satellite communication networks.
CO3: Able to learn the design of satellite links.
CO4: Able to study the design of Earth station and tracking of the satellites.

Module	Content	Lecture
Module1	**Introduction:** A brief history of satellite communication, future scope satellite communication. Orbital Mechanism: Orbits, look angle, orbital period and velocity, azimuth and orbital inclination, coverage angle slant range, orbital perturbation, placement of satellite in geostationary orbit.	**4**
Module2	**Satellite Subsystems:** Attitude and Orbit Control system, TT&C subsystem, Attitude Control subsystem, Power systems, Communication subsystems, Satellite Antenna Equipment.	**4**
Module3	**Satellite Link Design:** Basic link analysis, interference analysis, attenuation due to rain, Design of satellite link with specified C/N(with and without frequency reuse). Link budget. Propagation effects and their impact on satellite earth link.	**6**
Module4	**Multiple Access Techniques:** Frequency Division Multiple Access (FDMA) - Intermodulation, Calculation of C/N,Time Division Multiple Access (TDMA) - Frame Structure, Burst Structure, Satellite Switched TDMA,On-board Processing, Demand Assignment Multiple Access (DAMA) – Types of Demand Assignment,Characteristics, CDMA Spread Spectrum Transmission and Reception. Introduction to VSAT systems: low earth orbit and non-geostationary satellite systems. Direct broadcast Television and Radio.	**8**
Module 5	**Satellite Navigation and the Global Positioning System**: Radio and Satellite Navigation, GPS Position, Location Principles, GPS Receivers, GPS C/A Code, Accuracy, Differential GPS.	**8**
Module 6	**Remote Sensing:** Basic of remote sensing, Electromagnetic Radiation principles, Atmospheric window, Indian satellite sensing satellite system, Active, Passive, ground based and space based remote sensing. 2. Spatial, spectral, Radiometric and temporal resolution, satellite sensors, detectors and scanning technique, FOV and error sources, Image analysis and Interpretation weather RADAR, LIDAR, acoustic sounding systems, TRMM, AURA-MLS, Megha Tropiques Alitmeter , Scatterometer, Radiometer. 3. Ground based and radio oceulation	**10**

	techniques, spectral response of water, Sea surface temperature, wind spced, colour monitor, clouds and acrosal, water vopor, convective system, Trace gases.	

Text/Reference Books:

1. Timothy Pratt, Charles Bostian, Jeremy Allnutt, "Satellite Communications", 2nd Edition, 2003, John Wiley & Sons.
2. Wilbur, L. Pritchand, Robert A. Nelson and Heuri G. Suyderhoud, "Satellite Communications Engineering", 2nd Edition, Pearson Publications.
3. Tri. T. Ha, "Digital Satellite Communications", 2nd Edition, 1990, Mc. Graw Hill.
4. Dennis Roddy, "Satellite Communications", 2nd Edition, 1996, McGraw Hill.
5. B. S. Rao, " Global Navigation satellite systems" ,TMH.
6. 5. B. Bhatta , "Remote Sensing and GIS" - Oxford University Press
7. J.R. Jenson , "Remote Sensing of the Environment", 2nd Edition, Pearson
8. R. N. Mutagi, Satellite Communication: Principles and Applications, Oxford, 2016.

Laboratory-I	**ECEPGPC51**	**Optical Communication and Signal Processing Lab**	**0L-0T-4P**	**2Credits**

Course Outcomes (CO):

At the end of this course the students will be able to understand the concepts of Optical Communication and Signal Prosessing through hands-on and practical experiments.

List of Experiments:

Part-A:

Sl. No.	Name of the Experiments
1.	Study of GVD on Gaussian pulse propagation
2.	Study of non linear fiber optic effects: XPM and FWM
3.	Study of transmitter using LED and its modulation characteristics
4.	Study of transmitter using Laser and its modulation characteristics
5.	Design of optical transmitter using external modulator-Mach-Zehnder/$LiNob_3$
6.	Study of fiber optic receiver noise characteristics
7.	Study of EDFA-basic concepts
8.	Study of EDFA gain optimization for WDM
9.	Study of 16 Ch WDM network
10.	Performance analysis of bi-directional broadband optical network(BPON)

Part B:

1	Introduction to Generation of different sequences
2	Simulation of sampled Sinusoidal signal, various sequences and different arithmetic operations.
3	Input-Output Relations in the Time-Domain of an UP-SAMPLER and a Down-SAMPLER
4	Input-Output Relations in the Frequency Domain of an Up-Sampler
5	Input-Output Relations in the Frequency Domain of an Down-Sampler
6	Decimator and Interpolator Design and Implementation
7	Fractional-Rate Sampling Rate Alteration
8	Design of Filter Banks
9	Design of Nyquist Filters
10	TMS320C6713 DSP STARTER KIT (DSK) Digital Signal Processing Board
11	Generation of Sine wave and Square wave using TMS320C6713 DSK FIR and IIR filter design using 6713 processor
12	DFT and FFT using 6713 processor
13	A study on DM6437 Digital Video Development platform- for Audio, Image/ Video
14	Applications (MATLAB/SIMULINK Compatible) Design and implementations of adaptive signal processing and their applications

PCC	**ECEPGPC03**	**ADVANCED COMMUNICATION AND NETWORKS**	**0L-0T-4P**	**2 Credits**

Course Outcomes (CO):

At the end of this course the students will be able to :

CO1: Understand and appreciate the need of various modulation and spread spectrum techniques. CO2:.Analyze the properties of basic Modulation techniques and apply them to Digital Communication

CO3: Apply different types of M-ary mod-demod techniques for digital communication

CO4: Understanding MIMO system for wireless communication

Module	Content	Lecture
Module1	**Baseband Transmission and Reception Techniques:** Fundamentals of Digital transmission through band limited channels, Power spectrum of digitally modulated signals, Signal design for band limited channels, Band limited signal design for zero ISI, Band limited signal design for controlled ISI. Probability of error in detection of digital PAM, Eye pattern, Channel equalization, Linear Equalizers, Adaptive equalizers, Decision feedback equalizers, fractionally spaced equalizers.	6
Module2	**Inphase and Quadrature (I-Q) Modulation and Demodulation**: Binary modulation schemes, Coherent and non-coherent detection of binary modulation schemes, Performance analysis of binary modulation schemes under AWGN channel, Minimum Shift Keying (MSK), Gaussian Minimum Shift Keying (GMSK). M-ary Phase Shift Keying, M-ary Quadrature Amplitude Modulation, M-ary Frequency Shift Keying, Performance analysis of M-ary modulation schemes under AWGN channel, non-coherent detection of M-ary orthogonal signals, Carrier and timing recovery, Synchronization, Applications.	**10**
Module3	**Multichannel and Multicarrier Systems:**Basic Principles of Orthogonality, Single vs. Multicarrier Systems,OFDM Block Diagram and Its Explanation, OFDM Signal Mathematical Representation, Selection parameter for Modulation, Peak-to-mean power ratio, Synchronization, Pulse shaping in OFDM Signal and Spectral Efficiency, Window in OFDM Signal and Spectrum, Synchronization in OFDM, Pilot Insert in OFDM Transmission and Channel Estimation, Amplitude Limitations in OFDM, FFT Point Selection Constraints in OFDM, CDMA vs OFDM, Hybrid OFDM.	**8**
Module4	**MIMO Systems:** Introduction, Space Diversity and System Based on Space Diversity, Smart Antenna system and MIMO, MIMO Based System Architecture, MIMO Exploits Multipath, Space – Time Processing, Antenna Consideration for MIMO, MIMO Channel Modeling, MIMO Channel Measurement, MIMO Channel Capacity, Cyclic Delay Diversity (CDD), Space Time Coding, Advantages and Applications of MIMO in Present Context, MIMO Applications in 3G Wireless System and Beyond, MIMO-OFDM.	**8**
Module 5	**Wireless Networks and Mobile IP**: Infrastructure of Wireless Networks, Wireless LAN Technologies, IEEE 802.11 Design Issues, IEEE 802.11 Services IEEE 802.11 a/b/g/n Higher Rate Standards, Typical WLAN Hardware, Wireless PANs/IEEE 802.15x, Wireless PAN Applications and Architecture, Wireless MANs /IEEE 802.16x, Mobile IP, Wireless Mesh Networks (WMNs), Bluetooth networks, WiMAX, and RFID.	**8**

Text/Reference Books:

1.Bernard Sklar,"Digital Communications", 2nd Edition Pearson Education
2. J. G. Proakis,"Digital Communications", McGraw-Hill, Edition 2005
3.Simon Haykin,"Communication System", Wiley India Edition
4. Principle of Communication Systems – Taub, Schilling, TMH
5. Gary J. Mullett, "Introduction to Wireless Telecommunications Systems and Networks", CENGAGE

6. Upena Dalal, "Wireless Communication", Oxford University Press, 2009

PCC	**ECEPGPC04**	**VLSI ARCHITECTURE FOR DSP**	**0L-0T-4P**	**3 Credits**

Course Outcomes(CO):
At the end of this course the students will be able to:
CO1:Evaluate different implementation platforms for digital designs.
CO2:Evaluate impact of data representation on digital signal processing architectures.
CO3:Design, analyze and apply methods for timing closure of digital design sign-off.
CO4:Optimize sampling time, throughput, area and power dissipation of digital signal processing architectures.

Module	Content	Lectures
Module1: Digital design approaches.	Types of IC Design flows. ASIC, custom Design, Structured ASIC, Gate Array, FPGA organization, CLB, LUT, RAM based logic implementation, Shannon's expansion rule & multiplier based implementation of combinational logic.	9
Module2: Data representation	Fixed point and floating point representations, Qm.n format, IEEE754 formats, Floating points for GPU, Fixed point multiplier and adder (signed, and unsigned). Tree adder, (4,2) Compressor, implementation of multiplier using Compressor tree, Multiplier-less implementation of X(i+1)=X(i)+A(i)B(i), Case study -- Walsh-Hadamard transform implementation.	9
Module3: Sequential Circuits & Static Timing Analysis.	Flip flop circuit, Implementation of asynchronous set & reset, setup & hold time, clk2q delay, min .clock pulse width, reset recovery & reset removal time. Static Timing Analysis (STA) of critical paths – input, output, clk , cross clock paths, multi cycle path , false path etc, timing data as function of voltage, temperature process. Different VTP conditions, timing data/file format, interpolation, setup and hold time analysis, negative slack and fixing, clock jitter, skew, phase, insertion delay etc. Time borrowing and time stealing in latch based design. State machine -Moore vs Mealy, their impact on timing paths. An example protocol design using state machine.	9
Module4: Optimization of DSP architectures.	Representation of DSP algorithms – block diagram, SFG, DFG, Dependence Graph, Interaction Bound and related algorithm. Pipelining and parallel processing, retiming, unfolding, folding, shortest path algorithms. Systolic Array design, FIR Systolic Arrays, Matrix-multiplier, fast convolution- Cook-Toom, Winograd ,etc algorithms. .	12

Text/Reference Books:

1. Verilog by Example: A Concise Introduction for FPGA Design by Blaine Readler (Pub: Full Arc Press).
2. Embedded Systems Design with Platform FPGAs: Principles and Practices by Ronald Sass and Andrew G. Schmidt (Pub**:** Morgan Kaufmann).

3. VLSI Digital Signal Processing Systems- Design and Implementation by Keshab K. Parhi (Pub: John Wiley – India)
4. FPGA Prototyping by VHDL Examples (Xilinx Spartan 3 Version) by Pong P. Chu (Pub: Wiley)
5. Synthesis of Arithmetic Circuits- FPGA, ASIC and Embedded Systems by Jean-Pierre Deschamps, Gery Jean Antoine Bioul and Gustavo D. Sutter
6. CMOS VLSI Design- A Circuit and System Perspective 3ed by Neil H. Weste and David Harris, (Pub: Pearson)
7. Xilinx ISE User guide, available online, also along with s/w installation.

Laboratory-II	**ECEPGPC52**	**ADVANCED COMMUNICATION AND VLSI ARCHITECTURE FOR DSP LABORATORY**	**0L-0T-4P**	**2Credits**

Course Outcomes (CO):

At the end of this course the students will be able to understand the concepts of Digital Communication and DSP-VLSI through hands-on and practical experiments.

Sl. No.	Name of the Experiments
PART A	
1.	Study of Pulse Shaping and Matched Filtering
2.	Study of QPSK Modulation and Demodulation
3.	Study of QPSK with Rayleigh fading and AWGN
4.	Study of M-ary QAM with AWGN fading
5.	Study and performance analysis of Multicarrier Modulation techniques
PART B	
1	Design of a Fixed Point Arithmetic Unit in FPGA
2	Emulation of RAM in FPGA
3	Basic Static Timing Analysis of a Synchronous Circuit
4.	Implementation of CORDIC operation in rotation mode in FPGA
5.	Implementation of FFT operation in FPGA

PEC III	**ECEPGPE07**	**IOT AND WIRELESS SENSOR NETWORKS**	**0L-0T-4P**	**3 Credits**

Course Outcomes(CO):

At the end of this course the students will be able to :

CO1:To Understand the Architectural Overview of IoT

CO2: To Understand the IoT Reference Architecture and RealWorld Design Constraints

CO3: To Understand the various IoT Protocols (Datalink, Network, Transport, Session, Service)

CO4: Understand basic sensor network concept . Also to know physical layer issues, understand and analyze Medium Access Control Protocols

Module	Content	Lectures
Module I	**Overview of Internet of Things**: IoT Conceptual Framework, IoT Architectural View, Technology Behind IoT, Sources of IoT,M2M communication, Examples of IoT. Modified OSI Model for the IoT/M2M Systems, data enrichment, data consolidation and device management at IoT/M2M Gateway, web communication protocols used by connected IoT/M2M devices, Message communication protocols (CoAP-SMS, CoAP-MQ, MQTT,XMPP) for IoT/M2M devices.	7
Module II	**Architecture and Design Principles for IoT**: Internet connectivity, Internet-based communication,IPv4, IPv6,6LoWPAN protocol, IP Addressing in the IoT, Application layer protocols: HTTP, HTTPS,FTP,TELNET and ports.	7
Module III	**Data Collection, Storage and Computing using a Cloud Platform**: Introduction, Cloud computing paradigm for data collection, storage and computing, Cloud service models, IoT Cloud- based data collection, storage and computing services.	8
Module IV	**Sensor Network Architecture:** Data Dissemination, Flooding and Gossiping-Data gathering Sensor Network Scenarios, Optimization Goals and Figures of Merit, Design Principles for WSNs- Gateway Concepts, Need for gateway, WSN and Internet Communication, WSN Tunneling.	8
Module V	**IP based WSN:** Circuit switching, packet switching, concept of IPV4, IPV6, LOWPAN and IP, IP based WSN, LOWPAN based WSN. Recent trends :	10

Text/Reference Books:

1. Kazem Sohraby, Daniel manoli , "Wireless Sensor networks- Technology, Protocols and Applications", Wiley InterScience Publications 2010.
2. Holger Karl, Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks" 2011, 1 st ed., John Wiley & Sons, New Jersey.
3. Jun Zheng, Abbas Jamalipour, "Wireless Sensor Networks: A Networking Perspective", 2014, 1 st ed., Wiley-IEEE Press, USA.
4. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016
5. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.

PEC III	ECEPGPE08	ADVANCED SENSOR DESIGN	3L-0T-0P	3Credits

Course Outcomes(CO):

At the end of this course the students will be able to :

CO1:To acquire knowledge of sensors and signal processing system in real life problem.
CO2: To learn the construction and working of different types of micro sensors.
CO3: To design smart sensor systems for real life problems.
CO4: To provide knowledge to use of modern sensor for real time projects.

Module	Content	Lecture
Module I	**Classification of instruments transducers:** Input and output characteristics of various sensors and transducers, construction and performance studies of variable resistance, inductance and capacitance transducer and its equivalent circuit.Types of Error, Statistical Analysis, Probability of Errors, Limiting Errors. Relevant problems.	**8**
Module II	**Design techniques for sensor signal conditioning:** Sensor and signal conditioning circuit design for strain, force, pressure, flow, level and temperature measurement, Bridge configurations, Amplifying and linearising bridge outputs, Driving bridge circuits. Photodiodes and high impedance charge output sensors, Signal conditioning of high impedance sensors.	**10**
Module III	**Advanced Sensing Technology:** Sensors, instruments and measurement techniques for emerging application areas such as environmental measurement, agricultural measurements such as soil moisture, wind speed, leaf wetness duration, sensors for food processing like smell or odour, taste.	**8**
Module IV	**Sensor fabrication and hardware design techniques:** Design considerations and selection criterion as per standards, Sensor fabrication techniques, process details and latest trends in sensor fabrication. Thick film sensing	**8**

	and system design. Grounding in mixed signal systems, Power supply noise reduction and filtering, Shielding and isolation technique, Over-voltage and Electrostatic discharge (ESD) protection techniques.	
Module V	**Micro-sensors and smart sensors:** Construction of micro-sensors, characteristics, signal conditioning and A/D conversion and applications of smart sensor.	**6**

Text/Reference Books:

1. Tai Ran Hsu, MEMS & Micro systems Design and Manufacture Tata McGraw Hill, New Delhi, 2002.
2.Ramon Pallas-Arenyand Johan G. Webster "Sensor and Signal Conditioning" John Wiley, New York 1991.
3. Elliot Williams, "AVR Programming: Learning to Write Software for Hardware", Maker Media, Incorporated, 2014.
4. Dan Sheingold-Editior "Transducer Interfacing Handbook", Analog Devices Inc 1980.
5. A.K. Sawhney, "A course in Electrical and Electronic Measurements and Instrumentation", Dhanpat Ray & Co.
6. Henry Ott, "Noise Reduction Technique In Electronic Systems", N.Y.John Wiley And Sons 1988.

PECIII	**ECEPGPE09**	**ARTIFICIAL INTELLIGENCE**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO):

At the end of this course the students will be able to :
CO1: Recognize the characteristics of machine learning that make it useful to real-world problems.
CO2:Characterize machine learning algorithms as supervised, semi-supervised, and unsupervised.
CO3:Effectively use machine learning toolboxes.
CO4:Use support vector machines.
CO5:Understand the concept behind neural networks for learning non-linear functions.

Module	Contents	Lectures
Module I	Introduction to Artificial Intelligence: Overview, Turing test, Applications	2
Module II	**Introduction** History of Machine Learning, Programs vs learning algorithms, Machine Learning definition, Components of a learning, Different Types of Learning	4
Module III	Linear Regression, Polynomial Regression, Features, Scaling, Cost Function, Gradient Descent, Learning Rate	4
Module IV	Supervised Learning, Linear classifier, Logistic Regression, Decision Boundary, Cost Function Optimization, Multi-class Classification, Bias and Variance, L1 and L2 Regularization	4
Module V	Performance Measure, Error Analysis, Confusion Matrix, Precision and Recall Tradeoff, F1 Score, Macro F1, Accuracy, Skewed Classes	6
Module VI	Unsupervised Learning, Clustering, K-Means, Optimization	6

	Using Evolutionary Techniques, Number of Clusters, Advanced discussion on clustering, Expectation Maximization, Dimensionality Reduction	
Module VII	Discriminative Vs Generative Models, Probability Theory Basics: Marginalization, Conditioning, Normalization, and Conditional Independence, Bayes Theorem, Markov Random Field, Naive Bayes Model, Decision Tree, Random Forest Classifier	8
Module VIII	VC Dimensions, Large Margin Classifiers, Support Vector Machines and Kernel Methods, Neural Networks Learning, Forward Propagation, Backward Propagation, Introduction to Deep Neural Networks	6

Text/Reference Books:

1. Artificial Intelligence – a modern approach. By Stuart Russell and Peter Norvig (Pearson)
2. Artificial Intelligence. By Kevin Knight, Elaine Rich, and Shivashankar B. Nair (3rd Edition, McGraw Hill Education)
3. Christopher Bishop. Pattern Recognition and Machine Learning. First Edition. Springer, 2006.
4. Mitchell Tom M. "Machine Learning", Tata McGraw-Hill
5. Ethem A lpaydin. "Introduction to Machine Learning" Second Edition, PHI Learning
6. Shai Shalev-Shwartz and Shai Ben-David. Understanding Machine Learning. Cambridge University Press. 2017.
7. P. Flach. *Machine Learning: The Art and Science of Algorithms that Make Sense of Data.* First Edition, Cambridge University Press, 2012.
8. S. J. Russell, P. Norvig. *Artificial Intelligence: A Modern Approach.* Third Edition, Prentice-Hall, 2010.
9. Müller Andreas C. and Sarah Guido. "Introduction to Machine Learning with Python: A Guide for Data Scientists" 2016

PEC IV	**ECEPGPE10**	**MICROWAVE INTEGRATED CIRCUITS**	**3L-0T-0P**	**3Credits**

Course Outcomes (CO):

At the end of this course the students will be able to :

CO1: Understand the Monolithic Microwave Integrated Circuits (MMICs),applications, various fabrication techniques such as thin and thick films technologies, encapsulation and mounting of active devices.

CO2: Understand stripline and microstrip line. Have an ability to analyze the method of conformal transformation for microstrip analysis, transverse resonance method and approximate analysis for slot lines.

CO3: Understand the directional coupler, analysis of even and odd mode for microstrip, design and fabrication of lumped elements.

CO4: Understand and design different non reciprocal devices, high power and low power circuits.

Module	Content	Lecture
Module I	Introduction to 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. Microstrips on semiconductor substrates	**12**
Module II	Analysis of stripline and microstripline, Method of conformal Transformation, Characteristic parameters of strip, Microstrip lines,	**10**

	Microstrip Circuit Design, Impedance transformers, Filters, Lumped constant Microstrip circuits.	
Module III	Coupled Microstrips and Directional couplers, Even and odd mode analysis, Theory of coupled microstrip, Calculations for a coupled pair of Microstrips, Branch line couplers. Lumped Elements for MICs, Design and fabrication of lumped elements, circuits using lumped elements.	**10**
Module IV	Nonreciprocal components for MICs, Microstrip on Feri-magnetic substrates, Microstrip circulators. Isolators and phase shifters, Design of microstrip circuits – high power and low power circuits.	**8**

Text/Reference Books:

1. Gupta KC and Amarjit Singh, "Microwave Integrated circuits", Wiley Eastern, 1974.
2. Leo Young, "Advances in Microwaves", Academic Press.
3. Bharathi Bhat,and S.K. Koul, "Strip line-like Transmission Lines for Microwave Integrated Circuits", New Age International, 2007
4. Microwave Integrated circuit, K. C. Gupta.

PEC IV	ECEPGPE11	Smart Antennas	3L-0T-0P	3Credits

Course Outcomes(CO):

At the end of this course the students will be able to :

CO1: Understand applications of antenna arrays, switch- beam, adaptive antenna, space division multiple access

CO2: Conceptualize different DOA estimation methods.

CO3: Learn the beam formation algorithms and techniques.

CO4: Understand the different kind of smart antenna systems

Module	Content	Lecture
Module I	**Applications of Antenna Arrays to Mobile Communications:** 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	**8**
Module II	**DOA Estimation Fundamentals:** Introduction, Array Response Vector, Received Signal Model, Subspace-Based Data Model, Signal Auto-covariance, Conventional DOA Estimation Methods, Conventional Beamforming Method, Capon's Minimum Variance Method, Subspace Approach to DOA Estimation, MUSIC Algorithm, ESPRIT Algorithm, Uniqueness of DOA Estimates.	**8**
Module III	**Beam Forming Fundamentals:** Classical Beam former, Statistically Optimum Beamforming 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	**8**
Module IV	**Smart antenna systems :** The Vector Channel Impulse Response and the Spatial Signature,	**8**

	Spatial Processing Receivers, Fixed Beam forming Networks, Switched Beam Systems, Adaptive Antenna Systems, Wideband Smart Antennas, Spatial Diversity, Diversity Combining, and Sectoring, Digital Radio Receiver Techniques and Software Radios for Smart Antennas, Transmission Beam forming.	
Module V	**Smart Antennas Techniques for CDMA :** Non-Coherent CDMA Spatial Processors, Coherent CDMA Spatial Processors and the Spatial Processing Rake Receiver, Multi-User Spatial Processing, Dynamic Re-sectoring Using Smart Antennas, Downlink Beam forming for CDMA.	**8**

Text/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-2
3. T.S. Rappaport and J.C. Liberti, "Smart Antennas for Wireless Communications", Prentice Hall, 1999
4. Tapan K Sarkar ," Smart Antennas ",IEEE Press, John Wiley & Sons Publications,2003
5. L.C.Godara, "Applications of antenna arrays to mobile communications, Part I: Performance improvement, feasibility, and system considerations", Proc. IEEE, vol. 85, no.7, pp.1031-1060, 1997.

PEC IV	**ECEPGPE12**	**COMPUTATIONAL ELECTROMAGNETICS**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO):

At the end of this course the students will be able to :

CO1: To solve EM problems from different angle.

CO2:To have in-depth knowledge and explain various numerical methods of electromagnetics.

CO3: To formulate real life problem to mathematical model.

CO4: To apply various numerical methods to different scattering and radiation problems.

CO5:To develop computational skills in applied electromagnetics and related disciplines.

Module	Content	Lecture
Module I	**Introduction** Basic Principles of Electromagnetic Theory, Analytical Methods and Orthogonal Functions, Green's Function, Fourier Transform Method	**4**
Module II	**Introduction to Computational Methods** Elements of Computational Methods, Basis Functions, Convergence and Discretization Error, Stability of Numerical Solutions, Formulations for the Computational method.	**6**
Module III	**Method of Finite Differences** Finite Difference Approximations, Treatment of Interface and Boundary Conditions, Finite Difference Analysis of Guiding Structures, Analysis of Enclosed Microstrip Line, Analysis of Geometries with Open Boundaries ,Wave Propagation and Numerical Dispersion, Analysis of Ridge Waveguide.	**6**
Module IV	**Finite-Difference Time-Domain Analysis** Pulse Propagation in a Transmission Line, FDTD Analysis in One Dimension, Source or Excitation of the Grid .Absorbing Boundary	**10**

	Conditions for One-Dimensional Propagation, Applications of One Dimensional FDTD Analysis, Reflection at an Interface, Determination of Propagation Constant, Design of Material Absorber, Exponential Time-Stepping Algorithm in the Lossy Region, Extraction of Frequency Domain Information from the Time Domain Data, Dispersive Materials ,FDTD Analysis in Two Dimensions ,Unit Cell in Two Dimensions ,Numerical Dispersion in Two Dimensions, Absorbing Boundary Conditions for Propagation in Two Dimensions, Perfectly Matched Layer ABC, FDTD Analysis in Three Dimensions ,Yee Cell ,Numerical Dispersion in Three Dimensions, Absorbing Boundary Conditions and PML for Three Dimensions , Implementation of Boundary Conditions in FDTD, Perfect Electric and Magnetic Wall Boundary Conditions	
Module V	**Finite Element Method** Basic Steps in Finite Element Analysis ,Segmentation or Meshing of the Geometry, Derivation of the Element Matrix ,Assembly of Element Matrices, Solution of System Matrix, Post processing, FEM Analysis in One Dimension, Treatment of Boundary and Interface Conditions ,Accuracy and Numerical Dispersion, FEM Analysis in Two Dimensions , Solution of Two-Dimensional Wave Equation ,Element Matrix for Rectangular Elements, Element Matrix for Triangular Elements ,Capacitance of a Parallel Plate Capacitor Cutoff Frequency Waveguide Modes	**8**
Module VI	**Method of Moments** Introduction, Point Matching and Galerkin's Methods , Eigen value Analysis Using MoM Static Charge Distribution on a Wire, Analysis of Strip Line	**6**

Text/Reference Books:

1. Analytical and computational methods in Electromagnetics by Ramesh Garg, Artech House
2. Computational Electromagnetics by Raj Mittra, Springer
3. Computational Electromagnetics by Anders Bondeson, Springer

PEC IV	ECEPGPE13	MOBILE NETWORKS AND COMPUTING	3L-0T-0P	3Credits

Course Outcomes(CO):

At the end of this course the students will be able to :

CO1: Demonstrate knowledge on : cellular concepts like frequency reuse, fading, equalization, GSM ,CDMA .

CO2: Demonstrate knowledge of mobile communication protocol

CO3: Demonstrate knowledge of wireless mobile communication technologies

Module	Content	Lecture
Module I	**MOBILE COMMUNICATIONS: AN OVERVIEW** Mobile communication-Mobile computing-Mobile Computing Architecture-Mobile devices-Mobile System Networks – Data dissemination – Mobile managementsecurity. Mobile devices and systems- Mobile phones — Handheld devices – Smart systems – Limitations of mobile devices – Automotive systems	**3**
Module II	**GSM AND SIMILAR ARCHITECURES** GSM – services and architectures – Radio interfaces – Protocols –	**8**

	Localization – Calling – Handover – Security – New data services – General packet radio serviceHigh speed circuit switched data – DECT. wireless medium access control-based communication-Medium Access Control – Introduction to CDMA –based Systems – Spread spectrum in CDMA Systems – coding methods in CDMA – IS-95– IMT – 2000 – i-mode – OFDM	
Module III	**MOBILE IP NETWORK LAYER AND MOBILE TRANSPORT LAYER** IP and mobile Network layers – Packet Delivery and Handover Management – Location management – Registration – Tunnelling and Encapsulation - Route Optimization - Dynamic Host Configuration Protocol. Conventional TCP/IP Transport Layer Protocols – Indirect TCP – Snooping TCP – Mobile TCP – Other methods of mobile TCP – layer transmission – TCP over 2.5G/3G Mobile networks	**9**
Module IV	**MOBILE DEVICES: SERVER AND MANAGEMENT** Mobile agent – Application server – Gateways – Portals -Service Discovery – Device management – Mobile file systems-Security. mobile adhoc and wireless 16 sensor networks-Introduction to mobile Ad hoc network – MANET –Wireless Sensor Networks –Applications	**10**
Module V	**WIRELESS LAN, MOBILE INTERNET CONNECTIVITY, AND PERSONAL AREA NETWORK** Wireless LAN(WiFi) Architecture and Protocol layers- WAP 1.1 and WAP 2.0 Architecture – XHTML-MP (Extensible Hypertext Markup Language Mobile Profile) - Bluetooth enabled devices network – layers in Bluetooth protocol- security in Bluetooth protocol- IrDA – ZigBee - Mobile application languages and mobile application development platforms.	**10**

Text/Reference Books:

1. Raj Kamal, "Mobile Computing", Oxford Higher education, Second Edition, 2007
2. J. Schiller, "Mobile Communication", Addison Wesley, 2000.
3. William Stallings, "Wireless Communication and Networks", Pearson Education,2003.
4. Singhal, "WAP-Wireless Application Protocol", Pearson Education, 2003.
5. LotherMerk, Martin.S. Nicklaus and Thomas Stober, "Principle of Mobile Computing",Second Edition, Springer, 2003.
6. William C.Y.Lee, "Mobile Communication Design Fundamentals", John Wiley,1993.

PEC IV	**ECEPGPE14**	**MULTIMEDIA COMMUNICATION**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO):

At the end of this course the students will be able to :
CO1:Deploy the right multimedia communication models.
CO2:pply QoS to multimedia network applications with efficient routing techniques.
CO3:Solve the security threats in the multimedia networks.
CO4:Develop the real-time multimedia network applications

Module	Content	Lecture
Module I	**Introduction** Introduction, multimedia information representation, multimedia networks, multimedia applications, Application and networking	**3**

	terminology, network QoS and application QoS, Digitization principles,. Text, images, audio and video.	
Module II	**Text and Image Compression** Text and image compression,, compression principles, text compression- Runlength, Huffman, LZW, Document Image compression using T2 and T3 coding, image compression- GIF, TIFF and JPEG	**8**
Module III	**Audio and Video Compression** Audio and video compression, audio compression – principles, DPCM, ADPCM, Adaptive and Linear predictive coding, Code-Excited LPC, Perceptual coding, MPEG and Dolby coders video compression, video compression principles.	**9**
Module IV	**Standards** **V**ideo compression standards: H.261, H.263, MPEG, MPEG 1, MPEG 2, MPEG-4 and Reversible VLCs, MPEG 7 standardization process of multimedia content description, MPEG 21 multimedia framework.	**10**
Module V	**Multimedia Management:** Notion of synchronization, presentation requirements, reference model for synchronization, Introduction to SMIL, Multimedia operating systems, Resource management, process management techniques.	**10**

Text/Reference Books:

1.Fred Halsall, "Multimedia Communications", Pearson education, 2001.
2. Raif Steinmetz, Klara Nahrstedt, "Multimedia: Computing, Communications and Applications", Pearson education, 2002.
3. K. R. Rao, Zoran S. Bojkovic, Dragorad A. Milovanovic, "Multimedia Communication Systems", Pearson education, 2004.
4. John Billamil, Louis Molina, "Multimedia : An Introduction", PHI, 2002.

PEC IV	**ECEPGPE15**	**SECURITY IN MOBILE NETWORKS**	**3L-0T-0P**	**3Credits**

Course Outcomes(CO):

At the end of this course the students will be able to:

CO1: Comprehend the fundamental concepts of mobile and wireless network security

CO2. Identify security threats in wireless networks and design strategies to manage network security

CO3. Design secured network application considering all possible threats

Module	Content	Lecture
Module I	**Security in General Wireless/Mobile Networks**: High Performance Elliptic Curve Cryptographic Co-processor, An Adaptive Encryption Protocol in Mobile Computing	**3**
Module II	**Security in General Wireless/Mobile Networks**: High Performance Elliptic Curve Cryptographic Co-processor, An Adaptive Encryption Protocol in Mobile Computing	**8**
Module III	**Security in Wireless LANs:** Cross Domain Mobility Adaptive Authentication, AAA Architecture	**9**

	and Authentication for wireless LAN Roaming, Experimental Study on Security Protocols in WLANs	
Module IV	**Security in Ad Hoc Networks:** Pre-authentication and authentication models in Ad Hoc Networks, Promoting Identity-based key management, attacks and countermeasures, Secure and resilient data aggregation, Secure routing in MANET, Intrusion Detection System in MANET	**10**
Module V	**Security in Mobile Cellular Networks:** Security issues in GSM, 3G and 4G networks, Authentication and encryption, Security concerns in 5G networks	**10**
Module VI	**Security in Sensor Networks and IoT:** Security Issues, Key Management Schemes, Secure Routing in Sensor Networks, Energy-aware security mechanisms, Security and privacy issues in IoT, Identity and access management, Data Integrity, Best practices for IoT security.	

Text/Reference Books:

1. Y. Xiao, X. Shen, D. Z.Du, Wireless Network Security, Springer International Edition.
2. Lei Chen, JiahuangJi, Zihong Zhang, Wireless Network Security, Springer Science & Business Media 3. W. Stallings. Cryptography & Network Security: Principles and Practice, Prentice Hall
4. Noureddine Boudriga, Security of Mobile Communications, CRC Press
5. Levente Buttyán and Jean-Pierre Hubaux, Security and Cooperation in Wireless Networks, Cambridge University Press
6. James Kempf, Wireless Internet Security: Architectures and Protocols, Cambridge University Press 7. Patrick Traynor, Patrick McDaniel, and Thomas La Porta, Security for Telecommunications Networks, Springer
8. Frank Adelstein, Sandeep K.S. Gupta, Golden G. Richard III, and Loren Schwiebert, Fundamentals of Mobile and Pervasive Computing, McGraw-Hill Professional

Open Electives

OEC	**ECEPG0E01**	**LASER SYSTEMS AND APPLICATIONS**	**3L-0T-0P**	**3 Credits**

Course Outcomes (CO):

At the end of this course students will be able to
CO1: Understand principle of operation and characteristics of lasers
CO2:Know various laser types and their operations
CO3:To learn various applications of lasers

Module	Content	Lecture
Module I	**Basic Laser Principles:** Absorption, Spontaneous and Stimulated Emission process and Einstein's coefficients. Population inversion, Pumping and pumping schemes, laser gain, Optical resonator cavities and its types, stability	**10**
Module II	**Characteristics of Laser:** Concept of coherence, Temporal and Spatial coherence, Coherence length and time, Brightness and Intensity, Directionality and Monochromacity, Laser modes, CW	**8**

	and Pulsed Lasers	
Module III	**Types of Lasers and operation:** Solid, liquid & gas lasers, operational principle of Ruby, He-Ne, Nd:YAG, CO_2, Dye and Semiconductor Lasers, fiber laser	**10**
Module IV	**Laser Applications:** Material processing with lasers, Interaction mechanism, Material processing mechanism, Drilling, Cutting and Welding process with laser. Laser hardening. *Medical Applications:* Laser diagnostic, Laser in ophthalmology, laser in glaucoma, Laser for general surgery, Laser in dermatology, laser in dentistry, Laser in medicine. *Optical Communication:* Optical source for fiber optical communication, Hologram, LIDAR	**10**
Module V	**Laser Safety:** Laser hazards for different laser classes and laser safety measures	**2**

Text/Reference Books:

1. Laser Principles, Types and Application, by K. R. Nambiar, New Age International.
2. Laser concepts and Applications, by S. A. Ahmad, New Age International.
3. Fundamentals of Laser Systems and Applications, A. K. Katiyar, CK Pandey and Manisha Bajpai, Wiley, India.
4. Lasers Theory and Applications by K. Thyagarajan and A.K. Ghatak, Mcmillan
5. Laser Fundamentals, by William T. Silfvast, Cambridge University Press.

OEC	**ECEPG0E02**	**CYBER PHYSICAL SYSTEMS**	**3L-0T-0P**	**3 Credits**

Course Outcomes(CO):

At the end of this course students will be able to

CO1:Understand the core principles behind CPS
CO2: Identify safety specifications and critical properties
CO3: Understand abstraction in system designs
CO4: Express pre- and post-conditions and invariants for CPS models

Module	Content	Lecture
Module I	**Introduction:** Cyber-Physical System, Key Features of CPS, Application Domains of CPS, Basic principles of design and validation of CPS, Challenges in CPS.	**10**
Module II	**CPS Platform components:** CPS HW platforms, Processors, Sensors and Actuators, CPS Network - Wireless, CAN, Automotive Ethernet, Scheduling Real Time CPS tasks, Synchronous Model and Asynchronous Model.	**8**
Module III	**Synchronous and Asynchronous Model:** Reactive Components, Components Properties, Components Composing, Synchronous Designs and Circuits, Asynchronous Processes and operations, Design Primitives in Asynchronous Process, Coordination Protocols in Asynchronous Process, Leader Election, Reliable Transmission.	**10**

Module IV	**Security of Cyber-Physical Systems:** Introduction to CPS Securities, Basic Techniques in CPS Securities, Cyber Security Requirements, Attack Model and Countermeasures, Advanced Techniques in CPS Securities.	**10**
Module V	**CPS Application:** Health care and Medical Cyber-Physical Systems, Smart grid and Energy Cyber Physical Systems, WSN based Cyber-Physical Systems, Smart Cities.	**2**

Text/References Books:

1. E. A. Lee and S. A. Seshia, "Introduction to Embedded Systems: A Cyber-Physical Systems Approach", 2011.
2. R. Alur, "Principles of Cyber-Physical Systems," MIT Press, 2015.
3. Raj Rajkumar, Dionisio de Niz and Mark Klein, "Cyber-Physical Systems", Addison-Wesley, 2017
4. Jean J. Labrosse, Embedded Systems Building Blocks: Complete and Ready-To-Use Modules in C, The publisher, Paul Temme, 2011

OEC	ECEPG0E03	SIGNAL AND IMAGE PROCESSING	3L-0T-0P	3 Credits

Course Outcomes(CO):

At the end of this course students will be able to

CO1: Understand the concept of discrete time signal processing

CO2: Understand the concept of digital filtering

CO3: Understand the concept of image processing and apply them to real life problems

Module	Content	Lecture
Module I	**Discrete-time Signals:** Discrete-time sequences, their frequency domain behaviour, comparison with analog signals, convolution of two sequences, sampling theorem, Reconstruction of continuous-time signals. Unit-sample response of a system, Time-invariant systems, Superposition principle for linear systems, Stability criterion for discrete-time systems, Causality criterion for discrete-time systems, Linear constant-coefficient difference equations.	**3**
Module II	**Discrete-time Transformation** : FT of special sequences, the inverse FT; Computation of the DFT from the discrete-time sequence, linear and circular convolution; computations for evaluating the DFT: increasing the computational speed of the DFT. Definition and properties of the z-transform, the inverse z-transform; relationship between the Fourier transform and the z-transform	**6**
Module III	**Digital Filters**: Filter categories: IIR and FIR, recursive and non-recursive. Digital Filter Structures: The direct form I and II structures, Cascade combination of second-order sections, parallel combination of second-order sections, Linear-phase FIR filter structures, Polyphase decomposition; Frequency-sampling structure for the FIR filter. Uniform DFT filter banks.	**6**
Module IV	**Digital Signal Processor:** **A**rchitecture of TMS320C 6416/6713 Processor (any one;	**2**

	programs in Assembly Language.)	
Module V	**Digital Image Fundamentals:** Introduction – Origin – Steps in Digital Image Processing – Components – Elements Of Visual Perception – Image Sensing And Acquisition – Image Sampling And Quantization – Relationships Between Pixels – Color Models.	**3**
Module VI	**Image Enhancement and Restoration:** Spatial Domain: Basic Gray Level Transformations – Histogram Processing – Basics Of Spatial Filtering–Smoothing And Sharpening Spatial Filtering – Frequency Domain: Introduction To Fourier Transform – Smoothing And Sharpening Frequency Domain Filters – Ideal, Butterworth And Gaussian Filters. Noise Models – Mean Filters – Order Statistics – Adaptive Filters – Band Reject Filters – Band Pass Filters – Notch Filters – Optimum Notch Filtering – Inverse Filtering – Wiener Filtering	**8**
Module VII	**Color Image Processing:** Colour fundamentals – Colour models – Colour transformation – Smoothing and Sharpening	**3**
Module VIII	**Wavelets :** Wavelets – Subband Coding – Multiresolution Expansions – Compression: Fundamentals – Image Compression Models – Error Free Compression –Lossy Compression – Compression Standards.	**3**
Module IX	**Morphological Processing :** Introduction, Logic Operations involving Binary Images, Dilation and Erosion, Opening and Closing, The Hit-or-Miss Transformation, Morphological Algorithms – Boundary Extraction, Region Filling, Extraction of Connected Components, Convex Hull, Thinning, Thickening. Segmentation: Detection Of Discontinuities–Edge Linking And Boundary Detection – Thresholding – Region Based Segmentation.	**6**

Text/References Books:

1. Digital Image Processing by Rafael C Gonzalez & Richard E Woods, 3rd Edition
2. Fundamentals of Digital Image Processing by Anil K Jain
3. Digital Image Processing by William K Pratt
4. Fundamentals of electronic image processing by Arthur R. Weeks Jr., Wiley
5. Digital Image Processing Using MATLAB, 2nd ed. by Gonzalez, Woods, and Eddins.
6. Digital Signal Processing – Principles, Algorithms and Applications - J.G.Proakis& D.G. Manolakis, Pearson Education/ PHI.
7. Digital Signal Processing- Alan V. Oppenheim, Ronald W. Schafer
8. Digital Signal Processing by Sanjit Mitra, 4th edition, 2011, McGraw-Hill, New York, NY.
9. Digital Signal Processors Architectures, Implementations and Applications – S.M.Kuo& W. Gan, Pearson Education

	ECEPGPR02	**RESEARCH METHODOLOGY AND IPR**	**2L-0T-0P**	**2CREDITS**

Course Outcomes:

At the end of this course, students will be able to

CO1:Understand research problem formulation.

CO2.Analyze research related information

CO3. Follow research ethics

CO4.Understand that today's world is controlled by Computer, Information Technology, but tomorrow world will be ruled by ideas, concept, and creativity.

CO5.Understanding that when IPR would take such important place in growth of individuals & nation, it is needless to emphasis the need of information about Intellectual Property Right to be promoted among students in general & engineering in particular.

CO6. Understand that IPR protection provides an incentive to inventors for further research work and investment in R & D, which leads to creation of new and better products, and in turn brings about, economic growth and social benefits.

Module	Content	Lecture
Module I	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.	**3**
Module II	Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	**5**
Module III	Effective literature studies approaches, analysis Plagiarism, Research ethics,	**5**
Module IV	Effective technical writing, how to write report, Paper Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	**2**
Module V	Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. International Scenario: International cooperation on Intellectual Property. Procedure for grants of patents, Patenting under PCT.	**5**
Module VI	Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications.	**3**

Module VII	New Developments in IPR: Administration of Patent System. New developments in IPR; IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs.	**4**

Text/References:

1. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
2. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
3. Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
4. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
5. Mayall , "Industrial Design", McGraw Hill, 1992.
6. Niebel , "Product Design", McGraw Hill, 1974.
7. Asimov , "Introduction to Design", Prentice Hall, 1962.
8. Robert P. Merges, Peter S. Menell, Mark A. Lemley, " Intellectual Property in New Technological Age", 2016.
9. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

Mini Project/Dissertation I/Dissertation II

Mini project should be on suitable research area/field to be identified in consultation with the project guide based on literature reviews on appropriate area of study which leads towards dissertation works to be carried out in forth coming semesters.

The dissertation topic should be selected to ensure the satisfaction of the urgent need to establish a direct link between education, national development and productivity and thus reduce the gap between the work and the study. The dissertation should have the following:

- Relevance to societal needs
- Relevance to value addition to existing facilities
- Relevance to industry need
- Problems of national importance
- Research and development in various domain

The student should complete the following in Dissertation I:

- Literature survey and Problem Definition
- Motivation for study and Objectives
- Preliminary design / feasibility studies
- Report and presentation

The Dissertation II will be the complete project work. It may be based on:

- Literature survey and Problem Definition
- Motivation for study and Objectives
- Implementation and Experimental verification.
- Design & fabrication of prototype, if applicable.

- Presentation and viva-voce examination based on the above work and report.

Guidelines for Dissertation I and II:

- As per the AICTE directives, the dissertation is a yearlong activity, to be carried out and evaluated in two phases i.e. Phase – I: July to December and Phase – II: January to June.
- The dissertation may be carried out preferably in-house i.e. department's laboratories and centers OR in industry allotted through department's T & P coordinator/HOD/Supervisor.
- After multiple interactions with guide and based on comprehensive literature survey, the student shall identify the domain and define dissertation objectives. The referred literature should preferably include referred journals in the areas of Computing and Processing (Hardware and Software), Circuits-Devices and Systems, Communication-Networking and Security, Robotics and Control Systems, Signal Processing and Analysis, Photonics and any other related domain. In case of Industry sponsored projects, the relevant application notes, while papers, product catalogues should be referred and reported.
- Student is expected to detail out specifications, methodology, resources required, critical issues involved in design and implementation and phase wise work distribution, and submit the proposal within a month from the date of registration.
- Phase – I deliverables: A document report comprising of summary of literature survey, detailed objectives, project specifications, paper and/or computer aided design, proof of concept/functionality, part results, a record of continuous progress.
- Phase – I evaluation: A committee comprising of guides of respective specialization shall assess the progress/performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend repeating the Phase-I work.
- During phase – II, student is expected to exert on design, development and testing of the proposed work as per the schedule. Accomplished results/contributions/innovations should be published in terms of research papers in reputed journals and reviewed focused conferences OR IP/Patents.
- Phase – II deliverables: A dissertation report as per the specified format, developed system in the form of hardware and/or software, a record of continuous progress.
- Phase – II evaluation: Guide along with appointed external examiner shall assess the performance of the student based on report, presentation and Q & A. In case of unsatisfactory performance, committee may recommend for extension or repeating the work.

----------End----------