Course Curriculum for Post Graduate Programme

in

Electronics & Communication Engineering

Department of Electronics & Communication Engineering

Sant Longowal Institute of Engineering & Technology
Longowal-148106
Phone: 01672-253117 Fax: 01672-280057
Website: www.sliet.ac.in

VISION

The Department of Electronics & Communication Engineering shall strive to create engineering technocrats for addressing the global challenges in relevant areas to cater the ever changing needs of society at National and International level.

MISSION

1. To ensure dissemination of knowledge through effective teaching and learning in Electronics and Communication Engineering.
2. To excel in Research and Development activities in emerging areas.
3. To promote industry-institute and institute-institute linkages for sustainable development of academic, research, training and placement activities.
4. To establish center of excellence in thrust areas to nurture the spirit of innovation and creativity among faculty and students.

Programme Educational Objectives (PEOs)

The M. Tech. (Electronics & Communication Engineering) program shall produce professionals:

1. To provide in-depth knowledge of modern design tools to solve real-life problems in the field of Electronics and Communication Engineering.
2. To develop employability skills to meet dynamic educational and industrial needs for betterment of society.
3. To impart research skills with professional and ethical attributes.
4. To attain professional leadership qualities for effective delivery in multi-disciplinary domains.

Programme Outcomes (POs)

After successful completion of M.Tech. (Electronics & Communication Engineering) program, the student will be able to:

1. Use mathematics, science and engineering knowledge for solving complex problems in the field of Electronics and Communication Engineering.
2. Identify and analyze engineering problems to formulate appropriate solutions proficiently.
3. Design and develop real-time system to meet desired needs in the field of Electronics and Communication Engineering.
4. Compile, interpret and present research data in an appropriate format, taking into consideration scientific principles and methodology.
5. Use effectively modern tools and techniques for modeling complex problems to provide alternative solutions.
6. Design engineering systems to address societal, legal, cultural, security, health and safety issues.
7. Use techniques, skills, and modern engineering tools required for environmental and sustainable development.
8. Adopt and exhibit professional knowledge with ethical responsibilities.
9. Function effectively as an individual as well as team-member for achieving desired goals.
10. Communicate in both verbal and written forms to compete globally.
11. Exhibit confidence, leadership qualities and remain engaged in life-long learning.
12. Take up administrative responsibilities involving both project and financial management, confidently.

M.TECH. (ELECTRONICS AND COMMUNICATION ENGINEERING)

Semester-I

Sr. No.	Subject Code	Subject Name	L	T	P	Hrs.	Credits
1	PCEC 811	Optical Communication Systems	3	0	0	3	3
2	PCEC 812	Advanced Communication Systems	3	0	0	3	3
3	PEEC 811	Core Elective-I	3	0	0	3	3
4	PEEC 812	Core Elective-II	3	0	0	3	3
6	RMAL-811	Research Methodology and IPR	2	0	0	2	2
7	ACMH-811	English Research Paper Writing and Professional Communication	2	0	0	2	0
8	PEEC 813	Core Elective-1 Lab	0	0	4	4	2
9	PCEC 814	Optical Communication System Lab	0	0	4	4	2
		Total	**16**	**0**	**8**	**24**	**18**

Semester-II (A)

Sr. No.	Subject Code	Subject Name	L	T	P	Hrs.	Credits
1	PCEC 821	Microwave Integrated Circuits	3	1	0	4	4
2	PCEC 822	VLSI Design	3	0	0	3	3
3	PEEC 821	Core Elective-III	3	0	0	3	3
4	PEEC 822	Core Elective-IV	3	0	0	3	3
5	ACMH-821	Constitution of India	2	0	0	2	0
6	PCEC 823	VLSI Design Lab	0	0	4	4	2
7	PEEC 824	Core Elective - II Lab	0	0	4	4	2
8	PCEC 824	Seminar	0	0	2	2	1
		Total	**14**	**1**	**10**	**25**	**18**

Semester-II (B)

	Four weeks training in reputed industry/laboratory in Institutions of repute such as IITs, NITs, CSIR, DRDO, CSIO etc.				40	S/US

Semester-III

Sr. No.	Subject Code	Subject Name	L	T	P	Hrs.	Credits
1	PEEC 911	Core Elective -5	3	0	0	3	3
2	OEEC 911	Open Elective	3	0	0	3	3
3	PCEC 911	Dissertation (Part-1)	0	0	20	20	10
		Total	**6**	**0**	**20**	**26**	**16**

Semester-IV

Sr. No.	Subject Code	Subject Name	L	T	P	Hrs.	Credits
1	PCEC 921	Dissertation (Part-2)	0	0	32	32	16
		Total	**0**	**0**	**32**	**32**	**16**

Total Credits: 68

List of Program Specific/ Core Elective Courses

CORE ELECTIVE-I (PEEC811)		
Sr. No.	Subject Code	Subject Name
1	PEEC-811A	Micro & Nano-photonics
2	PEEC-811B	RF Circuit Design
3	PEEC-811C	Statistical Information Processing
CORE ELECTIVE-II (PEEC 812)		
Sr. No.	Subject Code	Subject Name
1	PEEC 812A	Antenna and Radiating System
2	PEEC 812B	Internet of Things
3	PEEC 812C	Remote Sensing
CORE ELECTIVE-III (PEEC 821)		
Sr. No.	Subject Code	Subject Name
1	PEEC 821A	Advanced Digital Signal Processing
2	PEEC 821B	Soft Computing
3	PEEC 821C	Digital Image Processing
4	PEEC 821D	Artificial Intelligence and Deep Learning
CORE ELECTIVE-IV (PEEC 822)		
Sr. No.	Subject Code	Subject Name
1	PEEC 822A	Electronic Product Design
2	PEEC 822B	Satellite Communication
3	PEEC 822C	Digital Circuit Logic Design
CORE ELECTIVE-V (PEEC 911)		
Sr. No.	Subject Code	Subject Name
1	PEEC 911A	Wireless Sensor Networks
2	PEEC 911B	Network Security and Cryptography
3	PEEC 911C	Advanced Computer Networks
CORE ELECTIVE-I LAB		
Sr. No	Subject Code	Subject Name
1	PEEC 813A	Communication Systems Lab
2	PEEC 813B	Wireless Communication Lab
CORE ELECTIVE-II LAB		
Sr. No	Subject Code	Subject Name
1	PEEC 824A	Microwave Engg. Lab
2	PEEC 824B	Computer-Aided Design Lab

List of Open Elective Courses

Sr. No.	Subject Code	Subject Name
1	OEEC 911A	Electronic Product Design
2	OEEC 911B	Soft Computing
3	OEEC 911C	Optical Communication Systems

PCEC-811 Optical Communication Systems				
	L	T	P	Credits
	3	0	0	4
	Sessional Marks			50
	End Semester Examination Marks			50
Course Objectives:	The aim of this course is to train students in methods of analysis and installation of optical fiber-based communications systems; systems planning to use different photonic technologies as well as advanced optical signal processing models. Further, focuses on different nonlinearities in optical fiber and their mitigation in modern optical fiber communication system; design and evaluation of modern optical fiber communication systems.			
Course Outcomes:	1. To understand the basic concept of optical fiber communication system. 2. To understand the various dispersion nonlinearities effect in optical communication system 3. Ability to design high bit-rate fiber optic communication systems. 4. Ability to analyze, model and implement advanced optical communication systems. 5. Capable to use optical communications simulation tools to assess the results obtained from theoretical studies.			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	W	N	N	N	W	N	N	W	N	N	N
CO2	M	N	N	S	N	N	N	N	M	N	N	N
CO3	W	M	M	N	N	S	N	N	N	N	M	M
CO4	M	S	S	N	M	S	M	N	N	N	W	M
CO5	N	N	M	S	M	M	M	N	N	N	N	N

Unit-I — **16 hrs**

Overview of optical fiber communication: Evolution of basic fiber optic communication system, benefits and disadvantages of fiber optics, transmission windows, transmission of light through optical fiber, numerical aperture (NA), optical fiber modes & configurations, types of fiber, wave propagation in step index & graded index fiber, MFD, propagation modes in step index fibers, attenuation in optical fibers, fiber optic loss calculations, bending loses, absorption, scattering, fiber dispersion, dispersion shifted fiber, D -flattened fiber, polarization, cut-off condition and V-parameter, connectors & splices.

Dispersion and nonlinearities: Dispersion in single mode and multimode fibers, attenuation and dispersion limits in fibers, dispersion management, Kerr nonlinearity, self -phase modulation, cross phase modulation, FWM.

Unit-II — **12 hrs**

Optical sources: Direct and indirect band gap materials, semiconductor light-emitting diodes and laser diodes, LED power & efficiency, double hetero -junction LED, planner & dome LED, surface-emitting LEDs, edge-emitting LEDs, super luminescent LED, characteristic of LED, modulation, laser diodes: basic concepts for emission of radiation, threshold condition for laser oscillation, quantum well laser, distributed feedback laser, laser characteristics.

Optical detectors: Principles of photodiodes, PIN & avalanche photodiodes, photodetector noise, detector response time, avalanche multiplication noise, temperature effect on a valanche gain, receiver SNR and BER calculations.	
Unit-III	**10 hrs**
Optical amplifiers: Semiconductor amplifiers, Erbium-doped fiber amplifiers (EDFAs) and Raman amplifiers, analytical modeling of gain saturation, gain equalization, ASE noise, amplifier cascades. **Optical sensors:** Advantages, generic optical fiber sensor, fiber selection for sensor, wavelength modulated sensors - pH, humidity, temperature, carbon dioxide sensors, fiber Bragg grating based sensors - principle, strain, pressure sensors, chemical sensors.	
Unit-IV	**10 hrs**
Optical networks design: Fiber optic system design considerations -power budget, bandwidth and rise time budgets, electrical and optical bandwidth etc. **Advanced multiplexing strategies:** Optical TDM, subscriber multiplexing (SCM), WDM and hybrid multiplexing methods, optical networking - optical network topologies, network architecture- SONET/TDH, optical burst switching, OADM, wavelength conversion, optical filters, MZI.	

RECOMMENDED BOOKS

Title	Author	Publisher
1. Fiber-optic communication Systems	G. P. Aggarwal	2nd Ed., J. Wiley & Sons, 1997
2. Optic Communication Systems	Mynbaev	Pearson education, 2001
3. Optical Fiber Communication	Gerd Keiser	5th edition, McGraw Hill, 2013
4. Optical Fiber Communication	J. Senior	PHI

PCEC-812
Advanced Communication Systems

	L	T	P	Credits
	3	0	0	4
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: Aim of the course is to study the fundamentals of fading channels. It also gives deep insight into the basics of GSM and CDMA. It discusses the different types of diversity techniques and equalization algorithm used in communication systems. Finally, it introduces the concept of 3G, 4G and 5G wireless communication standards.

Course Outcomes:
1. Design appropriate mobile communication systems.
2. Apply frequency reuse concept in mobile communications and to analyze its effects on interference, system capacity, and handoff techniques.
3. Distinguish various multiple access techniques for mobile communications e.g., FDMA, TDMA, CDMA and their advantages and disadvantages.
4. Analyze and design CDMA system functioning with knowledge of forward and reverse channel details, advantages and disadvantages of using the technology.
5. Understanding upcoming technologies like 3G, 4G etc.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	M	S	S	M	W	W	W	W	W
CO2	S	S	S	M	S	M	M	M	W	W	W	W
CO3	S	S	S	S	M	W	W	M	W	W	W	M
CO4	S	S	S	M	S	W	M	S	W	W	W	M
CO5	M	M	W	M	M	M	S	S	W	W	W	M

Unit-I — **12 hrs**

Cellular communication fundamentals: Cellular system design, frequency reuse, cell splitting, handover concepts, co channel and adjacent channel interference, interference reduction techniques and methods to improve cell coverage, frequency management and channel assignment.

Unit-II — **12 hrs**

Mobile radio propagation: Large scale path loss, free space propagation model, radio wave propagation mechanisms, ground reflection (two ray) model, outage probability, small scale fading and multipath propagation, types of small scale fading, diversity techniques and algorithms for adaptive equalization.

Unit-III — **12 hrs**

GSM and Code division multiple access: GSM architecture, GSM subsystems, GSM logical channels, data encryption in GSM, mobility management, call flows in GSM. Introduction to CDMA technology, IS-95 system architecture, air interface, physical and logical channels of IS-95, forward link and reverse link operation, call processing in IS-95, call processing in IS-95, soft handoff, evolution of IS-95 to CDMA 2000.

Unit-IV	12 hrs
Higher generation cellular standards: Evolved EDGE, 4G standards and its architecture, call flow for LTE, VOLTE and UMTS, introduction to 5G.	

RECOMMENDED BOOKS

Title	Author	Publisher
1. Mobile Cellular Telecommunications Analog and Digital systems	William C.Y. Lee.	2nd edition, TMH Publication,1995
2. Wireless Communications Principles and Practice	T.S. Rappaport	2nd edition, PHI,2002
3. V.K. Garg	IS-95 CDMA and CDMA-2000	Pearson education ,4th edition,2009
4. A GSM system Engineering	Asha Mehrotra	Artech House Publishers, Boston, London,1997

PEEC-811A
Micro and Nano- Photonics

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The motivation for the course is to make the students understands the fundamentals of photonics with focus on micro-photonic and nano-photonic devices and physics.

Course Outcomes:
1. To understand the fundamentals of photonics.
2. To understand the fundamentals of surface plasmon polaritons both at single, flat interfaces and in metal/dielectric multilayer structures.
3. Able to design different types of plasmonic sensors and solar cells.
4. Able to design nano-photonic devices.
5. Able to model and analyze the nano-photonic devices using finite-difference time- domain method.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	M	M	N	S	M	N	N
CO2	S	S	M	M	M	N	M	N	M	M	N	N
CO3	S	M	S	S	S	S	S	M	S	S	N	N
CO4	S	S	S	S	S	M	M	N	S	S	N	N
CO5	S	S	M	M	M	N	M	N	M	M	N	N

Unit-I — **14 hrs**

Ray optics: Introduction, postulates of ray optics, Hero's principal, Snell's Law, simple optical components, graded-index optics, ray equation (Paraxial ray equation) matrix optics, ray-transfer matrix, matrix of simple optical components (free-space propagation, refraction at a planar boundary, refraction at a spherical boundary, transmission through a thin lens, reflection from a planar mirror, reflection from a spherical mirror), matrices of cascaded optical components.

Wave optics: Postulates of wave optics, intensity, power, and energy, monochromatic waves: complex representation and Helmholtz equation, wave fronts (plane waves, spherical waves, interference, diffraction), paraxial waves, beam optics, Fabry Perot cavity, micro resonators - ring resonator and disc resonator devices.

Electromagnetic optics: TM and TE polarized light, boundary conditions, transmission and reflection of P-polarized and S-polarized light from a planar boundary, single and multi-layer problem polarization of light; matrix representation (The Jones vector).

Unit-II — **12 hrs**

Review of electromagnetic (EM) theory: Boundary conditions, some relevant EM problems, FDTD and FEM modelling, electromagnetics of metals- Maxwell's equations and electromagnetic wave propagation, the dielectric function of the free electron gas, dispersion of the free electron gas and volume plasmon, real metals and inter band transitions, fundamentals of plasmonics, surface plasmon resonance, surface plasmon polaritons at a single interface, dispersion relation, multilayer system, propagation length, penetration depth, Drude model without considering damping, Drude model considering damping, Lorentz model, Lorentz Drude model.

Unit-III	**12 hrs**
Excitation of surface plasmon polaritons at planar interfaces: Coupling mechanism, prism coupling, Kretschmann configurations, Otto configurations, angular interrogation, spectral interrogation, reflectivity, transmittivity, complete resonance condition, grating coupling, wave guide coupling: 1-D coupling, 2-D coupling, plasmonic gratings, models describing the refractive index of metals, localized surface plasmon resonance, plasmonic sensors and devices, surface-enhanced Raman scattering.	
Unit-IV	**10 hrs**
Plasmonic waveguides and interconnects: Metal dielectric interface, MI wave guide, MIM wave guide, IMI wave guide, symmetric and anti-symmetric mode, propagation length and penetration depth of MIM and IMI wave guide, photonic crystals and devices.	

RECOMMENDED BOOKS

Title	Author	Publisher
1. Principles of Nano-optics	L. Novotny and B. Hecht	Cambridge University
2. S. Maier	Plasmonics - Fundamentals and Applications	Springer

PEEC-811B
RF Circuit Design

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives:	The course aims to design and analyze basic resonators, RF filters, and RF transistor amplifier; study the operation and characteristics of RF active components, oscillators and mixers used in RF design.
Course Outcomes:	1. To discuss, design and analysis of filters and amplifiers. 2. To understand the working concepts of RF active components and impedance matching. 3. To study the operation of mixers and oscillators.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	N	S	N	N	M	N	M	W
CO2	S	M	N	N	N	M	M	N	N	N	M	N
CO3	M	N	N	N	N	M	N	N	M	N	N	N

Unit-I — **12 hrs**

Introduction: Importance of radio frequency design, RF behavior of passive components, chip components and circuit board considerations, general transmission line equation, microstrip transmission lines.

Unit-II — **12 hrs**

RF network and filter: Interconnecting networks, network properties and applications, scattering parameters, basic resonator and filter configurations, special filter realizations, filter implementation, coupled filter.

Unit-III — **12 hrs**

Active RF components and modeling: Semiconductor basics, RF diodes, bipolar-junction transistor, RF field effect transistors, diode models, transistor mod els.

Matching and biasing networks: Impedance matching using discrete components, microstrip line matching networks, amplifier classes of operation and biasing networks.

Unit-IV: — **12 hrs**

RF transistor amplifier, oscillators and mixers: Characteristics of amplifiers, amplifier power relations, stability considerations, constant gain, noise figure circles, constant VSWR circles, broadband, high power, and multistage amplifiers, basic oscillator model, high frequency oscillator configuration, basic characte ristics of mixers.

RECOMMENDED BOOKS

Title	Author	Publisher
1. RF Circuit Design	Reinhold Ludwig, Pavel Bretchko	Pearson Education, 1st Indian Reprint, 2001.
2. Design of Analog CMOS Integrated Circuits	B Razavi	Mc Graw Hill, 2000.
3. RF Microelectronics	BehzadRazavi	2nd edition, Pearson Education, 1997.
4. RF Circuit Design: Theory & Applications	Reinhold Ludwig, Gene Bdgdanov	2nd edition, Pearson, 2008.

PEEC-811C Statistical Information Processing				
	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50
Course Objectives:	The main objective of the course is to understand the basics of discrete & continuous random variables and processes, random signal modelling, statistical decision theory, parameter estimation and spectral analysis. How discrete channels and measures of information generalize to their continuous forms; complexity, compression, and efficient coding of text, and audio-visual information coding schemes; including error detecting and correcting codes, Huffman, Shannon-Fano, arithmetic, adaptive coding, BCH codes & decoder, Reed - Solomon codes & decoder.			
Course Outcomes:	1. To Characterize and apply probabilistic techniques in modern decision systems, such as information systems, receivers, filtering, and statistical operations. 2. To demonstrate mathematical modeling and problem solving using such models. 3. Comparatively evolve key results developed in this course for applications to signal processing, communications systems. 4. To develop frameworks based on probabilistic and stochastic themes for modeling and analysis of various systems involving functionalities in decision making, statistical inference, estimation and detection.			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	W	N	S	N	W	N	M	W	N	N	N
CO2	M	N	N	S	S	N	N	N	M	N	N	N
CO3	W	M	M	N	M	S	N	S	N	S	M	M
CO4	M	S	S	N	M	N	M	N	N	N	W	M

Unit-I — **14hrs**

Review of random variables: Probability concepts, distribution and density functions, moments, independent, uncorrelated and orthogonal random variables; vector-space representation of random variables, vector quantization, Tchebaychef inequality theorem, central limit theorem, discrete & continuous random variables.

Random process: Expectations, moments, ergodicity, discrete-time random processes stationary process, autocorrelation and auto covariance functions, spectral representation of random signals, properties of power spectral density, Gaussian process and white noise process.

Unit-II — **12 hrs**

Random signal modelling: MA(q), AR(p), ARMA(p,q) models, hidden Markov model & its applications, linear system with random input, forward and backward predictions, Levinson Durbin algorithm.

Statistical decision theory: Bayes' criterion, binary hypothesis testing, M ary hypothesis testing, minimax criterion, Neyman-Pearson criterion, composite hypothesis testing.

Unit-III	**12 hrs**
Parameter estimation theory: Maximum likelihood estimation, generalized likelihood ratio test, some criteria for good estimators, Bayes' estimation minimum mean-square error estimate, minimum, mean absolute value of error estimate maximum, a-posteriori estimate, multiple parameter estimation best linear unbiased estimator, least-square estimation recursive least-square estimator. **Spectral analysis:** Estimated autocorrelation function, periodogram, averaging the periodogram (Bartlett method), Welch modification, parametric method, AR(p) spectral estimation and detection of harmonic signals.	
Unit-IV	**14hrs**
Information theory and source coding: Review of information and entropy, source coding theorem, Huffman, Shannon-Fano, arithmetic, adaptive coding , RLE , LZW, data compaction,LZ-77, LZ-78. discrete memory less channels, mutual information, channel capacity, channel coding theorem, differential entropy and mutual information for continuous ensembles. **Application of information theory:** Group, ring & field, vector, GF addition, multiplication rules, introduction to BCH codes, primitive elements, minimal polynomials, generator polynomials in terms of minimal polynomials, some examples of BCH codes and decoder, Reed- Solomon codes & decoder, implementation of Reed Solomon encoders and decoders.	

RECOMMENDED BOOKS

	Title	**Author**	**Publisher**
1.	Probability, Random Variables and Stochastic Processes	Papoulis and S.U. Pillai	4th Edition, McGraw-Hill, 2002.
2.	Statistical and Adaptive Signal Processing	D.G. Manolakis, V.K. Ingle and S.M. Kogon	McGraw Hill, 2000.
3.	Signal Detection and Estimation	Mourad Barkat	Artech House, 2nd Edition, 2005
4.	Information theory and reliable communication	R G. Gallager	Wiley, 1st edition, 1968
5.	Elementary Number Theory	Rosen K.H,	Addison-Wesley, 6th edition, 2010.
6.	The Theory of Error-Correcting Codes	F. J. Mac Williams and N. J. A. Sloane	New York, North-Holland, 1977.

PEEC-812A
Antenna And Radiating System

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The objective of this course is to introduce the fundamental principles of antenna Different types of antennas and their applications will be introduced, with focus on loop antennas, aperture antenna, reflector antenna, microstrip antenna, broadband antenna and antenna arrays; the characterization and design considerations of using antennas in wireless communication systems.

Course Outcomes:

1. Familiarization with radiation mechanism, antenna parameters and classes of antennas.
2. Be able to pick a particular class of antenna for given specifications.
3. Apply design principles to design antennas and antenna arrays.
4. Familiarize with some advanced antenna types.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	M	M	N	M	N	M	N	N	W	N
CO2	N	S	M	N	N	M	N	N	M	N	M	M
CO3	S	M	S	N	M	S	M	N	N	N	M	M
CO4	N	N	M	N	N	M	N	N	M	N	M	M

Unit-I — **12 hrs**

Fundamental concepts: Physical concept of radiation, radiation pattern, near- and far-field regions, reciprocity, directivity and gain, effective aperture, polarization , input impedance, efficiency, Friis transmission equation, radiation integrals and auxiliary potential functions.

Radiation from wires and loops: Infinitesimal dipole, finite-length dipole, linear elements near conductors, dipoles for mobile communication, small circular loop.

Unit-II — **12 hrs**

Antenna arrays: Analysis of uniformly spaced arrays with uniform and non-uniform excitation amplitudes, extension to planar arrays.

Reflector antennas: Prime focus parabolic reflector and Cassegrain antennas, design concept.

Unit-III — **12 hrs**

Aperture antennas: Huygens principle, radiation from rectangular and circular apertures, design considerations, Babinet's principle, radiation from scrotal and pyramidal horns, design concepts.

Microstrip Antennas: Basic characteristics of microstrip antennas, feeding methods, methods of analysis, design of rectangular and circular patch antennas.

Unit-IV — **12 hrs**

Broadband antennas: Broadband concept, log-periodic antennas, frequency independent antennas.

Basic concepts of smart antennas: Concept and benefits of smart antennas, fixed weight beam forming basics, adaptive beam forming.

RECOMMENDEDBOOKS

Title	Author	Publisher
1. Antenna	K D Parsad	Parkash Publications
2. Antennas	John D. Karans	Tata McGraw Hill
3. Antenna Theory and Design	Balanis, C.A.	3rd Ed., John Wiley &Sons
4. Electromagnetic Waves and Radiating Systems	Jordan, E.C. and Balmain, K.G	2nd Ed, Pearson Education
5. Antenna Theory and Design	Stutzman, W.L. and Thiele, H.A.,	2nd Ed, John Wiley & Sons
6. Antenna Theory and Design, Revised edition	Elliot, R.S.	Wiley-IEEE Press
7. Microstrip Antenna Design Handbook,	Garg. R. Bhartia, P. Bahl, I. and Ittipiboon.	Artech House

PEEC-812B
Internet of Things

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The aim of this course is to familiarize with IoT technologies and its requirement in certain scenarios, utilization of latest technologies to implement IoT solutions in different scenarios and experimental platform for implementing prototypes and testing them as running applications.

Course Outcomes:
1. To understand the application areas of IoT.
2. To realize the revolution of Internet in smart cities, cloud & sensor networks.
3. To understand building blocks of internet of things and characteristics.
4. To understand the various operating systems and security issues in IoT.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	W	N	N	N	N	N	N	N	N	S
CO2	M	M	M	N	N	N	N	N	N	N	W	S
CO3	W	S	W	N	N	N	N	N	N	N	W	W
CO4	S	S	M	N	N	N	N	N	N	N	N	M

Unit-I — **14 hrs**

IoT Architecture: Smart objects as building blocks for IoT, open source hardware and embedded systems platforms for IoT, edge/gateway, I/O drivers, C programming, multithreading concepts.
Application domains of IoT: Smart cities and IoT revolution, fractal cities, from IT to IoT, M2M and peer networking concepts, IPV4 and IPV6, software defined networks SDN.

Unit-II — **12 hrs**

Fog computing: From cloud to fog and MIST networking for IoT communications, principles of edge/P2P networking, protocols to support IoT communications, modular design and abstraction, security and privacy in fog.
IoT technology fundamentals: Introduction to WSN and IoT networks (PAN, LAN and WAN), edge resource pooling and caching, client side control and configuration.

Unit-III — **10 hrs**

Operating systems in IoT: Requirement of operating system in IoT environment, study of Mbed, RIoT and Contiki operating systems.

Unit-IV — **12 hrs**

Application of IoT: Connected cars IoT transportation, smart grid and healthcare sectors using IoT, introductory concepts of big data for IoT applications.
Security in IoT: Security and legal considerations, IT Act 2000 and scope for IoT legislation.

RECOMMENDED BOOKS		
Title	**Author**	**Publisher**
1. Internet of Things- Hands on approach	Arshdeep Bahga and Vijay K. Madisetti	VPT publisher
2. Designing the Internet of Things	Adrian McEwen and Hakim Cassimally	Wiley
3.Getting started with Internet of Things	CunoPfister	Maker Media
4. Internet of things	Samuel Greenguard	MIT Press

PEEC-812C
Remote Sensing

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The course aims to provide an understanding about basic concepts of remote sensing, different types of spacecrafts and remote sensing platforms, photographic products and optomechanical electrooptical sensors used in RADARs and Altimeter-LiDAR

Course Outcomes:

1. To understand basic concepts, principles, and applications of remote sensing, particularly the geometric and radiometric principles.
2. To apply principles of variety of topics of remote sensing to data collection, radiation, resolution, and sampling.
3. To understand various thermal data analysis, interpreting and processing techniques.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	M	S	M	M	S	W	W	M	W	W
CO2	S	S	S	M	M	M	M	W	W	W	W	W
CO3	S	S	S	S	S	M	M	M	W	W	W	W

Unit-I — **12 hrs**

Physics of remote sensing: Electromagnetic spectrum, physics of remote sensing, effects of atmosphere scattering, different types of atmosphere scattering, absorption, atmospheric window, energy interaction with surface features, spectral reflectance of vegetation, soil and water atmospheric influence on spectral response patterns, multi concept in remote sensing.

Unit-II — **12 hrs**

Data acquisition: Types of platforms, different types of aircrafts, manned and unmanned spacecrafts, sun synchronous and geosynchronous satellites, t ypes and characteristics of different platforms: LANDSAT, SPOT, IRS, INSAT, IKONOS, QUICK BIRD etc., photographic products, B/W, color, color IR film and their characteristics, resolving power of lens and film, optomechanical electro optical sensors –across track and along track scanners, multispectral scanners and thermal scanners, geometric characteristics of scanner imagery, calibration of thermal scanners.

Unit-III — **12 hrs**

Scattering system: Microwave scatterometry, types of RADAR, SLAR: resolution, range and azimuth, real aperture and synthetic aperture RADAR, characteristics of microwave image topographic effect, different types of remote sensing platforms, airborne and space borne , sensors, ERS, JERS, RADARSAT, RISAT, scatterometer, altimete-rLiDAR remote sensing, principles, applications.

Unit-IV: — **12 hrs**

Thermal and hyper spectral remote sensing: Sensors characteristics, principle of spectroscopy, imaging spectroscopy, field conditions, compound spectral curve, spectral library, radiative models, processing procedures, derivative spectrometry, thermal remote sensing, thermal sensors, principles, thermal data processing, applications, data analysis, spatial resolution, spectral resolution, radiometric and temporal resolution, signal to noise ratio, data products and their characteristics, visual and digital interpretation, basic principles of data processing, radiometric correction, image enhancement, image classification, principles of LiDAR, aerial laser terrain mapping.

RECOMMENDED BOOKS

Title	Author	Publisher
1. Remote Sensing and Image interpretation	T.M. Lilles and R. W. Kiefer	6th Edition, John Wiley & Sons, 2000
2. Introductory Digital Image Processing: A Remote Sensing Perspective	John R. Jensen	2nd Edition, Prentice Hall,1995.
3. Remote Sensing Digital Image Analysis	Richards, John A., Jia, Xiuping	5th Edition, Springer-Verlag Berlin Heidelberg, 2013
4. Principles of Remote Sensing	P.J.Paul Curran	1st Edition, Longman Publishing Group, 1984
5. Introduction to The Physics and Techniques of Remote Sensing	Charles Elachi, Jakob J. van Zyl	2nd Edition, Wiley Series, 2006
6. Remote Sensing Principles and Image Interpretation	F.F.Jr, Sabins	3rd Edition, W.H. Freeman & Co, 1978

PEEC-813 A
Core Elective -1 Lab
(Communication System Lab)

	L	T	P	Credits
	0	0	4	2
	Internal Assessment Marks			50
	End Semester Marks			50

Course Objectives: The aim of this course is to study and understand the aspects of different types of signals, their operation, the spectrum in time and frequency domain, generation, and demodulation of AM signals. Thorough knowledge would enable students to understand characterization and design considerations in communication systems.

Course Outcomes:

1. To familiarize the use of MATLAB for solving communication engineering problems.
2. To Learn the basics of signals and its operations as used in Analogue and Digital Communication.
3. To analyze the spectrum, in time and frequency domain, of Amplitude Modulation.
4. To familiarize with generation and demodulation of ASK, PSK and FSK signals using MATLAB.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	N	S	N	M	N	M	N	S	M	N
CO2	N	N	S	N	N	S	M	N	N	S	S	M
CO3	N	M	M	N	S	M	N	N	M	S	M	M
CO4	S	N	S	N	N	S	M	N	M	S	S	S

List of Experiments:

1. To the use of MATLAB for generation of different signals important in communication theory.
2. To learn the use of MATLAB for different operations on signals.
3. To identify the spectrum analyzer as used in frequency domain analysis using SIMULINK.
4. To identify various types of linear modulated waveforms in time and frequency domain representation using SIMULINK.
5. To analyze the spectrum, in time and frequency domain, of Amplitude Modulation using MATLAB.
6. To generate and demodulate amplitude shift keyed (ASK) signal using MATLAB
7. To generate and demodulate phase shift keyed (PSK) signal using MATLAB.
8. To generate and demodulate frequency shift keyed (FSK) signal using MATLAB.
9. To generate a scatter plot for QPSK and BPSK using MATLAB.

PEEC-813 B
Core Elective-1 Lab
(Wireless communication Lab)

	L	T	P	Credits
	0	0	4	2
	Internal Assessment Marks			50
	End Semester Marks			50

Course Objectives: The aim of this course is to study and understand the practical aspects of wireless communication system with focus on basic digital baseband communication, waveform analysis with MATLAB, channel impact on path loss model using MATLAB, various filter application and multi-dimensional signal analysis in communication system. Thorough knowledge would enable students to understand characterization and parameters in wireless communication systems.

Course Outcomes:

1. To familiarize with some advanced communication system.
2. To familiarize with the different waveform features via simulation.
3. To aware about the losses in the communication channel.
4. To familiarize about the usefulness of the filters in the communication.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	N	M	N	M	N	N	N	M	N	S	N	N
CO2	M	M	W	M	N	M	N	N	N	S	N	N
CO3	W	M	N	N	N	M	N	N	M	S	M	N
CO4	M	M	M	S	N	S	M	N	M	S	M	S

List of Experiments:

1. To study the baseband communication using Trainer KIT.
2. To study the CDMA for both multipath and multiuser on Trainer KIT.
3. To study the spread spectrum- DSSS modulation and demodulation using Trainer KIT.
4. To study and familiarize with MATLAB and its function widely used in wireless communication simulation and plot using MATLAB simulation
5. To study and Develop an QPSK detector and understand the relation between BER and SNR
6. To study and understand the various waveforms, their properties and process to capture transmitted waveforms and their processing using MATLAB simulation.
7. To Study the Propagation Path loss Models for Free Space Propagation using MATLAB.
8. To Study the Propagation Path loss Models for Link Budget Equation in Satellite Communication using MATLAB.
9. To Study the Propagation Path loss Models for Carrier to Noise Ratio in Satellite Communication using MATLAB.
10. To Study the various pulse shaping filters widely used in wireless communication system
11. To study and understand the features of matched filter.
12. To study the importance of coarse and fine synchronization, effect of frequency offset and its correction.
13. To Study tools to find out several unknown parameters of wireless communication system through multi-dimensional signal analysis

PCEC-814
Optical Communication System Lab

	L	T	P	Credits
	0	0	4	2
	Internal Assessment Marks			50
	End Semester Marks			50

Course Objectives: The aim of this course is to study and understand the practical aspects of advanced communication system and optical fiber. It also gives the insight into various optical nonlinearities in optical communication and their mitigation. Finally, it will provide platform for the student to design and evaluation of modern optical communication networks, wireless communication network and OFDM.

Course Outcomes:

1. Able to understand various losses occurs in optical communication system and their mitigation.
2. Enables the implementation of optical fiber communication link.
3. Ability to model and analyze the optical communication system for higher data rate.
4. Capable to integrate wireless technology with optical communication technology.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	N	S	N	M	N	M	N	S	M	N
CO2	N	N	S	N	N	S	M	N	N	S	S	M
CO3	N	M	M	N	S	M	N	N	M	S	M	M
CO4	S	N	S	N	N	S	M	N	M	S	S	S

List of Experiments:

1. To study the effect characteristics of Mach-Zender modulator in Opti-system.
2. Designing of an intensity modulator using Lithium Niobate Mach-Zehnder modulator in Opti-system.
3. To establish a point-to-point optical communication link on Opti-System and optical kit.
4. Characterization of laser diode and photodetector using simulator/light runner.
5. Characterization of the electrical parameter of the intensity modulator using Opti-System.
6. Measurement of attenuation in optical fiber using Opti-System simulator and light runner.
7. Measurement of dispersion in optical fiber using Opti-System simulator and light runner.
8. Minimization of the effect of dispersion in optical communication link.
9. Evaluation of power budget of an optical fiber link using Opti-System simulator and light runner.
10. Designing of a DWDM point-to-point link using Opti-system.
11. To study the effect of channel spacing and operating bit rate in DWDM optical network.
12. To study the effect of four-wave mixing in DWDM network in Opti-system.
13. To study the effect of cross-phase modulation in DWDM network in Opti-system.
14. Designing of an all-optical wavelength convertor using Opti-system.
15. Experimental study of SMF cutting and splicing.
16. Demonstration of SMF connection.
17. Designing of external metal deposition-based PCF-SPR sensor model.
18. Modelling of spectroscopy-based sensing setup for liquid analytes.

PCEC- 821
Microwave Integrated Circuits

	L	T	P	Credits
	3	1	0	4
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The objective of this course is to analyze and design of various strip lines, launching techniques, and microwave planner filters; analyze the various coupler for network design; study the different devices of active microwave circuits and nonlinear RF circuits.

Course Outcomes:

1. To gain knowledge about the design of various striplines, launching and lumped, elements.
2. Ability to design and fabricate various microwave planar filters.
3. Ability to analyze and model network design based on various couplers.
4. Select various components to characterize circuit and verify the performances.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	W	N	N	S	N	N	N	N	W	N
CO2	S	M	M	N	N	S	N	N	M	N	M	M
CO3	M	S	N	N	M	S	N	N	N	N	N	N
CO4	N	N	M	S	N	M	M	N	M	N	M	M

Unit-I — **12 hrs**

Introduction: Review of transmission lines, foundations of microstrip lines, striplines, higher modes in microstrips and strip lines, slot lines, coplanar waveguides, coplanar strips, launching techniques - coaxial line to microstrip transition, rectangular waveguide to microstrip transition, microstrip to slot-line transition, microstrip to coplanar waveguide (CPW) transition, lumped components - capacitors, inductors and resistors.

Unit-II — **12 hrs**

Microwave planar filters: Periodic structures, filter design by the image parameter method, filter design by the insertion loss method, filter transformations, filter implementation, stepped-impedance low-pass filters, coupled line filters, filters using coupled resonators.

Unit-III — **12 hrs**

4-Port network design: Review of network design, even and odd-mode analysis, branch-line couple, branch-line coupler with improved coupling performance, branch-line coupler with multiple sections, introduction to hybrid-ring couplers, qualitative description and complete analysis of hybrid-ring couplers, hybrid-ring couplers with modified ring impedances, introduction to parallel-coupled lines and directional couplers, even and odd-analysis of parallel-coupled lines, coupled-line parameters, multiple-section directional couplers.

Unit-IV — **12 hrs**

Nonlinear RF circuits: Review of non-linear circuits, power gain relations, simultaneous conjugate matching, stability considerations, power gain for matched, unmatched, unilateral conditions, noise characterization and design options, switches - PIN diode switches, FET switches, mems switch, variable attenuators, phase shifters, detectors and mixers, amplifiers - small signal amplifiers, low noise amplifiers, power amplifiers, oscillators.

RECOMMENDED BOOKS

Title	Author	Publisher
1. Microwave Engineering	D.M. Pozar	3rd Ed., John Wiley & Sons, 2004
2. Microwave Engineering Using Microstrip Circuits	E.H. Fooks and Zakarevicius	Prentice-Hall, 1990
3. Networks and Devices using Planar Transmission Lines	Franco di Paolo	CRC Press, 2000
4. RF Circuit Design	R. Ludwig and P. Bretchko	Pearson Education, 2000
5. Microwave and RF Engineering	Roberto Sorrentino and Giovanni Bianchi	John Wiley & Sons, 2010

PCEC-822
VLSI Design

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The objective of VLSI Design is to help the students to get brief knowledge of MOS, PMOS, NMOS, CMOS &Bi -CMOS technologies. It also aims at introducing the fundamental principles of VLSI circuit design and to examine the basic building blocks of gate level design and subsystem design.

Course Outcomes:

1. Model the behaviour of MOS transistor and understand the switching characteristics of inverter.
2. Design combinational and sequential circuits using CMOS gates.
3. Identify the sources of dynamic, leakage power components in a given VLSI circuit and analyze the performances of VLSI circuits.
4. Analyze and design VLSI subsystem structures.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	N	N	N	N	S	M	M	N	N	N	W	N
CO2	S	M	M	N	N	S	M	N	M	N	M	M
CO3	S	M	N	S	N	N	N	N	W	N	M	M
CO4	N	S	M	N	N	S	W	N	N	N	M	M

Unit-I — **14 hrs**

Device physics: Review of MOS transistor theory, MOS device equations- basic dc equations, concept of threshold voltage, second order effects and small signal ac characteristics.

Inverter analysis: Complementary CMOS inverter, DC characteristics, ratio, noise margin, CMOS inverter as an amplifier, static load CMOS inverters, pseudo NMOS inverter, saturated load inverters, cascode inverter, TTL interface inverter, differential inverter, transmission gate, tri - state inverter and Bi-CMOS inverter.

Unit-II — **14 hrs**

Fabrication process: Basic MOS technology, NMOS and CMOS process flow, stick diagrams, design rules, layout design and tools and latch up in CMOS.

Circuit characterization and performance estimation: Resistances and capacitance estimation, SPICE modding, switching characteristics, delay models, rise and fall times, propagation delays, body effect, CMOS gate transistor sizing, power dissipation, design margining and scaling principles.

Unit-III — **10 hrs**

CMOS circuit and logic design: CMOS logic gate design, basic physical design of simple logic gates. CMOS logic structures, clocking strategies, low power CMOS logic structures, chip input and output (I/O) structures.

Unit-IV — **10 hrs**

VLSI design methodologies: VLSI design flow, structured design strategies, VLSI design styles and chip design options.

Subsystem structures: Arithmetic logic unit (ALU), shifters, memory elements, high density memory structures, finite state machines (FSM) and programmable logic arrays (PLA)

RECOMMENDED BOOKS		
Title	**Author**	**Publisher**
1. CMOS Digital Integrated Circuits	Sung- Mo Kang, Yusuf Leblebici	TMH, 2003
2. Basic VLSI Design, Systems And Circuits	Pucknell DA and Eshraghian K	PHI, 1988
3. Integrated Circuits	KR Botkar	Khanna Publishers, 2015

PEEC-821A
Advanced Digital Signal Processing

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The aim of this course is to acquire knowledge of discrete time systems. This course will contain study of different transform methods such as Z-transform, discrete Fourier transform (DFT) and fast Fourier transform (FFT) and how FIR and IIR filters can beimplemented, and their structures will be realized. Then the course will study the concept of linear prediction and estimation, equalization algorithms and the concept of multirate signal processing and sample rate conversion.

Course Outcomes:
1. Master the representation of discrete-time signals in the frequency domain, using z-transform, discrete Fourier transform (DFT) and discrete cosine transform.
2. Understand the implementation of the DFT in terms of the FFT, as well as some of its applications.
3. Learn the basic forms of FIR and IIR filters, and how to design filters with desired frequency responses.
4. Ability to implement adaptive signal processing algorithms based on second order statistics.
5. Analyze various multi-rate processing techniques.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	N	N	N	N	M	N	N	N	M	N
CO2	M	N	N	N	N	M	M	N	N	N	W	N
CO3	S	M	M	M	N	S	N	N	N	N	M	M
CO4	N	S	N	N	M	N	M	N	M	N	M	N
CO5	M	N	N	N	S	M	S	N	N	N	N	N

Unit-I — **12 hrs**

Discrete time signals and systems: Advantages and limitations of digital signal processing, review of discrete time signals and system analysis using z transform and Fourier transform, properties and applications of DFT, FFT and decimation algorithms, DCT and its applications in multimedia coding.

Unit-II — **12 hrs**

Design of digital filters: Review of structures for discrete time systems, design of digital FIR and IIR filters.

Real time DSP: General and special purpose hardware for DSP, real time digital signal processing using TMS320 family, implementation of DSP algorithm on digital signal processors.

Unit-III — **12 hrs**

Estimation and prediction: Linear prediction and optimum linear filters, forward & backward linear prediction, Levinson-Durbin algorithm, Schur algorithm, properties of linear prediction error filter, Wiener filters for filtering and over sampling.

Equalization algorithms: Adaptive equalizer, the zero-forcing algorithm, decision feedback equalizer, block decision feedback equalizer, LMS algorithm convergence properties of LMS algorithm, recursive least squares algorithm, Kalman filtering, blind equalization.

Unit-IV	12 hrs
Multi-rate signal processing: Introduction, decimation and interpolation, sample rate conversion, efficient poly-phase structures, design of phase shifters, filter banks, quadrature mirror filters, applications of digital signal processing.	

RECOMMENDED BOOKS

Title	Author	Publisher
1. Digital Signal Processing	John G.Prokis	Prentice Hall of India
2. Digital Signal Processing	Oppenheuim	Prentice Hall of India
3. Digital Signal Processing: A Computer-Based Approach	Sanjit K. Mitra	Tata McGraw Hill

PEEC-821B Soft-Computing				
	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives:

The course aims to learn the key aspects of Soft computing. The course will study how to apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems; understand the features of neural network, and its applications; know about the components and building block hypothesis of genetic algorithm. Next focus to gain insight onto neuro fuzzy modeling & control and gain knowledge in machine learning through Support vector machines.

Course Outcomes:

1. Analyze the genetic algorithms and their applications
2. Gain knowledge to develop genetic algorithm and support vector machine-based machine learning system.
3. Write genetic algorithm to solve the optimization problem.
4. Analyze various neural network architectures.
5. Understand fuzzy concepts and develop a fuzzy expert system to derive decisions.
6. Able to model neuro fuzzy system for data clustering and classification.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	N	N	N	M	N	M	W	N	N	N
CO2	S	M	M	N	M	M	S	N	N	N	M	M
CO3	N	M	N	N	N	M	M	N	N	S	M	M
CO4	N	M	N	N	N	W	N	M	M	N	M	W
CO5	S	N	S	N	N	S	S	N	N	N	M	M
CO6	S	N	W	N	S	W	M	N	N	N	N	N

Unit-I — **12 hrs**

Neural network fundamentals: Basic concepts, human brain, artificial neuron model, neural network architectures-Rosenblatt's perceptron, ADALINE and MADALINE networks, neural network characteristics, learning methods, architecture taxonomy, bac k-propagation network (BPN), BPN architecture, perceptron model, single layer network, multilayer perceptron model, back-propagation learning, back-propagation algorithm, tuning parameters effect and parameter selection, application of ANN to channel equalization.

Unit-II — **12 hrs**

Fuzzy logic fundamental: Crisp sets, fuzzy sets, membership function, basic fuzzy set operations, fuzzy set properties, crisp relations, fuzzy relations, fuzzy Cartesian product, operation on fuzzy relations, fuzzy systems, crisp logic, predicate logic, fuzzy logic, fuzzy rule based system and defuzzification methods.

Unit-III	12 hrs
Genetic algorithm fundamentals: Basic concepts, biological background, working principle, encoding, fitness function, reproduction including roulette-wheel selection, Boltzmann selection, tournament selection, rank selection and steady state selection, design of rapid nickel cadmium battery charger and rule base generation from numerical data using GA.	

Unit-IV:	12 hrs
Genetic modeling: Inheritance operators, cross-over-single site crossover, two-point crossover, multipoint crossover, uniform crossover, matrix crossover, crossover rate, inversion, deletion and duplication, mutation operator, generation cycle, convergence of genetic algorithms.	

RECOMMENDED BOOKS

Title	Author	Publisher
1. Neural Networks, Fuzzy Logic and Genetic Algorithms	S. Rajasekaran and G.A. Vijayalakshmi Pai	PHI
2. Artificial Neural Networks	B. Yegnarayana	PHI
3. Introduction to Applied Fuzzy Electronics	Ahmad M. Ibrahim	PHI
4. Fuzzy Logic with Engineering Applications	J T Ross	McGraw-Hill

PEEC- 821C
Digital Image Processing

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: Aim of the course is to study the fundamentals of digital image processing. It also gives deep insight in to the basic of image processing operations like filtering of noise and image enhancement; design, analyze and implement algorithms for advanced image analysis like image compression, image reconstruction, image segmentation and edge detection techniques.

Course Outcomes:

1. Examine various types of images, intensity transformations and applying various filtering techniques.
2. Show how higher-level image concepts such as edge detection, segmentation, representation can be implemented and used.
3. To manipulate both binary and grayscale digital images using morphological filters and operators to achieve a desired result.
4. Apply image processing algorithms in practical applications.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	N	S	M	M	M	N	N	N	N	N
CO2	S	M	M	S	N	M	M	N	N	N	M	N
CO3	N	N	M	S	N	M	M	N	S	N	W	N
CO4	M	S	M	N	N	S	M	N	M	N	M	M

Unit-I — **12 hrs**

Digital image fundamentals: Scenes and images, different stages of image processing and analysis, components of image processing system, visual preliminaries, brightness adaptation and contrast, acuity and contour, texture and pattern discrimination, shape detection and recognition, color perception, image formation, geometric and photometric models, digitization including sampling, quantization and digital image visual details.

Unit-II — **12 hrs**

Image enhancement and restoration: Contrast intensification comprising of linear stretching, non-linear stretching, fuzzy property modification, histogram specification, modifying grey level co-occurrence matrix and local contrast stretching, smoothing including image averaging, mean filter, ordered statistic filter, edge-preserving smoothing and low pass filtering, image sharpening including high-pass filtering and homomorphic filtering, image restoration fundamentals, minimum mean square error restoration least square error restoration and constrained least square error restoration.

Unit-III — **12 hrs**

Image compression: Fundamentals of image compression, error criterion, lossy compression including transform compression, block truncation compression, vector quantization compression and lossless compression including Huffman coding method.

Unit-IV — **12 hrs**

Image segmentation and edge detection: Region extraction, pixel based approach including feature thresholding, optimum thresholding and threshold selection methods, edge detection fundamentals, derivative operators including Roberts, 4-neighbour, Prewitt and Sobel operators, Canny edge detector, Laplacian edge detector, Laplacian of Gaussian edge detector.

RECOMMENDED BOOKS		
Title	**Author**	**Publisher**
1. Digital Image Processing	Rafael C. Gonzalez	Pearson
2. Digital Image Processing and Analysis	Chanda and Majmuder	PHI
3. Computer Vision and Image Processing	S Nagabhushana	New Age International

PEEC-821 D
Artificial Intelligence and Deep Learning

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives:

The availability of a huge volume of Image and Video data over the internet has made data analysis and interpretation a challenging task. Deep Learning has proved itself to be a possible solution to such Computer Vision tasks.

This course provides introduction to traditional Machine Learning approaches, e.g., Bayesian Classification, Multilayer Perceptron etc. and then move to modern Deep Learning architectures like Convolutional Neural Networks, Autoencoders etc. Upon completing the course, students will acquire the knowledge of applying Deep Learning techniques to solve various real-life problems.

Course Outcomes:

1. Understand the difference between classification and regression.
2. Appreciate the optimization techniques and differentiate between overfitting and regularization.
3. Analyze and differentiate various deep learning architectures and their merits and demerits.
4. Acquire the knowledge of latest trends in deep learning domain and various other techniques.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	3	3	3	1	2	1	1	1	1	0	2	2
CO2	3	3	2	1	1	1	2	1	1	0	3	2
CO3	3	3	3	3	2	2	2	1	1	0	3	2
CO4	3	3	3	1	3	2	2	1	1	0	3	2

Unit-I — **12 hrs**

Introduction: Introduction to Deep Learning, History of Deep Learning, Bayesian Learning, Decision Surfaces, Linear Classifiers, Linear Machines with Hinge Loss. Optimization Techniques, Gradient Descent, Stochastic GD, Batch Optimization, Momentum Optimizer, RMS Prop, Adam.

Unit-II — **12 hrs**

Neural Network Architectures: Introduction to Neural Network, Feed Forward Neural Networks, Multilayer Perceptron, Back Propagation Learning, Convolutional Neural Network, CNN Operations, Building blocks of CNN, Transfer Learning, Google Net, Res Net. Transformer architecture.

Regularization: Bias Variance Trade-off, L2 regularization, Early stopping, Dataset augmentation

Unit-III — **12 hrs**

Normalization in Neural Network: Revisiting Gradient Descent, Effective training in Deep Net - early stopping, Dropout, Batch Normalization, Instance Normalization, Group Normalization.

Unsupervised Learning: Unsupervised Learning with Deep Network, Autoencoders, Denoising auto encoders, Sparse auto encoders, Variational Autoencoder, Encoder Decoder Models, Attention Mechanism, Atten tion over images.

Unsupervised Learning: Unsupervised Learning with Deep Network, Autoencoders, Denoising auto encoders, Sparse auto encoders, Variational Autoencoder, Encoder Decoder Models, Attention Mechanism, Attention over images**.**	
Unit -IV	**12 hrs**
Deep Learning Architectures: Recent Trends in Deep Learning Architectures, Residual Network, Skip Connection Network, Classical Supervised Tasks with Deep Learning, Image Denoising, Semantic Segmentation, LSTM Networks. Generative Modeling with DL, Generative Adversarial Network.	

Recommended Books

Title	Author	Publisher
1. Deep Learning	Ian Goodfellow and Yoshua Bengio	An MIT Press book. (2019).
2. Deep Learning for Coders with Fastai and PyTorch	Jeremy Howard and Sylvain Gugger	O'Reilly (2020).
3. Deep Learning From Scratch	Seth Weidman	O'Reilly (2020).
4. Deep Learning with PyTorch	Eli Stevens, Luca Antiga, Thomas Viehmann	Manning Publications**.** (2019).

PEEC-822A
Electronic Product Design

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The objective of this course is to provide adequate knowledge about the reliability, control panel design, thermal consideration and packaging required for electronic industry.

Course Outcomes:
1. Explain reliability and methods of solving complex problems.
2. Explain the importance of aesthetics and ergonomics in electronics product design.
3. Explain need of control panel design and thermal consideration in electronic industry.
4. Explain the types of interconnections for packaging.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	W	N	N	N	N	M	N	M	N	N	N	N
CO2	M	M	S	M	N	S	M	N	N	N	M	M
CO3	M	M	S	S	N	S	M	N	S	N	S	M
CO4	N	M	M	N	N	M	N	N	M	N	M	N

Unit-I — **11hrs**

System reliability concepts: Introduction to concepts of reliability, nature of reliability problems in electronics equipment, series configurations, parallel configuration, mixed configuration, methods of solving complex systems, mean time to failure (MTTF) and mean time between failure (MTB) of systems. maintainability, availability concepts, system downtime, mean time to repair (MTTR), fault tree analysis-concepts and procedures, rules for fault tree construction.

Unit-II — **12hrs**

Ergonomics and aesthetics in electronics product design: Overview of electronics product design, top-down and bottom-up approach, considering power supply design as an example, ergonomics and display w.r.t. ergonomics and aesthetics consideration **.**

Unit-III — **12 hrs**

Control panel design and thermal consideration: Types of controls, design and organization of control panel, engineering consideration, layout of components, selection of materials, sheet metals and plastic, structural design and control cabinets fabrications, thermal management of electronics equipment, thermal design consideration, component level, board level, system level, fans and system operating characteristics, heat sink design.

Unit-IV — **10 hrs**

Packaging: Design consideration for inter-connections, types of inter-connections, wires, cables, connectors, treatment of vibration, grounding

RECOMMENDED BOOKS

Title	Author	Publisher
1. Materials and Processes in Manufacturing	Ernest Paul De Garmo, J.T. Black, Ronald A. Kohser	12th Edition, John Wiley & Sons.
2. Advanced Thermal of Electronics Equipment	Raiph Remsburg	Springer, 2011
3. Product Design of Electronics Equipment	V.S. Bagad	4th Edition 2009, Technical Publication

PEEC-822B
Satellite Communication

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: This course provides fundamental knowledge about orbital theory and satellite link design. Students will understand the role of various modulation, multiplexing and multiple access techniques used in satellite communication networks. study of various satellite services also presented in this course.

Course Outcomes:

1. Visualize the architecture of satellite systems as a means of high speed, high range communication system.
2. State various aspects related to satellite systems such as orbital equations, sub-systems in a satellite, link budget, modulation and multiple access schemes.
3. Solve numerical problems related to orbital motion and design of link budget for the given parameters and conditions.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	W	N	S	N	W	N	M	W	N	N	N
CO2	M	N	N	S	S	N	N	N	M	N	N	N
CO3	W	M	M	N	M	S	N	S	N	S	M	M

Unit-I **12hrs**

Architecture of satellite communication system: Principles and architecture of satellite communication, brief history of satellite systems, advantages, disadvantages, applications, and frequency bands used for satellite communication and their advantages/drawbacks.

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.

Unit-II **12 hrs**

Satellite sub-systems: 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 sub-systems, antenna sub-system.

Satellite sub-systems: 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 sub-systems, antenna sub-system.

Unit-III **10 hrs**

Satellite link budget: Flux density and received signal power equations, calculation of system noise temperature for satellite receiver, noise power calculation, drafting of satellite link budget and C/N ratio calculations in clear air and rainy conditions, case study of personal communication system (satellite telephony) using LEO.

Unit-IV **14hrs**

Typical phenomena in satellite communication: Solar eclipse on satellite, its effects, remedies for eclipse, sun transit outage phenomena, its effects and remedies, Doppler frequency shift phenomena and expression for Doppler shift, modulation and multiple access schemes used in satellite communication, typical case studies of VSAT, DBS-TV satellites and few recent communication satellites launched by NASA/ISRO,GPS.

RECOMMENDED BOOKS

Title	Author	Publisher
1. Satellite Communications	Timothy Pratt and Others	Wiley India, 2nd edition, 2010.
2. Fundamentals of Satellite Communication	S. K. Raman	Pearson Education India, 2011
3. Digital Satellite Communications	Tri T. Ha	Tata McGraw Hill, 2009
4. Satellite Communication	Dennis Roddy	McGraw Hill, 4th Edition, 2008

PEEC- 822 C Digital Circuit Logic Design				
	L	**T**	**P**	**Credits**
	3	**0**	**0**	**3**
	Sessional Marks			**50**
	End Semester Examination Marks			**50**
Course Objectives:	The objective of this course is to provide a comprehensive understanding of how logic circuits are analyzed, designed, verified, tested and further used to solve engineering problems. Topics in sequential circuit design are treated, including finite state machines, Mealy and Moore models, state diagrams and state tables, optimization, asynchronous sequential circuits, and races and hazards; analyze and design simple systems composed of programmable logic, such as ROMs, PLDs, FPGAs and CPLDs.			
Course Outcomes:	1. To learn different types of digital systems and to understand and deal with various practical issues related to their design. 2. Able to design, simulate, and built synchronous sequential and asynchronous sequential circuits. 3. Ability to analyze and design simple systems composed of programmable logic, such as ROMs PLDs, FPGAs and CPLDs.			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	N	N	S	N	N	M	N	M	N
CO2	M	M	S	S	N	S	M	N	M	N	S	M
CO3	M	S	S	M	M	S	M	N	M	N	S	S

Unit-I	**12 hrs**
Synchronous FSM design: Review of digital concepts, MSI and LSI circuits and their applications, synchronous state machine design and analysis-models, latches and flip-flops, setup and hold times, tristate logic and busses, Mealy and Moore FSM design, design of iterative circuits, timing analysis of FSMs, FSM optimization, binary and one-hot encoding and pipelining.	
Unit-II	**12 hrs**
Dealing with asynchronous inputs: Synchronizers and meta-stability, asynchronous machines analysis and design- models for asynchronous FSMs, detection and elimination of timing defects in asynchronous FSMs- cycles, races and hazards.	
Unit-III	**12 hrs**
Clock distribution: Clock skew, low-skew clock buffers, zero delay buffers - PLL, delay-locked loops, timing analysis of synchronous, source synchronous and embedded clock bus interfaces.	
Unit-IV	**12 hrs**
Memory devices: ROM, programmable logic devices (PLDs) and programmable gate arrays architecture, various architectures of FPGA, designing with PLDs, FPGAs and CPLDs.	

RECOMMENDED BOOKS

Title	**Author**	**Publisher**
1. Engineering Digital Design	Richard F Tinder	2nd Ed., Academic Press, 2000
2. Digital Design-principles and practices	John F Wakerly	3rd Ed., Pearson Education Asia,1999
3. Digital Logic and State Machine Design,	David J Comer	3rd Ed., Oxford University Press
4. An Engineering Approach to Digital Design	William I Fletcher	PHI, 1980

PCEC-823
VLSI Design Lab

	L	T	P	Credits
	0	0	4	2
	Internal Assessment Marks			50
	End Semester Marks			50

Course Objectives: To introduce the fundamental principles of VLSI circuit design in CMOS technology and to examine performance parameters of combinational circuits; design, layout and simulation of combinational circuits and amplifiers.

Course Outcomes:

5. Ability to analyze CMOS inverter.
6. Ability to estimate and compute the resistance, capacitance, inductance and power consumption of a NMOS/CMOS.
7. Ability to design logic circuit layouts for both static CMOS and dynamic clocked CMOS circuits.
8. Be able to complete a significant VLSI design project having a set of objective criteria and design constraints

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	N	M	N	M	N	N	N	M	N	S	N	N
CO2	M	M	W	M	N	M	N	N	N	S	N	N
CO3	W	M	N	N	N	M	N	N	M	S	M	N
CO4	M	M	M	S	N	S	M	N	M	S	M	S

List of Experiments:

14. Design of NMOS and CMOS inverters for DC signal.
15. NMOS and CMOS inverters-transient characteristics and switching times.
16. Evaluation of resistance in NMOS/CMOS.
17. Evaluation of capacitance and inductance in CMOS.
18. Design of multiplexers and demultiplexers.
19. Design of full adder and comparator.
20. Design of MOS capacitor for small signal.
21. Design and simulate common source (CS) amplifier.
22. Design and simulate cascode and active current mirrors.
23. C-V and I-V characterization of MOS capacitors.
24. Modeling and simulation of NMOS and CMOS circuits using SPICE.

PEEC-824 A Core Elective Lab -2 (Microwave Engineering Lab)				
	L	**T**	**P**	**Credits**
	0	**0**	**4**	**2**
	Internal Assessment Marks			**50**
	End Semester Marks			**50**
Course Objectives:	This lab aims to design and simulate various microwave circuits using software tool. After designing and simulation, students will be able to fabricate these components/circuits.			
Course Outcomes:	1. Design various microwave components using software tools. 2. Simulate the characteristics of microwave components using software tools and can investigate and interpret the results. 3. Fabricate the simulated circuits to provide sustainable products in said domain			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	M	M	S	S	S	N	M	N	N	W
CO2	W	S	N	S	S	M	S	M	M	S	M	M
CO3	M	M	S	N	S	S	M	M	M	S	M	S

List of Experiments:

1. Design of quarter wave microstrip line on an appropriate substrate, resonated at 2.54 GHz and simulate using HFSS and plot its S_{11} and VSWR performance.
2. Fabrication of quarter wave microstrip line mentioned in experiment No. 1.
3. Design of microstrip line step transformer on an appropriate substrate at f_o = 2.54 GHz for impedance 50 ohms to 75 ohms, simulate using HFSS and plot its impedance plot for both ports over the span from 0.5 f_o to 1.5 f_o.
4. Fabrication of microstrip line step transformer mentioned in experiment No. 3.
5. Using HFSS, design and performance of equal split Wilkinson Power Divider for a 50 Ω system impedance at frequency f_o = 2.54 GHz. Plot the return loss S_{11}, insertion loss $S_{21} = S_{31}$ and isolation $S_{23} = S_{32}$ verses frequency from 0.5 f_o to 1.5 f_o.
6. Fabrication of Wilkinson Power Divider mentioned in experiment No. 5.
7. Design of microstrip rectangular patch antenna resonated at f_o = 2.54 GHz. Simulated using HFSS and plot it S_{11} parameter and 2D radiation pattern at theta 0 degree and phi 90 degree.
8. Fabrication of microstrip rectangular patch antenna mentioned in experiment No. 7.
9. Design the microstrip line bends at 45^o with matched ports at frequency 2.54 GHz. Simulate using HFSS and study the bending loss over the frequency from 0.5 f_o to 1.5 f_o.
10. Fabrication of microstrip line bends mentioned in experiment No. 9.
11. Design the microstrip line curve bends with matched ports at frequency 2.54 GHz. Simulate using HFSS and study the bending loss over the frequency from 0.5 f_o to 1.5 f_o.
12. Fabrication of microstrip line curve bends mentioned in experiment No. 11.

PEEC-824 B
Core Elective Lab -2
(Computer Aided Design Lab)

	L	T	P	Credits
	0	0	4	2
	Internal Assessment Marks			50
	End Semester Marks			50

Course Objectives: This lab aims to design and simulate various features of wireless network, artificial intelligence, microwave antenna, digital signal processing and image processing using the different software available which can help the students to work on inter-disciplinary projects.

Course Outcomes:

1. Design and understand the basic of WSN using NS3 software.
2. Learn and understand the basic design procedure of neural network using Python programming.
3. Simulate and analyze the characteristics of different types of microwave antenna using software.
4. Understand the application of MATLAB in digital signal and image processing.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	M	M	S	S	S	N	M	N	N	W
CO2	W	S	N	S	S	M	S	M	M	S	M	M
CO3	M	M	S	N	S	S	M	M	M	S	M	S
CO4	M	M	S	N	S	S	M	M	M	S	M	S

List of Experiments:

1. To understand the basic concepts about the wireless sensor network (WSNs), types and application.
2. To design and simulate a wireless sensor network (WSN) using NS3 simulator.
3. To study and design WSN using LEACH, a cluster-based routing protocol for WSN.
4. To understand and write a PYTHON programme to wrap inputs of neural network with NumPy.
5. To understand and write a PYTHON programme to make the prediction in neural network.
6. To understand and write a PYTHON programme to train a Neural Network.
7. To understand and write a PYTHON programme to minimize the errors.
8. To study and understand the Digital signal Processing using MATLAB.
9. To study and understand the Image Processing using MATLAB.
10. To design and simulate E-plane, H-plane, and Magic Tee for operation in X-band frequency range using HFSS software.
11. To Design and simulate Horn Antenna for operation in X-band frequency range using HFSS.
12. To Design and simulate rectangular and circular patch microstrip antenna for 5G application using ADS/ HFSS software.
13. To Design and simulate wire monopole antenna for 5G application using ADS/ HFSS software.
14. To Design and simulate triple-frequency microstrip-fed monopole antenna using defected ground structure using ADS/ HFSS software.

PCEC-824 Seminar				
	L	T	P	Credits
	0	0	2	1
Course Objectives:	To carry out a presentation in one of the specializations of the program with substantial multidisciplinary component.			
Course Outcomes:	1. An ability to write technical documents and give oral presentations related to the work completed and improves personality development and communication skills. 2. Train the students to approach ethically any multidisciplinary engineering challenges with economic, environmental and social contexts and to set them for future recruitment by potential employers. 3. Identify and apply appropriate well-rehearsed note-taking interactive and time management strategies to their academic studies. 4. Develop audience-centred presentations meeting concrete professional objectives and integrating ethical and legal visual aids. 5. Identify and critically evaluate the quality of claims, explanation, support, and delivery in public and professional discourse, and understand the factors influencing a speaker's credibility.			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	N	N	N	S	N	N	N	S	M	S	S	S
CO2	N	N	N	N	N	N	N	S	N	N	M	N
CO3	N	N	N	N	N	N	N	S	M	N	W	M
CO4	N	N	N	S	N	N	N	S	M	S	S	S
CO5	N	N	N	S	N	N	N	S	M	S	M	M

PEEC-911A
Wireless Sensor Networks

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: This course is aimed to study the sate- of- the- art wireless sensor network architecture, routing protocols, performance metrics, challenges as well as the applications of wireless sensor networks.

Course Outcomes:
1. Understand the principles and characteristics of wireless sensor networks.
2. Identify, evaluate and analyze the problems related to wireless sensor network.
3. Understand the different clustering algorithms and their usefulness.
4. Design different protocols to solve the existing issues.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	N	N	M	N	M	N	M	N	N	N	N
CO2	N	S	M	N	N	M	N	N	M	N	M	M
CO3	S	M	M	S	M	M	M	N	N	N	M	N
CO4	S	M	M	N	M	M	S	N	M	N	M	M

Unit-I — **10 hrs**

Introduction: Characteristic requirements for WSN, challenges for WSNs, comparison with ad-hoc wireless networks, single node architectures – hardware components, energy consumption of sensor nodes, commercially available sensor nodes – I mote, IRIS, mica mote, EYES nodes, BT-nodes, Telos-B.

Unit-II — **16 hrs**

Medium access control protocols: Fundamentals of MAC protocols - location discovery, other issues - low duty cycle and wake up concepts, IEEE 802.15.4 MAC protocols, energy efficiency.

Unit-III — **10 hrs**

Routing and data gathering protocols: Routing challenges and design issues in wireless sensor networks, flooding and gossiping, data centric routing, gradient based routing, hierarchical routing, location-based routing, data aggregation operations, aggregation techniques

Unit-IV — **12 hrs**

Applications of WSN: WSN applications - home control, building automation, industrial automation, medical applications, reconfigurable sensor networks, highway monitoring, military applications, civil and environmental engineering applications, wildfire instrumentation, habitat monitoring etc.

RECOMMENDED BOOKS

Title	Author	Publisher
1. Wireless Sensor Networks Technology, Protocols and Applications	Kazem Sohraby, Daniel Minoli and Taieb Znati	John Wiley & Sons, 2007
2. Protocols and Architectures for Wireless Sensor Networks	Holger Karl and Andreas Willig	John Wiley & Sons Ltd, 2005
3. Wireless Sensor Networks: Heterogeneous Clustered Data Aggregation and Routing Protocols	D. Kumar, T.C Aseri, and R.B. Patel	Lap Lambert Academic Publishing GmbH & Co., Germany, 2012

PEEC-911B
Network Security and Cryptography

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The aim of this course is to identify and utilize different forms of cryptography techniques, incorporate authentication and security in the network applications and distinguish among different types of threats to the system and handle the same.

Course Outcomes:
1. Understand the need of network and system security.
2. Understand the basics of private key and public key cryptography.
3. Familiarize with the concept of number theory.
4. Understand the various authentication techniques in security.

Mapping of Course Outcomes with Program Outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	W	N	N	N	N	N	N	N	N	N
CO2	M	M	M	N	N	N	N	N	N	N	W	N
CO3	W	S	W	N	N	N	N	N	N	N	W	N
CO4	S	S	M	N	N	N	N	N	N	N	N	N

Unit-I — 12 hrs

Security: Need, security services, attacks, OSI security architecture, one-time passwords, model for network security, classical encryption techniques like substitution ciphers, transposition ciphers, cryptanalysis of classical encryption techniques.

System security: Intruders, intrusion detection, password management, worms, viruses, trojans, virus countermeasures, firewalls, firewall design principles, trusted systems.

Unit-II — 10hrs

Number theory: Introduction, Fermat's and Euler's theorem, the Chinese remainder theorem, Euclidean algorithm, extended Euclidean algorithm and modular arithmetic.

Unit-III — 14 hrs

Private-key (symmetric) cryptography: Block ciphers, stream ciphers, RC4 stream cipher, data encryption standard (DES), advanced encryption standard (AES), triple DES, RC5, IDEA,linear and differential cryptanalysis.

Public-key (asymmetric) cryptography: RSA, key distribution and management, Diffie-Hellman key exchange, elliptic curve cryptography, message authenticat ion code, hash functions, message digest algorithms: MD4 MD5, secure Hash algorithm, RIPEMD-160, HMAC

Unit-IV — 12 hrs

Authentication - IP and web security digital signatures, digital signature standards, authentication protocols, Kerberos, IP security architecture, encapsulating security payload, key management, web security considerations, secure socket layer and transport layer security, secure electronic transaction.

RECOMMENDED BOOKS

Title	Author	Publisher
1. Cryptography and Network Security, Principles and Practices	William Stallings	Pearson Education
2. Network Security, Private Communication in a Public World	Charlie Kaufman, Radia Perlman and Mike Speciner	Prentice Hall
3. Security Architecture, Design Deployment and Operations	Christopher M. King, Ertem Osmanoglu, Curtis Dalton,	RSA Press
4. Inside Network Perimeter Security	Stephen Northcutt, Leny Zeltser, Scott Winters, Karen Kent, and Ronald W. Ritchey	Pearson Education

PEEC-911C Advanced Computer Networks				
	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50
Course Objectives:	The aim of this course is to provide a broad coverage of some new advanced topics in the field of computer networks (wireless networks, mobile networks, VPN networks, etc.) and to give the student ideas and insights on important design issues associated with computer networks.			
Course Outcomes:	1. Understand the main abstract concepts related to the layered communication architecture. 2. Analyze and implement some of the most advanced routing and congestion control algorithm. 3. Evaluate the performances of computer networks (through mathematical modeling and simulation).			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	N	W	N	M	W	N	N	N	N	W	N
CO2	M	S	M	N	N	M	M	N	M	N	M	M
CO3	N	N	N	S	M	N	M	N	N	N	M	N

Unit-I — **12 hrs**

Introduction to computer networks: Reference models: OSI model, TCP/IP model, comparison of TCP/IP and OSI models, types of data transmission, error detection and correction, multiple access protocols.

Unit-II — **12 hrs**

Network types and topologies: LANs, WANs, others and hybrids, ethernet, token bus, token ring; star, ring, bus, other. network hardware : wiring, network interface cards, hubs, routers, switches, introduction to Novell NetWare, and ARPANET.

Unit-III — **12hrs**

Introduction to distributed systems: Characteristics of distributed Systems, examples, resource sharing, system models, architectural fundamentals: basic concepts, client-server model, cooperation between client and servers, extension to the client server model: mobile agents, proxy servers.

Unit-IV — **12hrs**

Networking and internetworking: Network types, principles, IP delivery review, options and encapsulation. IPv4 Vs. IPv6 , inter process communication: external data representation, client server communication, group communication.

RECOMMENDED BOOKS

Title	Author	Publisher
1. Computer Networks	Andrew S. Tanenbaum	2nd edition, PHI, 1988
2. Computer network and Distributed processing	James Martin	Prentice-Hall.
3. Data Communications and Networking	B.A. Forouzan	4th edition, McGraw Hill Education, 2006

OEEC-911A
Electronic Product Design

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The objective of this course is to provide adequate knowledge about the reliability, control panel design, thermal consid eration and packaging required for electronic industry.

Course Outcomes:
1. Explain reliability and methods of solving complex problems.
2. Explain the importance of Aesthetics and Ergonomics in electronics product design.
3. Explain need of control panel design and thermal consideration in electronic industry.
4. Explain the types of inter-connection for packaging.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	W	N	N	N	N	M	N	M	N	N	N	N
CO2	M	M	S	M	N	S	M	N	N	N	M	M
CO3	M	M	S	S	N	S	M	N	S	N	S	M
CO4	N	M	M	N	N	M	N	N	M	N	M	N

Unit-I — **11hrs**

System reliability concepts: Introduction to concepts of reliability, nature of reliability problems in electronics equipment, series configurations, parallel configuration, mixed configuration, methods of solving complex systems, mean time to failure (MTTF) and mean time between failure (MTB) of systems. maintainability, availability concepts, system downtime, mean time to repair (MTTR), fault tree analysis-concepts and procedures, rules for fault tree construction.

Unit-II — **12hrs**

Ergonomics and aesthetics in electronics product design: Overview of electronics product design, top-down and bottom-up approach, considering power supply design as an example, ergonomics and display w.r.t. ergonomics and aesthetics consideration **.**

Unit-III — **12 hrs**

Control panel design and thermal consideration: Types of controls, design and organization of control panel, engineering consideration, layout of components, selection of materials, shee t metals and plastic, structural design and control cabinets fabrications, thermal management of electronics equipment, thermal design consideration, component level, board level, system level, fans and system operating characteristics, heat sink design.

Unit-IV — **10 hrs**

Packaging: Design consideration for inter-connections, types of inter-connections, wires, cables, connectors, treatment of vibration, grounding .

RECOMMENDED BOOKS

Title	Author	Publisher
1. Materials and Processes in Manufacturing	Ernest Paul De Garmo, J.T. Black, Ronald A. Kohser	12th Edition ,John Wiley & Sons.
2. Advanced Thermal of Electronics Equipment	Raiph Remsburg	Springer, 2011
3. Product Design of Electronics Equipment	V.S. Bagad	4th Edition 2009, Technical Publication

OEEC-911B
Soft Computing

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The course aims to learn the key aspects of Soft computing. The course will study how to apply fuzzy logic and reasoning to handle uncertainty and solve engineering problems; understand the features of neural network, and its applications; know about the components and building block hypothesis of Genetic algorithm. Next focus to gain insight onto neuro fuzzy modeling & control and gain knowledge in machine learning through Support vector machines.

Course Outcomes:

1. Analyze the genetic algorithms and their applications
2. Gain knowledge to develop genetic algorithm and support vector machine-based machine learning system.
3. Write genetic algorithm to solve the optimization problem.
4. Analyze various neural network architectures.
5. Understand fuzzy concepts and develop a fuzzy expert system to derive decisions.
6. Able to model neuro fuzzy system for data clustering and classification.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	M	N	N	N	M	N	M	W	N	N	N
CO2	S	M	M	N	M	M	S	N	N	N	M	M
CO3	N	M	N	N	N	M	M	N	N	S	M	M
CO4	N	M	N	N	N	W	N	M	M	N	M	W
CO5	S	N	S	N	N	S	S	N	N	N	M	M
CO6	S	N	W	N	S	W	M	N	N	N	N	N

Unit-I — **12 hrs**

Neural network fundamentals: Basic concepts, human brain, artificial neuron model, neural network architectures-Rosenblatt's perceptron, ADALINE and MADALINE networks, neural network characteristics, learning methods, architecture taxonomy, back-propagation network (BPN), BPN architecture, perceptron model, single layer network, multilayer perceptron model, back-propagation learning, back-propagation algorithm, tuning parameters effect and parameter selection, application of ANN to channel equalization.

Unit-II — **12 hrs**

Fuzzy logic fundamental: Crisp sets, fuzzy sets, membership function, basic fuzzy set operations, fuzzy set properties, crisp relations, fuzzy relations, fuzzy Cartesian product, operation on fuzzy relations, fuzzy systems, crisp logic, predicate logic, fuzzy logic, fuzzy rule based system and defuzzification methods.

Unit-III — **12 hrs**

Genetic algorithm fundamentals: Basic concepts, biological background, working principle, encoding, fitness function, reproduction including roulette-wheel selection, Boltzmann selection, tournament selection, rank selection and steady state selection, design of rapid nickel cadmium battery charger and rule base generation from numerical data using GA.

Unit-IV:	**12 hrs**
Genetic modeling: Inheritance operators, cross-over-single site crossover, two-point crossover, multipoint crossover, uniform crossover, matrix crossover, crossover rate, inversion, deletion and duplication, mutation operator, generation cycle, convergence of genetic algorithms.	

RECOMMENDED BOOKS

Title	Author	Publisher
1. Neural Networks, Fuzzy Logic and Genetic Algorithms	S. Rajasekaran and G.A. Vijayalakshmi Pai	PHI
2. Artificial Neural Networks	B. Yegnarayana	PHI
3. Introduction to Applied Fuzzy Electronics	Ahmad M. Ibrahim	PHI
4. Fuzzy Logic with Engineering Applications	J T Ross	McGraw-Hill

OEEC-911C
Optical Communication Systems

	L	T	P	Credits
	3	0	0	3
	Sessional Marks			50
	End Semester Examination Marks			50

Course Objectives: The aim of this course is to train students in methods of analysis and installation of optical fiber based communications systems; systems planning using different photonic technologies as well as advanced optical signal processing models. Further, focuses on different nonlinearities in optical fiber and their mitigation in modern optical fiber communication system; design and evaluation of modern optical fiber communication systems.

Course Outcomes:

1. To understand the basic concept of optical fiber communication system.
2. To understand the various dispersion nonlinearities effect in optical communication system
3. Ability to design high bit-rate fiber optic communication systems.
4. Ability to analyze, model and implement advanced optical communication systems.
5. Capable to use optical communications simulation tools to assess the results obtained from theoretical studies.

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	W	N	N	N	W	N	N	W	N	N	N
CO2	M	N	N	S	N	N	N	N	M	N	N	N
CO3	W	M	M	N	N	S	N	N	N	N	M	M
CO4	M	S	S	N	M	S	M	N	N	N	W	M
CO5	N	N	M	S	M	M	M	N	N	N	N	N

Unit-I — 16 hrs

Overview of optical fiber communication: Evolution of basic fiber optic communication system, benefits and disadvantages of fiber optics, transmission windows, transmission of light through optical fiber, numerical aperture (NA), optical fiber modes & configurations, types of fiber, wave propagation in step index & graded index fiber, MFD, propagation modes in step index fibers, attenuation in optical fibers, fiber optic loss calculations, bending loses, absorption, scattering, fiber dispersion, dispersion shifted fiber, D-flattened fiber, polarization, cut-off condition and V-parameter, connectors & splices.

Dispersion and nonlinearities: Dispersion in single mode and multimode fibers, attenuation and dispersion limits in fibers, dispersion management, Kerr nonlinearity, self-phase modulation, cross phase modulation, FWM.

Unit-II — 12 hrs

Optical sources: Direct and indirect band gap materials, semiconductor light-emitting diodes and laser diodes, LED power & efficiency, double hetero-junction LED, planner & dome LED, surface-emitting LEDs, edge-emitting LEDs, super luminescent LED, characteristic of LED, modulation, laser diodes: basic concepts for emission of radiation, threshold condition for laser oscillation, quantum well laser, distributed feedback laser, laser characteristics.

Optical detectors: Principles of photodiodes, PIN & avalanche photodiodes, photodetector noise, detector response time, avalanche multiplication noise, temperature effect on avalanche gain, receiver SNR and BER calculations.

Unit-III	**10 hrs**

Optical amplifiers: Semiconductor amplifiers, Eerbium-doped fiber amplifiers (EDFAs) and Raman amplifiers, analytical modeling of gain saturation, gain equalization, ASE noise, amplifier cascades.

Optical sensors: Advantages, generic optical fiber sensor, fiber selection for sensor, wavelength modulated sensors - pH, humidity, temperature, carbon dioxide sensors, fiber Bragg grating based sensors - principle, strain, pressure sensors, chem ical sensors.

Unit-IV	**10 hrs**

Optical networks design: Fiber optic system design considerations -power budget, bandwidth and rise time budgets, electrical and optical bandwidth etc.

Advanced multiplexing strategies: Optical TDM, subscriber multiplexing (SCM), WDM and hybrid multiplexing methods, optical networking - optical network topologies, network architecture- SONET/TDH, optical burst switching, OADM, wavelength conversion, optical filters, MZI.

RECOMMENDED BOOKS

Title	**Author**	**Publisher**
1. Fiber-optic communication Systems	G. P. Aggarwal	2nd Ed., J. Wiley & Sons, 1997
2. Optic Communication Systems	Mynbaev	Pearson education, 2001
3. Optical Fiber Communication	Gerd Keiser	5th edition, McGraw Hill, 2013
4. Optical Fiber Communication	J. Senior	PHI

PCEC-911
Dissertation (Part-I)

	L	T	P	Credits
	0	0	20	10
Course Objectives:	The aim of the course is that students learn the process of research proposal writing, conducting research in Electronics & Communication Engineering. Students are expected to work on formulation research problem, and literature survey. By the end of the semester, they are expected to complete and present their research proposals.			
Course Outcomes:	1. Review of literature as pertains to their dissertation topic. 2. Design a conceptual framework, research design and data analysis plan as they pertain to their dissertation topic. 3. Have abilities and capabilities in developing and applying computer software and hardware to electronic design.			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	M	M	W	S	M	M	N	N	M	M	M	N
CO2	N	N	N	S	N	N	N	S	S	S	M	S
CO3	N	N	M	S	S	M	M	N	N	N	M	M

PCEC-921
Dissertation (Part-II)

	L	T	P	Credits
	0	0	32	16
Course Objectives:	The aim of the course is that the student will work on their research topic in consultation with the supervisor. Students will conduct experimental and/or analytical study and analyzing results with modern mathematical / scientific methods and use of software tools on their research topic. The next focus is on preparing the students for their research and dissertation writing. By the end of the semester, they are expected to complete and present their research dissertation.			
Course Outcomes:	1. Apply/develop solutions or to do research in the areas of Electronics & Communication Engineering. 2. Design and validate technological solutions to defined problems. 3. Organize, analysis and interpret experimental results. 4. Describe the significance of experimental outcomes in a well-reasoned discussion. 5. Communicate clearly and effectively for the practical application of their work. 6. Defend the experimental approach, methods, and interpretation in an oral defence before the evaluation committee.			

Mapping of course outcomes with program outcomes

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12
CO1	S	S	S	S	S	S	S	M	S	M	S	M
CO2	S	S	S	W	M	S	S	W	M	N	M	M
CO3	M	S	M	S	W	M	M	M	M	S	M	M
CO4	N	N	N	S	N	N	N	S	S	S	S	S
CO5	N	N	N	S	N	N	N	S	M	S	S	S
CO6	N	N	N	S	N	N	N	S	M	S	S	S