Scheme and Syllabus
of
M. Tech.
in
Electronics and Communication Engineering
(2025-2026 onwards)

Offered by:

Department of Electronics & Communication Engineering

NATIONAL INSTITUTE OF TECHNOLOGY DELHI

Delhi-110036

Department of Electronics and Communications Engineering
National Institute of Technology Delhi

1. About the Department

Welcome to the Department of Electronic and Communication Engineering (ECE), National Institute of Technology Delhi. It was established in 2010, immediately with the beginning of the Institute under the aegis of the Ministry of Human Resource and Development (MHRD), Govt. of India. Currently, Department is offering one Undergraduate Program as B. Tech (ECE) and two Postgraduate programs as M. Tech. ECE and M. Tech. ECE (VLSI). The Department also offers Ph.D. and Post-Doctoral Fellowship (PDF) Programme in relevant areas. It has excellent laboratories and research facilities in electronic devices and circuits, electronic measurement and instrumentation, microprocessor and microcontroller, microwave and antenna design, optical fiber communication and optical device, multimedia, and advanced communication and VLSI design automation and simulation laboratory. The Department has received projects, grants, and fellowships from the Ministry of Electronics and Information Technology (MeitY), the Department of Science and Technology (DST)-SERB, and other funding agencies. The Department has active collaborations with academic & research institutes in India and abroad.

The Department of ECE has a blend of young as well as experienced dynamic faculty members and is committed to providing quality education and research in the field. Faculty members of the department have excellent academic & research credentials and published numerous peer-reviewed journal articles/ papers, Books, Book Chapters, etc. in the diversified field and have adequate experience in advanced research. The department of ECE provides a creative learning environment to the students for excellence in technical education. Here the students learn to face the challenges related to emerging technologies in electronics and communication engineering. The department of ECE promotes a self-learning attitude, entrepreneurial skills, and professional ethics. The department hopes to achieve the national goals and objectives of industrialization and self-reliance. As a result, it hopes to produce post graduates with strong academic and practical backgrounds so that they can fit into the academia, research and industry.

1.2 Vision

Create an educational environment to prepare the students to meet the challenges of the modern electronics and communication industry through state of art technical knowledge and innovative approaches beneficial to society.

1.3 Mission:

- To promote teaching and learning by engaging in innovative research and by offering state-of-the-art undergraduate, postgraduate, and doctoral programs.
- To cultivate an entrepreneurial environment and industry interaction, leading to the emergence of creators, innovators, and leaders.
- To promote co-curricular and extra-curricular activities for the overall personality development of the students.
- Building of responsible citizens through awareness and acceptance of ethical values.

M. Tech. in Electronics and Communication Engineering

2.1 Preamble:

M. Tech. ECE offered at NIT Delhi is designed to equip the students with a unique blend of skill sets that include:

- Strong theoretical and experimental foundation.
- Predominantly experiment oriented approach with access to well-equipped and specialized laboratories, and supervised internship/ Thesis work.
- Hands-on technical training on advanced experimental facilities.
- Life skills orientation.
- Hard and soft skills.
- Business perspective, along with emphasis on innovation and entrepreneurship.

2.2 Salient Features:

- Minimum Credits requirements for completion of M. Tech ECE program is 80.
- The Curriculum is based on the guidelines of National Education Policy (NEP) – 2020.
- The curriculum has embedded the multi exit/ multi entry in the M. Tech program.
- The curriculum is designed to meet the prevailing and ongoing industrial requirements.
- The curriculum includes project-based education with adequate exposure for Thesis work.
- The curriculum is flexible and offers adequate choice of electives (Program Elective Courses).
- The curriculum inherits the value- based education aims the holistic development of the students.
- The curriculum offers digital p pedagogy & flipped learning with adequate motivation for entrepreneurship/ start-ups.

2.3 Cardinal Mention:

Students exiting after completing 1st Year will be awarded Post Graduate Diploma in Electronics and Communication Engineering (ECE). A minimum Credit requirement for Post Graduate Diploma is 40 Credits.

2.4 Program Educational Objectives (PEOs)

PEO-1	To acquire advanced knowledge and to be technically competent in the design, development, and implementation of electronics and communication circuits/ systems and to solve complex problems in the wide domain of electronics and communication.
PEO-2	Students shall be competent in adapting to new technologies as well as lead research in order to achieve excellence in their professional career.
PEO-3	Enfold the capability to expand horizons beyond engineering for creativity, innovation and entrepreneurship.
PEO-4	Acquire competence and ethics for social and environmental sustainability with a focus on the welfare of humankind.

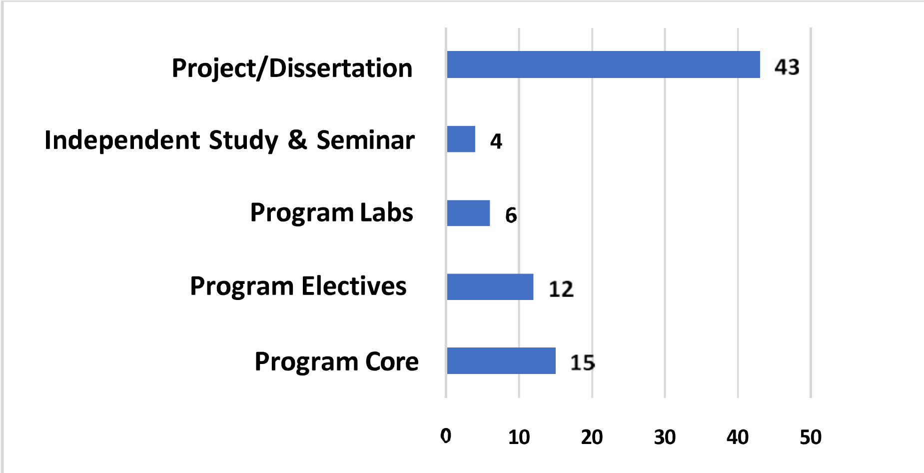
2.5 Program Outcomes (POs)

PO-1	Apply the knowledge of science, mathematics, and engineering principles for a problem-solving attitude and to acquire sound knowledge in the wide area of electronics and communication domain.
PO-2	To design and analyse complex electronic and communication circuits, using appropriate analytical methods as well as front-end and backend tools including prediction and modeling with an understanding of the limitations.
PO-3	An ability to independently carry out research/investigation and development work to solve practical problems towards the benefit of the society and have the preparedness for lifelong learning.
PO-4	Ability to design and conduct experiments, as well as to analyse and interpret data, and synthesis of information.
PO-5	To comprehend and write effective reports and design documentation by adhering to appropriate standards, and making effective presentations.
PO-6	Students will have a clear understanding of professional and ethical responsibility.

2.6 Program Specific Objectives (PSOs)

PSO -1	Enable students to get deep knowledge in the electronics and communication engineering and be able to solve complex problems in the field of Electronics and Communication Engineering.
PSO -2	Enable students to carry out research work in emerging technologies and to pursue career in higher studies and research.

3.1 Credit Distribution

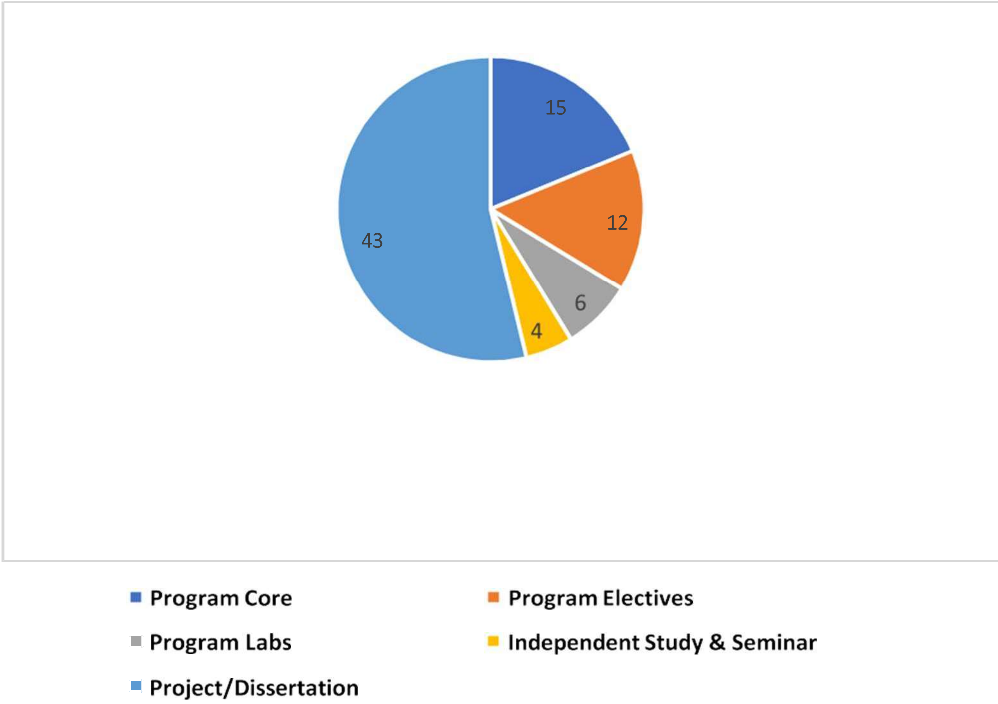


3.2 Semester wise Credit Structure

Sl. No.	Category of Courses	1st Year		2nd Year		Total
		Semester I	Semester II	Semester III	Semester IV	
1.	Program Core	9	6	-	-	**15**
2.	Program Electives	6	6	-	-	**12**
3.	Program Labs	3	3	-	-	**6**
4.	Independent Study & Seminar	2	2	-	-	**4**
5.	Project/Dissertation	-	3	20	20	**43**
Total		**20**	**20**	**20**	**20**	**80**

Minimum Credits Required for Award of Degree = 80

3.3 Credit Distribution (in %)



Course Coding Pattern		
Semester	**M. Tech ECE**	**M. Tech ECE (VLSI)**
Departmental Core Courses (Theory)		
Autumn Semester	ECEM (5/6)0x (onwards)	ECVM (5/6)0x (onwards)
Spring Semester	ECEM (5/6)5x (onwards)	ECVM (5/6)5x (onwards)
Departmental Elective Courses (Theory)		
Autumn Semester	ECEM (5/6)2x (onwards)	ECVM (5/6)2x (onwards)
Spring Semester	ECEM (5/6)7x (onwards)	ECVM (5/6)7x (onwards)

Numeric for 1^{st} year = 5; Numeric for 2^{nd} year = 6;

Teaching Scheme
for
M. Tech in Electronics and Communication Engineering

Semester I

Course Code	Course Title	L	T	P	Credits
ECEM 5xx	Core I	3	0	0	3
ECEM 5xx	Core II	3	0	0	3
ECEM 5xx	Core III	3	0	0	3
ECEM 5xx	Elective I	3	0	0	3
ECEM 5xx	Elective II	3	0	0	3
ECEM 5xx	Laboratory I	0	0	6	3
ECEM 518	Independent Study and Seminar	0	0	4	2
Total Credits		**15**	**0**	**10**	**20**

Semester II

Course Code	Course Title	L	T	P	Credits
ECEM 5xx	Core IV	3	0	0	3
ECEM 5xx	Core V	3	0	0	3
ECEM 5xx	Elective III	3	0	0	3
ECEM 5xx	Elective IV	3	0	0	3
ECEM 5xx	Laboratory II	0	0	6	3
ECEM 569	Core IV	0	0	6	3
ECEM 570	Independent Study and Seminar	0	0	4	2
Total Credits		**12**	**0**	**16**	**20**

Semester III

Course Code	Course Title	L	T	P	Credits
ECEM 604	Dissertation I	0	0	32	16
ECEM 602	MOOCS Course – I/ Independent Study Course - I	3	0	0	3
ECEM 603	Seminar - I	0	0	2	1
Total Credits		3	0	34	**20**

Semester IV

Course Code	Course Title	L	T	P	Credits
ECEM 654	Dissertation II	0	0	32	16
ECEM 652	MOOCS Course – II/ Independent Study Course - II	3	0	0	3
ECEM 653	Seminar - II	0	0	2	1
Total Credits		**3**	**0**	**34**	**20**

Special Note for Selection of Massive Open Online Courses (MOOCs)/ Independent Study Courses
• Students are encouraged to take the above-mentioned MOOCs courses in their 3rd and 4th semesters preferably. The MOOCs courses can only be decided by the students in consultation with the Convener, DPGC (ECE) and HoD (ECE) and should be in allied/ relevant area of ECE or related to the list of elective courses provided in the scheme. • However, students willing to take those above MOOCs courses during their 1st and 2nd semester are also allowed but their evaluation and marks to be credited during their 3rd and 4th semesters respectively as indicated above. • If a student completes a MOOC course and submits the evaluation result by the end of 3rd and 4th semester respectively, the they will be exempted from appearing for the Institute examination in the respective Independent Study Course – I (in the 3rd semester) and Independent Study Course – II (in the 4th semester). • A student failing to complete the MOOC courses will have to choose an Independent Study course-I (in the 3rd semester) and Independent Study Course – II (in the 4th semester), (*from the list of elective courses and also which is not running in that semester/ previously not studied by the concern student*), have to complete (as per the Institute's procedure) the self-study and examinations as per the Institute's rules and regulations.

List of Core Subjects

S. No.	Course Code	Course Title	L	T	P	Credits	Core Applicability
1.	ECEM 501	Advanced Digital Communication Systems	3	0	0	3	Core I + Core II + Core III
2.	ECEM 502	Computer Communication	3	0	0	3	
3.	ECEM 503	Advanced Optical Communication Systems	3	0	0	3	
4.	ECEM 504	Growth, Fabrication and Characterization of Semiconductor Devices	3	0	0	3	
5.	ECEM 505	Introduction to Nano electronics and Nano photonics	3	0	0	3	
6.	ECEM 506	Analog IC Design	3	0	0	3	
7.	ECEM 507	Advanced Digital Signal Processing	3	0	0	3	
8.	ECEM 508	Design of Analog and Mixed Mode VLSI Circuits	3	0	0	3	
9.	ECEM 509	Microelectronics	3	0	0	3	
10.	ECEM 510	Physics of MOS Transistors	3	0	0	3	
11.	ECEM 511	VLSI Technology and Design	3	0	0	3	
12.	ECEM 512	Data Communication and Networking	3	0	0	3	
13.	ECEM 513	Image and Video Compression	3	0	0	3	
14.	ECEM 514	Video Processing and Communications	3	0	0	3	
15.	ECEM 519	Wireless Communication and Sensor Networks	3	0	0	3	
16.	ECEM 551	Advanced Photonic Devices	3	0	0	3	Core IV + Core V
17.	ECEM 552	Embedded Core Design	3	0	0	3	
18.	ECEM 553	Advanced Wireless Communication Networks	3	0	0	3	
19.	ECEM 554	Solid State Microwave Devices	3	0	0	3	
20.	ECEM 555	Statistical Signal Analysis	3	0	0	3	
21.	ECEM 556	Modelling and Simulation	3	0	0	3	
22.	ECEM 557	Advanced Numerical Analysis	3	0	0	3	
23.	ECEM 558	Advanced Mathematics	3	0	0	3	
24.	ECEM 559	Organic Electronics	3	0	0	3	
25.	ECEM 560	Nano Materials	3	0	0	3	
26.	ECEM 561	Advanced Image Processing	3	0	0	3	
27.	ECEM 562	Lasers and Opto-electronics	3	0	0	3	
28.	ECEM 563	Bio-Imaging and Bio-Signal Processing	3	0	0	3	
29.	ECEM 564	Mathematical Methods for signal processing	3	0	0	3	
30.	ECEM 567	Visual Signal Processing	3	0	0	3	
31.	ECEM 568	Wireless and Adhoc Networks	3	0	0	3	
32.	ECEM 569	Optical Signal Processing	3	0	0	3	

List of Elective Subjects

S. No.	Course Code	Course Title	L	T	P	Credits	Elective Applicability
1.	ECEM 520	Advanced Error Control Codes	3	0	0	3	Elective I + Elective II
2.	ECEM 521	Introduction to MEMS	3	0	0	3	
3.	ECEM 522	Information and Network Security	3	0	0	3	
4.	ECEM 523	Photonic Integrated Devices and Systems	3	0	0	3	
5.	ECEM 524	Speech Processing	3	0	0	3	
6.	ECEM 525	Quantum Mechanics and its Applications to Engineering	3	0	0	3	
7.	ECEM 526	Digital CMOS Integrated Circuits	3	0	0	3	
8.	ECEM 527	Wireless Networks	3	0	0	3	
9.	ECEM 529	Digital IC Design	3	0	0	3	
10.	ECEM 530	Advanced Microwave Devices	3	0	0	3	
11.	ECEM 531	Introduction to Plasmonic and Meta-materials	3	0	0	3	
12.	ECEM 532	Optical, electronic & photonic Properties of Nanostructures	3	0	0	3	
13.	ECEM 533	Computer Vision for Signal Processing	3	0	0	3	
14.	ECEM 534	Deep Learning and AI for Signal Processing	3	0	0	3	
15.	ECEM 535	Deep Learning for Imaging	3	0	0	3	
16.	ECEM 570	Testing and Verification of VLSI Circuits	3	0	0	3	Elective III + Elective IV
17.	ECEM 571	Nano magnetism and Spintronics	3	0	0	3	
18.	ECEM 572	Computer Aided Design of VLSI Circuits	3	0	0	3	
19.	ECEM 573	Artificial Neural Networks	3	0	0	3	
20.	ECEM 574	Computational Electromagnetics	3	0	0	3	
21.	ECEM 575	Wavelets	3	0	0	3	
22.	ECEM 576	Microelectronics Chip Design	3	0	0	3	
23.	ECEM 577	Telematics	3	0	0	3	
24.	ECEM 578	Free Space Optical Networks	3	0	0	3	
25.	ECEM 579	Semiconductor Optoelectronics	3	0	0	3	
26.	ECEM 580	Low Power VLSI Design	3	0	0	3	
27.	ECEM 581	OFDM for Wireless Communication	3	0	0	3	
28.	ECEM 582	Carbon Nanotubes and Carbon Nano Structures	3	0	0	3	
29.	ECEM 583	Deep Learning and Computer Vision	3	0	0	3	
30.	ECEM 584	Photonics Materials & Devices for Communications	3	0	0	3	
31.	ECEM 585	Biomedical Signal Analysis	3	0	0	3	
32.	ECEM 586	Deep Learning for Computer Vision	3	0	0	3	
33.	ECEM 587	Deep Learning for Imaging	3	0	0	3	
34.	ECEM 588	Machine Learning for Computer Vision	3	0	0	3	

List of Laboratory Subjects

S. No.	Course Code	Course Title	L	T	P	Credits	Lab Applicability
1.	ECEM 515	Communication laboratory I	0	0	6	3	Lab I
2.	ECEM 565	Communication Laboratory II	0	0	6	3	Lab II
3.	ECEM 516	Fibre Optics Laboratory	0	0	6	3	Lab I
4.	ECEM 517	VLSI Design Laboratory	0	0	6	3	Lab I
5.	ECEM 566	VLSI Design with CAD Tools	0	0	6	3	Lab II

Core Courses

Course Title:	**ADVANCED DIGITAL COMMUNICATION SYSTEMS**
Course Code:	**ECEM 501**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	To describe the basic building blocks of a digital communication system and understand the concept of sampling and bandwidth. Revision of Communication channels, their characteristics and mathematical modeling. Uniform & Non-uniform Quantization, Error probability calculations	Understand (Level II)
CO-2	To analyze binary and multi-level digital modulation techniques, their comparison, design of optimum receivers for AWGN Channels, carrier and symbol synchronization. Design and analysis of Match Filter	Creating (Level VI)
CO-3	To implement the concept of equalizers in the communication system and analyze the performance of receivers in presence of equalizers, Linear and Adaptive equalization, decision feedback equalizer, ISI	Analysing (Level IV)
CO-4	To explain and discuss Spread spectrum communication systems, characterization of fading multipath channels, Channel coding, Channel capacity theorems, determine the performance using linear codes.	Evaluating (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2		1			3	
CO-2	3	3	3	2			3	2
CO-3	3	3	3	2			3	2
CO-4	3	2	2	2		1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Waveform and Line Coding Techniques: Elements of Digital Communication System; Review of Communication Channels, their characteristics, Linear quantizer, Quantization SNR calculations, non-uniform quantizer, PCM, DPCM, DM, Error probability calculations, baseband shaping for data and mathematical modelling.	12
Module-II	Digital Modulation Techniques and Optimum Receivers: Digital binary level and multi-level Modulation schemes, Bits vs. Symbol error probability and bandwidth efficiency, Comparison of QPSK, MSK techniques, Probability of error calculation for M-ary systems, Optimum receivers for AWGN channels, Carrier and symbol synchronization, Matched Filter	8
Module-III	Equalization and Diversity: Sampling of band pass signals with problem solving sessions, Characterization of band limited channels, Inter symbol Interference, Concept of Equalization, Types of equalizers, Linear equalization, adaptive linear equalization, adaptive decision feedback equalizer. Types of Diversity, receiver and transmitter diversity, Diversity-Interference trade-off	8
Module-IV	Spread Spectrum Modulation and Channel Coding: Model of Spread spectrum communication systems, direct sequence spread spectrum,	8

	Frequency hopped spread spectrum, Channel coding concept and channel capacity theorems, types of channel coding, Liner Block codes, cyclic codes, Huffman Coding	

Learning Resources:

Text books:	1.Digital Communication, John G. Proakis and Masoud Salehi Publisher McGraw-Hill Education, 5th edition, 2007. 2. Digital Communication: Fundamental and applications, Bernard Sklar and Pabitra Kumar Ray, Pearson Education, 2nd Edition. 2021. 3. Fundamentals of digital Communication, Upamanyu Madhow, Cambridge University
Reference Books:	Communication Systems, Simon Haykins, John Wiley & Sons 4th Edition, 2006 Electronic Communication Systems, Wayne Tomasi, Pearson Education, 4th Edition
Other Suggested Readings:	

Course Title:	**COMPUTER COMMUNICATION**
Course Code:	**ECEM 502**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Explain the fundamental concepts of data communication, signal types, bandwidth, and network architecture.	Understand (Level II)
CO-2	Analyze standard layered network models and switching mechanisms used in wired and wireless communication systems.	Analyze (Level IV)
CO-3	Apply addressing, routing, and cryptographic methods to network communication and security design	Apply (Level III)
CO-4	Evaluate communication network models using queuing theory and stochastic processes.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2		1			3	
CO-2	3	3	2	2			3	
CO-3	3	3	3			1	3	2
CO-4	3	3	3	3			3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Content of the course and reference materials; Introduction to data communication, discussion with students about their background and interest in this course, Concept of analog and digital Signal, bandwidth, Network architecture.	8
Module-II	OSI and TCP/IP reference model, architecture of other reference model, Wired and wireless connectivity: FDM, TDM and CDMA, Circuit and packet switching, Frame relays, ATM, ISDN, IEEE standards for LAN and WAN.	12
Module-III	Data link layer design issues, transport and application layer design issues, internet protocol, routing algorithm, congestion control, IP addressing schemes. Connection management, Cryptography: data encryption standards, key distribution, public key cryptography, authentication and digital signature.	8
Module-IV	Modeling and analysis of communication networks, pure birth and pure birth death process, Bernoulli's trials, Markov chain, Exercise problems for practice, Poisson process, Little's formula. Queuing Models: M/M/1 queue, M/M/1/N queue, embedded Markov chain, M/G/1 queue, Network layout and reliability consideration.	8

Learning Resources:

Text Books:	1. Data Communication and Networking, Behrouz A Forouzan, McGraw-Hill Education (India) Pvt Limited, 2006. 2. Computer Networks, Andrew S Tanenbaum, Dorling Kindersley Pvt Ltd, 4th Edition, 2008. 3. Data and Computer Communication, William Stalling, Pearson/ Prentice Hall, 2007
Reference Books:	
Other Suggested Readings:	

Course Title:	**ADVANCED OPTICAL COMMUNICATION SYSTEMS**
Course Code:	**ECEM 503**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Attain knowledge of basic optical fiber communication systems and learn the latest trends in optical communications.	Remembering (Level I) Understanding (Level II)
CO-2	Recognize and classify the structures, types, and impairments (losses, dispersion) in optical fibers.	Analyzing (Level IV) Creating (Level VI)
CO-3	Classify optical sources and detectors; analyze coupling losses.	Applying (Level III) Analyzing (Level IV)
CO-4	Understand and evaluate the design issues in deploying optical communication systems.	Understanding (Level II) Evaluating (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2		1			3	
CO-2	3	3	2	2			3	2
CO-3	3	2	2	2			3	2
CO-4	3	2	2	2		1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction to optical communication systems. Signal Propagation in Optical Fibre, optical fibre principle, classification of fibres, fibre modes and related definitions, optical fibre as a waveguide and different waveguide equations.	8
Module-II	Attenuation and Dispersion: Loss and band width windows, various losses in optical fibres, dispersion effects, intermodal, chromatic, waveguide dispersions, dispersion compensation and shifted fibres. Fiber Non-Linear effects, Effective length and area, SBS and SRS effects, self-phase modulation, SPM induced chirp for Gaussian pulses, cross –phase modulation, four wave mixing, introduction to soliton and photonic crystal fibres.	12
Module-III	Optical Components: Couplers, isolators, multiplexers and filters, optical amplifiers, wavelength converters, optical Transmitters and Detectors, LEDs, lasers, Tunable lasers, photo detectors, switch	6
Module-IV	Optical Modulation and Demodulation: Modulation, sub carrier modulation and multiplexing schemes, different modulation formats, spectral efficiency, demodulation, bit error rate and noise	6

	effects in receivers, coherent detection, errors and detection, cross talk.	
Module-V	Power Launching and Coupling: Source to fibre power launching, LED coupling to fibres, fibre splicing, and optical fibre connectors. Optical Networks, Client layers, SONET/ SDH, transport network, Ethernet, IP, protocols, WDM network elements	4

Learning Resources:

Text Books:	1. Optical Networks – A Practical Perspective, R. Ramaswami, K. N. Sivarajan and G. H. Sasaki, Elsevier, 3rd Edition, 2010. 2. Optical Fibre Communications, G. Keiser, Tata McGraw Hill, 3rd Edition, 2000. 3. Fibre-Optic Communication Systems, G. P. Agarwal, John Wiley and Sons, 3rd Edition
Reference Books:	
Other Suggested Readings:	

Course Title:	**GROWTH, FABRICATION AND CHARACTERIZATION OF SEMICONDUCTOR DEVICES**
Course Code:	**ECEM 504**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand miniaturization trends, hybrid vs monolithic technologies, and IC classification.	Understand (Level II)
CO-2	Analyze monolithic process techniques including epitaxy, diffusion, ion implantation, oxidation, and etching	Analyze (Level IV)
CO-3	Apply knowledge of monolithic components and CMOS VLSI to understand reliability and performance issues.	Apply (Level III)
CO-4	Evaluate VLSI packaging and SMT assembly techniques for ICs and system integration.	Evaluate (Level V)
CO-5	Analyze modern fabrication techniques like self-aligned silicides, junction formation, and CMOS/Bipolar processes.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	2		1			3	
CO2	3	3	2	2			3	2
CO3	3	3	2	2		1	3	2
CO4	3	3	3	2		1	3	2
CO5	3	3	2	2			3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Miniaturization & its impact on characterization of Electronic Systems: Introduction, Trends & Projections in IC Design & Technology. Comparison between semiconductor materials. Basics of Thick and thin Film Hybrid Technology and monolithic chips. Advantages, limitations & Classification of ICs. Bipolar & MOS Techniques: Flow chart of Bipolar, NMOS and CMOS technologies. Basics of VLSI Design & Process Simulation, SUPREM.	8
Module-II	Monolithic Techniques: Silicon Refining for EGS, Single Silicon Wafer Preparation & Crystal Defects, Epitaxial Process, Diffusion,Ficks' Laws, Oxidation, Ion-Implantation, Photolithography, Basics of Vacuum Deposition & CVD, Etching techniques, Plasma Etching, Metallization and Isolation Techniques.	8
Module-III	Monolithic Components: Diodes and Transistors, JFETs, MOSFETs, Resistors, Capacitors, MESFETs, Basics of VLSI CMOS technology, Reliability issues in CMOS VLSI, Latching, and Electromigration.	8
Module-IV	Assembly Techniques & Packaging of VLSI Devices: Introduction to packaging, Package design considerations, VLSI Assembly techniques, Packaging fabrication technology. Surface Mount	6

	Technology (SMT): Through hole technology, Surface Mount Technology, applications & SM Components.	
Module-V	Special Techniques for Modern Processes: Self alignedsilicides, hallow junction formation, nitride oxides etc. process flows for CMOS and bipolar IC processes.	6

Learning Resources:

Text Books:	1. VLSI Technology, S.M. Sze, Tata McGraw Hill, 1983 2. Introduction to VLSI, Eshraghian &Pucknell, Tata McGraw-Hill Publishing Company Ltd., New Delhi, , 2007 3. VLSI Fabrication Principles, S.K. Gandhi, Wiley-Blackwell, 2nd Edition 1994.
Reference Books:	CMOS Digital Integrated Circuits-Analysis and Design S.M. Kang & Y. Leblibici, McGraw-Hill, 3rd edition,2003
Other Suggested Readings:	

Course Title:	**INTRODUCTION TO NANO-ELECTRONICS AND NANO-PHOTONICS**
Course Code:	**ECEM 505**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand semiconductor fundamentals and band theory applicable to nanostructures.	Understand (Level II)
CO-2	Apply quantum mechanics to analyze electron behavior in low-dimensional nanostructures.	Apply (Level III)
CO-3	Analyze electronic transport mechanisms in nanoscale systems and their deviations from classical behavior.	Analyze (Level IV)
CO-4	Evaluate optical properties and effects like absorption, emission, and strain in nanostructures.	Evaluate (Level V)
CO-5	Understand design and function of photonic devices using nanostructures like QD lasers, VCSEL, etc.	Understand (Level II)
CO-6	Analyze and apply nanoscale electronic devices like HEMT, SETs, RTDs in modern high-speed circuits.	Analyze (Level IV)
CO-7	Compare nanomaterials (Si, Ge, carbon, Sn-based) and evaluate their relevance in electronic/photonic devices.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	2					3	
CO2	3	2	1				3	
CO3	3	3	2	2			3	
CO4	3	3	3	2			3	3
CO5	3	2	2				3	2
CO6	3	3	3	2		1	3	3
CO7	3	2	2				3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction and Overview, Semiconductor Fundamentals in Nanotechnology, Details of Band theory, Energy bands and sub bands, density of states and effective mass, carrier density, degeneracy, Kronig- Penney model, crystal momentum, band alignment, carrier mobility.	5
Module-II	Introduction to low dimensional nano-structures and Quantum Mechanics, Fundamentals of Quantum mechanics, quantization and low dimensional electron gas, alloying, electrons in nanostructures-Quantum wells, wires and dots, Schrodinger equation and its applications.	5

Module-III	Electronic transport in nanostructures, Ohms' Law, mobility, Scattering mechanisms, Diffusion, Excess carriers, Transport in 1D and 2 D systems, Resonant tunneling, carrier lifetimes and recombination mechanisms, Statistics of electron transport.	5
Module-IV	Optical properties of nanostructures, Basics of EM field, Photons, Scattering mechanisms, phonons, absorptions, spontaneous and stimulated emissions, Interband and intraband transitions, excitons, Strain Engineering, Basics of strain, classifications of strain, effect of strain in various quantum structures	6
Module-V	Photonic devices based on nano structures, LEDs, Quantum Well and Multiple QW lasers, QD Lasers, Transistor laser, vertical cavity surface emitting lasers (VCSEL), Contemporary and advanced (Multi junction, intermediate band etc.) solar cells, Photonic crystals, surface plasmons, spintronic devices, photo detectors etc.	5
Module-VI	Electronic Devices based on nano structures, Advance Heterostructure Devices: HBT and HEMT, downscaling of the MOSFETs., resonant tunneling Devices and circuits, single Electron Transistor and Coulomb blockade - applications of all devices in present day electronic circuits in terms of increasing speed, band width, time delay etc.	5
Module-VII	Materials for Nanostructures and evolution of Silicon Base Devices, Introduction to Si devices, optical interconnects, Optoelectronic Integrated circuits (OEICs), Si Ge based devices, Inorganic-organic materials, carbon-based materials, Sn based materials – their relative advantages and disadvantages.	5

Learning Resources:

Text Books:	1. Electronic and Optoelectronic Properties of Semiconductor Structures, Jasprit Singh, Cambridge University Press,2003. 2. Physics of Photonic Devices, S. L. Chuang, Wiley Series in Pure and Applied Optics, 2009 3. Solid State Electronic Devices, Streetman and Banerjee, PHI Learning Ltd, 2009
Reference Books:	Semiconductor Physics and Devices – Basic Principles, D. A. Neamen, Tata McGraw Hill, 3rd edition, 2003
Other Suggested Readings:	

Course Title:	ANALOG IC DESIGN
Course Code:	ECEM 506
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understanding the MOS operation and small signal models	Understanding (II)
CO-2	Analyze single-stage amplifiers with different loads	Analyzing (IV)
CO-3	Design one- and two-stage op-amps and VCO circuits	Applying (III)
CO-4	Understand the role of feedback in amplifiers	Understanding (II)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2		1			3	
CO-2	3	3	3	2			3	2
CO-3	3	3	3	2			3	2
CO-4	3	2	2	2		1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	Detailed Syllabus	Contact Hours
Module-I	Basic MOS Device Physics: Device Structure and Operation, General Considerations, MOS I/V Characteristics, Finite Output Resistance in Saturation, Transconductance, Second Order effects: body effect, Channel length modulation, Subthreshold conduction, MOS small signal models, SPICE, Short Channel Effects: DIBL, velocity saturation, hot carrier, impact ionization, surface scattering.	9
Module-II	Amplifiers: Basic concepts, Single Stage Amplifiers: Basic Concepts, Common Source Stage: resistive load, diode connected load, current source load, triode load, source degeneration. Source Follower, Common Gate Stage, Cascode Stage. Folded cascode. Differential Amplifiers: Single Ended and Differential Operation, Basic Differential Pair, Common Mode Response, Differential Pair with MOS loads, Gilbert Cell.	9
Module-III	Passive and Active Current Mirrors: Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors. Frequency Response of Amplifiers: Amplifier transfer function, General Considerations, Miller Effect, Common Source Stage, Source Followers, Common Gate Stage, Cascode Stage, Differential Pair.	9
Module-IV	Optic Feedback Amplifiers: General Considerations, Feedback Topologies, Effect of Loading. Operational Amplifiers: General Considerations, One Stage Op Amps, Two Stage Op Amps, Gain Boosting, Common Mode Feedback, Input Range limitations, Slew Rate, Power Supply Rejection, VCO Circuit design, phase-locked loop (PLL), delay-locked loop (DLL).	9

Learning Resources:

Text Books:	1. Analysis & Design of Analog Integrated Circuits, 2001, Gray& Meyer, Wiley, 4th edition, 2. Design of Analog CMOS Integrated Circuits, BehzadRazavi, Tata McGraw Hill, 2005. 3. CMOS Mixed Signal Circuit Design, Jacob Baker, Wiley India Pvt. Limited, 2008
Reference Books:	Design of Analog Integrated Circuits and Systems Kenneth R. Laker, Willy M.C. Sansen, Tata McGraw-Hill Companies, 1994.
Other Suggested Readings:	

Course Title:	ADVANCED DIGITAL SIGNAL PROCESSING
Course Code:	ECEM 507
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Introduce efficient computation methods for DFT with wide applications.	Analyzing (Level IV)
CO-2	Study and design digital filters and structures for applications.	Creating (Level VI)
CO-3	Understand basics of multirate DSP and its applications.	Understanding (Level II)
CO-4	Study and apply optimum filtering and power spectrum estimation techniques for DSP applications.	Applying (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2			3	2
CO-2	3	3	3	2			3	2
CO-3	3	2		1			3	
CO-4	3	3	2	2			3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction to DSP and Discrete Fourier Transform: Review of Discrete time signals and systems, Sampling, z-transform, Discrete Fourier transform, properties of DFT. Frequency domain sampling, linear filtering methods based on DFT, Frequency analysis of signals using the DFT, Decimation in time domain and decimation in frequency domain algorithms	9
Module-II	Design of FIR and IIR filters: Design of digital IIR filters, Design of digital FIR filters, Filter Structures, frequency transformations	9
Module-III	Multirate DSP: Decimation and Interpolation, Multistage design of interpolators and decimators; Poly-phase decomposition and FIR structures, Implementation of multirate conversion. Applications of multirate DSP.	9
Module-IV	Optimum filtering and spectrum estimation: Wiener filters, least mean square filters, Recursive least square filters, Power spectrum estimation techniques.	9

Learning Resources:

Text Books:	1. Digital Signal Processing: A Computer-Based Approach, S. K. Mitra McGraw-Hill, Third edition, 2006 2. Discrete-Time Signal Processing, A.Oppenheim and R. Schafer, Prentice Hall, Second edition, 1999 3. Digital Signal Processing: Principles, Algorithms and Applications, J. Proakis, D. Manolakis, Prentice-Hall, Fourth edition, 2006
Reference Books:	Theory and Application of Digital Signal Processing, L.R. Rabiner and B. Gold, Phi Learning, First edition, 2008
Other Suggested Readings:	

Course Title:	**DESIGN OF ANALOG AND MIXED MODE VLSI CIRCUITS**
Course Code:	**ECEM 508**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the fundamentals of analog-to-digital and digital-to-analog conversions and related specifications.	Understand (Level II)
CO-2	Analyze different DAC and ADC architectures and evaluate their suitability in various applications.	Analyze (Level IV)
CO-3	Design and apply non-linear analog circuits including comparators and analog multipliers.	Apply (Level III)
CO-4	Analyze and improve the signal-to-noise ratio (SNR) in data converters using filtering techniques.	Analyze (Level IV)
CO-5	Design and evaluate sub-micron CMOS analog building blocks for mixed-signal circuit design.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	2		1			3	
CO2	3	3	2	2			3	2
CO3	3	3	2	2			3	2
CO4	3	3	2	2			3	2
CO5	3	3	3	2		1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Data converter fundamentals: Analog versus Digital Discrete Time Signals, Converting Analog Signals to Data Signals, Sample and Hold Characteristics, DAC Specifications, ADC Specifications, Mixed-Signal Layout Issues.	8
Module-II	Data Converters Architectures: DAC Architectures, Digital Input Code, Resistors String, R-2R Ladder Networks, Current Steering, Charge Scaling DACs, Cyclic DAC, Pipeline DAC, ADC Architectures, Flash, 2-Step Flash ADC, Pipeline ADC, Integrating ADC, Successive Approximation ADC.	8
Module-III	Non-Linear Analog Circuits: Basic CMOS Comparator Design, Analog Multipliers, Multiplying Quad, Level Shifting.	6
Module-IV	Data Converter SNR: Improving SNR Using Averaging, Decimating Filters for ADCs Interpolating Filters for DAC, B and pass and High pass Sync filters.	8
Module-V	Sub-Microns CMOS circuit design: Process Flow, Capacitors and Resistors, MOSFET Switch, Delay and adder Elements, Analog Circuits MOSFET Biasing, OP-Amp Design.	6

Learning Resources:

Text Books:	1. Design, Layout, Stimulation, CMOS Circuit, R. Jacaob Baker, Harry W Li, David E Boyce, PHI Edn, 2005 2. CMOS- Mixed Signal Circuit Design (Volll of CMOS: Circuit Design, Layout and Stimulation), R. Jacaob Baker, IEEE Press and Wiley Inter science, 2002 3. Design of Analog CMOS Integrated Circuits, B Razavi, McGraw Hill First Edition, 2001
Reference Books:	CMOS Analog Circuit Design, P e Allen and D R Holberg, Oxford University Press, Second Edition, 2002
Other Suggested Readings:	

Course Title:	**MICROELECTRONICS**
Course Code:	**ECEM 509**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand MOSFET operation, small signal models, frequency response, and single-stage amplifier behavior.	Understand (Level II)
CO-2	Analyze and design single-stage IC amplifiers and current mirrors with frequency considerations.	Analyze (Level IV)
CO-3	Apply small-signal analysis to multistage and differential amplifiers with active loads.	Apply (Level III)
CO-4	Analyze feedback structures, loop gain, frequency compensation, and amplifier stability.	Analyze (Level IV)
CO-5	Evaluate CMOS op-amp architectures and performance of data converters	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	2		1			3	
CO2	3	3	2	2			3	
CO3	3	3	2	2			3	2
CO4	3	3	2	2			3	2
CO5	3	3	3	2		1	3	3
CO6	3	3	3	2		1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	MOSFETS: Device Structure and Physical Operation, V-I Characteristics, MOSFET Circuits at DC, Biasing in MOS amplifier Circuits, Small Signal Operation and Models, MOSFET as an amplifier and as a switch, biasing in MOS amplifier circuits, small signal operation modes, single stage MOS amplifiers. MOSFET internal capacitances and high frequency modes, Frequency response of CS amplifiers, CMOS digital logic inverter, and detection type MOSFET. Single Stage IC Amplifier: IC Design philosophy, Comparison of MOSFET and BJT, Current sources, Current mirrors and Current steering circuits, high frequency response.	6
Module-II	Single Stage IC amplifiers (continued): CS and CF amplifiers with loads, high frequency response of CS and CF amplifiers, CG and CB amplifiers with active loads, high frequency response of CG and CB	6

	amplifiers, Cascade amplifiers. CS and CE amplifiers with source (emitter) degeneration source and emitter followers, some useful transfer parings, current mirrors with improved performance. SPICE examples.	
Module-III	Differences and Multistage Amplifiers: The MOS differential pair, small signal operation of MOS differential pair, the BJT differences pair, other non-ideal characteristics and differential pair, Differential amplifier with active loads, frequency response and differential amplifiers. Multistage amplifier. SPICE examples	6
Module-IV	Feedback. General Feedback structure. Properties of negative feedback. Four basic feedback topologies. Series-Shunt feedback. Determining the loop gain. Stability problem. Effect of feedback an amplifier poles. Stability study using Bode plots. Frequency compensation. SPICE examples.	6
Module-V	Operational Amplifiers: The two stage CMOS Op-amp, folded cascade CMOS op-amp, 741 op-amp circuit, DC analysis of the 741, small signal analysis of 741, gain, frequency response and slew rate of 741. Data Converters. A-D and D-A converters.	6
Module-VI	Digital CMOS circuits. Overview. Design and performance analysis of CMOS inverter. Logic Gate Circuits. Pass-transistor logic. Dynamic Logic Circuits. SPICE examples.	6

Learning Resources:

Text Books:	1. Microelectronic Circuits, 5th Edition, 2009, Adel Sedra and K.C. Smith, Oxford University Press, International Version, 5th Edition, 2009 2. Fundamentals of Microelectronics, BehzadRazavi, John Wiley India Pvt. Ltd, 2008 3. Microelectronics – Analysis and Design, SundaramNatarajan, Tata McGraw-Hill, 2007
Reference Books:	
Other Suggested Readings:	

Course Title:	**PHYSICS OF MOS TRANSISTORS**
Course Code:	**ECEM 510**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand semiconductor physics, pn junctions, two-terminal MOS structures, and surface behavior under bias.	Understand (Level II)
CO-2	Analyze three-terminal MOSFET operation including inversion regions, body effect, and charge control modeling.	Analyze (Level IV)
CO-3	Evaluate charge sheet models for four-terminal MOSFETs including inversion behavior, mobility effects, and comparison of models	Evaluate (Level V)
CO-4	Analyze short-channel and small-dimension effects including scaling and non-ideal behaviors in MOS devices	Analyze (Level IV)
CO-5	Apply modeling concepts and simulate MOSFET behavior using physical models and parameter extraction techniques	Apply (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	2		1			3	
CO2	3	3	2	2			3	
CO3	3	3	3	2			3	2
CO4	3	3	2	2			3	2
CO5	3	3	3	2		1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	MOSFETS: Device Structure and Physical Operation, V-I Characteristics, MOSFET Circuits at DC, Biasing in MOS amplifier Circuits, Small Signal Operation and Models, MOSFET as an amplifier and as a switch, biasing in MOS amplifier circuits, small signal operation modes, single stage MOS amplifiers. MOSFET internal capacitances and high frequency modes, Frequency response of CS amplifiers, CMOS digital logic inverter, and detection type MOSFET. Single Stage IC Amplifier: IC Design philosophy, Comparison of MOSFET and BJT, Current sources, Current mirrors and Current steering circuits, high frequency response.	8
Module-II	Single Stage IC amplifiers (continued): CS and CF amplifiers with loads, high frequency response of CS and CF amplifiers, CG and CB amplifiers with active loads, high frequency response of CG and CB amplifiers, Cascade amplifiers. CS and CE amplifiers with source (emitter) degeneration source and emitter followers, some useful transfer parings, current mirrors with improved performance. SPICE examples.	8

Module-III	Differences and Multistage Amplifiers: The MOS differential pair, small signal operation of MOS differential pair, the BJT differences pair, other non-ideal characteristics and differential pair, Differential amplifier with active loads, frequency response and differential amplifiers. Multistage amplifier. SPICE examples	10
Module-IV	Feedback. General Feedback structure. Properties of negative feedback. Four basic feedback topologies. Series-Shunt feedback. Determining the loop gain. Stability problem. Effect of feedback an amplifier poles. Stability study using Bode plots. Frequency compensation. SPICE examples.	5
Module-V	Operational Amplifiers: The two stage CMOS Op-amp, folded cascade CMOS op-amp, 741 op-amp circuit, DC analysis of the 741, small signal analysis of 741, gain, frequency response and slew rate of 741. Data Converters. A-D and D-A converters.	5

Learning Resources:

Text Books:	1.Operation and Modeling of the MOS Transistor, Y. Tsividis, S. M. Sze, Physics of Semiconductor Devices, (2e), Wiley Eastern 2.MOSFET Models for VLSI Circuit Simulation, Springer-Verlag,N. D. Arora 3. Operation and Modeling of the MOS Transistor, Y. Tsividis
Reference Books:	
Other Suggested Readings:	

Course Title:	VLSI TECHNOLOGY AND DESIGN
Course Code:	ECEM 511
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Level
CO-1	Understand various techniques in VLSI fabrication processes.	Analyzing (Level IV)
CO-2	Understand diffusion and oxidation mechanisms in VLSI.	Creating (Level VI)
CO-3	Understand lithography methods and etching techniques.	Understanding (Level II)
CO-4	Analyze and design CMOS-based circuits.	Applying (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	2			3	2
CO-2	3	2	2	2			3	2
CO-3	3	2		1			3	
CO-4	3	3	3	2			3	2

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Crystal growth: Source of silicon; Single crystalline and Poly crystalline; Requirement of purity for electronics industry; Electronics grade silicon production; Crystal growth Czocharalski method, Silicon Wafer Preparation & Crystal Defects; Epitaxial Process: Need of epitaxial layer; vapors phase epitaxy, chemistry of epitaxial process, transport mechanism, doping & auto doping; selective epitaxy, epitaxial process induced defects, molecular beam epitaxy, merits and demerits among epitaxial processes; recent trends in Epitaxy. Oxidation: Importance of oxidation; types of oxidation techniques; growth mechanism & kinetics; factors affecting the growth mechanisms; silicon oxidation model, dry & wet oxidation; recent trends in oxidation.	9
Module-II	Lithography: Basic steps in lithography; lithography techniques lithography, electron beam lithography, x-ray lithography, ion beam lithography; resists and mask preparation of respective lithographies, printing techniques, proximity printing and projection printing; merits and demerits of lithographies; recent trends in lithography at nano regime; Etching: Performance metrics of etching; types of etching- wet and dry etching; dry etching techniques-ion beam or ion-milling, sputter ion plasma etching and reactive ion etching (RIE); merits and demerits of etching; etching induced defects; recent trends in etching.	9

Module-III	Diffusion and Ion Implantation: Diffusion mechanisms; diffusion reactor; diffusion profile; diffusion kinetics; parameters affecting diffusion profile; Dopants and their behavior, choice of dopants; Ion Implantation, channeling effect, Metallization: Desired properties of metallization for VLSI; metallization choices; metallization techniques vacuum evaporation, sputtering; Introduction to packaging; packaging process; package design considerations, various package types.	9
Module-IV	Review of Microelectronics and Introduction to MOS Technologies: MOS, CMOS, BiCMOS Technology. Basic Electrical Properties of MOS, Ids – Vds relationships, Threshold Voltage VT, body effect, MOS Transistor circuit model, CMOS inverter characteristics, Bi CMOS Inverters, Latch-up in CMOS circuits. Scaling of MOS devices and design rules, Design Styles, concept of hierarchy, regularity, modularity and locality. Gate design using CMOS, Transistor sizing, Pass Transistor and transmission gates.	9

Learning Resources:

Text Books:	VLSI Technology, S M Sze McGraw Hill Education (India) Private Limited, 2nd Edition VLSI Fabrication Principles: Silicon and Gallium Arsenide, Sorab Khushro Ghandhi, Wiley Publisher, Second edition (January 2008) CMOS Digital Integrated Circuits: Analysis and Design, Sung-Mo Kang, Yusuf Leblebici McGraw-Hill Higher Education; 41st edition (1 December 2002), 2002
Reference Books:	
Other Suggested Readings:	

Course Title:	DATA COMMUNICATION AND NETWORKING
Course Code:	ECEM 512
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course outcome		Cognitive Level
CO1	To understand overview of data communication and networking aspects.	Remembering / Understanding (Level I / II)
CO2	To apply various multiple access techniques to understand modern communication methodologies.	Applying (Level III)
CO3	To analyze the different routing algorithms needed.	Analyzing (Level IV)
CO4	To evaluate the different protocols used in transport and application layer.	Evaluating (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2					3	2
CO-2	3	3	2	2	1		3	2
CO-3	3	3	3	3	2		3	3
CO-4	3	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction to data communication and networking: Why study data communication? Data Communication, Networks, Protocols and Standards, Standards Organizations. Line Configuration, Topology, and Transmission Modes, Categories of Networks Internet works, history and development of computer networks. Basic Network Architectures: OSI reference model, TCP/IP reference model, and Networks topologies, types of networks (LAN, MAN, WAN, circuit-switched, packet-switched, message switched, extranet, intranet, Internet, wired, wireless)	8
Module-II	Study of Signals: Analog and Digital, Periodic and Aperiodic Signals, Analog Signals, Time and Frequency Domains, Composite Signals, Digital Signals, Physical layer: line encoding, block encoding, scrambling, and Different types of transmission media. Data Link Layer services: framing, error control, flow control, medium access control. Error & Flow control mechanisms: stop and wait, Go back N and selective repeat. MAC protocols: Aloha, slotted aloha, CSMA, CSMA/CD, CSMA/CA, polling, token passing,	8

	scheduling.	
Module-III	Guided Media, Unguided Media, Transmission Impairments, Performance Wavelength, Shannon Capacity, Media Comparison, PSTN, Switching, Local Area Network Technology: Token Ring. Error detection (Parity, CRC), Ethernet, Fast Ethernet, Gigabit Ethernet, Personal Area Network: Bluetooth and Wireless Communications Standard: Wi-Fi (802.11) and WiMAX.	8
Module-IV	Network layer: Internet Protocol, IPv6, ARP, DHCP, ICMP, Routing algorithms: Distance vector, Link state, Metrics, Inter-domain routing. Subnetting, Supernetting, Classless addressing, Network Address Translation. Introduction to networks and devices: Network classes, Repeaters, Hub, Bridges, Switches, Routers, Gateways Brouters Routing Algorithms, Distance Vector Routing, Link State Routing, Transport layer: UDP, TCP. Connection establishment and termination, sliding window, flow and congestion control, timers, retransmission, TCP extensions, Queuing theory, Single and multiple server queuing models, Little's formula. Application Layer. Network Application services and protocols including e-mail, www, DNS, SMTP.	12

Learning Resources:

Text Books:	1. Data Communications and Networking - Behrouz A. Forouzan, Fifth Edition TMH, 2013. 2. 3Data Communication & Networking by Forouzan, Tata McGraw Hill 3. Kurose and Ross, "Computer Networking- A Top-Down Approach", Pearson. 4. Computer Network, 4e, by Andrew S. Tenenbaum, Pearson Education/ PHI.
Other Suggested Readings:	

Course Title:	**IMAGE AND VIDEO COMPRESSION**
Course Code:	**ECEM 513**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Level**
CO1	Discuss video and waveform-based encoding techniques.	Remembering (Level I)
CO2	Illustrate various image and video encoding approaches.	Understanding (Level II)
CO3	Analyze and extract relevant features from domain-specific problems.	Analyzing (Level IV)
CO4	Apply techniques to solve advanced problems like Distributed Video Coding, Stereo, Multiview video processing.	Applying (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	1					2	
CO-2	3	2					3	2
CO-3	3	3	2	2			3	3
CO-4	3	2	3	2	1		3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Fundamental of video coding: Coding Systems, Entropy, Lossy and Lossless Coding, Exploiting Statistical Dependence, Binary Encoding (Arithmatic and Huffman), Scalar Quantization, Scalar and Vector Quantization. Waveform-based coding: transform coding, predictive coding. Video coding: motion compensated prediction and interpolation, block-based hybrid video coding.	9
Module-II	JPEG and JPEG -2000 Standard, 3D Video Coding: 3D Cinema, Stereo Video, Disparity, Autostereoscopic Displays, 3D Video Coding for Stereo Displays, 3D Video Coding for Autostereoscopic Displays.	9
Module-III	Video compression standards (H.261 and H.263, MPEG1, MPEG2, MPEG4, H.264/AVC, H.264/SVC,H.265/HEVC, AVS), Subband Video Coding: Hybrid video coding with motion-compensated prediction, Temporal DPCM is challenging when aiming for z transmission over lossy channels and z scalable video representations Alternative technique: Subband Video Coding	9
Module-IV	Distributed Video Coding: Lossless and lossy compression with receiver side information, Shifting the complexity of video encoding to the decoder, Error-resilient video transmission. Stereo and multiview video processing, Error control in video communications and video streaming over Internet and wireless networks, Video quality assessment.	9

Learning Resources:

Text Books:	1. Video Processing and Communications, Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Prentice Hall 2002 2. Digital Video Processing, M. Tekalp, Prentice Hall, 1995 3. Computer Vision: Algorithms and Applications, Richard Szeliski, Springer ,II Edition
Reference Books:	The Image Processing Handbook, J.C. Russ CRC Press; 6th edition 2011
Other Suggested Readings:	

Course Title:	**VIDEO PROCESSING AND COMMUNICATIONS**
Course Code:	**ECEM 514**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcome		**Cognitive Level**
CO1	Understand the basic concepts of video processing and its applications.	Remembering (Level I)
CO2	Analyze and extract relevant features of the concerned domain problem.	Understanding (Level II)
CO3	Deduce distinct compression and encoding techniques.	Analyzing (Level IV)
CO4	Understand and apply video compression techniques in real-time applications.	Applying (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	1					2	
CO-2	3	2		1			3	2
CO-3	3	3	2	2	1		3	3
CO-4	3	2	3	2	1		3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basics of analog and digital video, Frequency domain analysis of video signals, spatial and temporal frequency response of the human visual system: Multidimensional Continuous and Discrete - Space Signals and Systems, Frequency Domain Characterization of Video Signals and Response of the Human Visual System.Video sampling: Basics of the Lattice Theory, Sampling over Lattices, Sampling of Video Signals, Filtering Operations in Cameras and Display Devices, Conversion of Signals Sampled on Different Lattices, Sampling Rate Conversion of Video Signals.	9
Module-II	2D-3D Video Modeling: Camera Model, Illumination Model, Object Model, Scene Model, Two-Dimensional Motion Models, Optical Flow, General Methodologies, Pixel-Based Motion Estimation, Block-Matching Algorithm, Deformable Block-Matching Algorithms and advanced techniques (mesh-based, global motion estimation, multi-resolution approach).	9
Module-III	Basic compression techniques: information bounds for lossless and lossy source coding, binary encoding techniques (LZW, Arithmetic Coding) and scalar and vector quantization. Waveform-based	9

	coding: transform coding, predictive coding. Video coding: motion compensated prediction and interpolation, block-based hybrid video coding.	
Module-IV	Video compression standards (H.261 and H.263, MPEG1, MPEG2, MPEG4, H.264/AVC, H.264/SVC,H.265/HEVC, AVS) , Stereo and multiview video processing, Error control in video communications and video streaming over Internet and wireless networks, Video quality assessment.	9

Learning Resources:

Text Books:	Video Processing and Communications, Yao Wang, Joern Ostermann, and Ya-Qin Zhang, Prentice Hall 2002 Digital Video Processing, M. Tekalp, Prentice Hall, 1995 Computer Vision: Algorithms and Applications, Richard Szeliski Springer, II Edition
Reference Books:	The Image Processing Handbook J.C. Russ, CRC Press; 6th edition 2011
Other Suggested Readings:	

Course Title:	**WIREIRELESS COMMUNICATION AND SENSOR NETWORKS**
Course Code:	**ECEM 519**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Level**
CO1	Explain different types of wireless channels, examine mobile radio propagation effects, and discuss modern wireless systems.	Remembering / Understanding (Level I / II)
CO2	Analyze network architecture and sensor network design principles with physical layer/transceiver considerations.	Analyzing (Level IV)
CO3	Evaluate mobile/wireless channels, performance enhancement techniques, and justify observations.	Applying / Evaluating (Level III / V)
CO4	Modify existing or design new technologies to improve spectral efficiency and user experience in mobile communication.	Evaluating / Creating (Level V / VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	1					2	
CO-2	3	2					3	2
CO-3	3	3	2	2			3	3
CO-4	3	2	3	2	1		3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Single Node Architecture Hardware Components Network Characteristics unique constraints and challenges, Enabling Technologies for Wireless Sensor Network Types of wireless sensor networks.	8
Module-II	Network Architecture Sensor Networks Scenarios Design Principle, Physical Layer and Transceiver Design Considerations, Optimization Goals and Figures of Merit, Gateway Concepts, Operating Systems and Execution Environments introduction to Tiny OS and Internet to WSN Communication.	8
Module-III	MAC Protocols for Wireless Sensor Networks, Low Duty Cycle Protocols and Wakeup Concepts – SMAC, BMAC Protocol, IEEE 802.15.4 standard and ZigBee, the Mediation Device Protocol, Wakeup Radio Concepts, Address and Name Management, Assignment of MAC Addresses, Routing Protocols Energy Efficient Routing, Geographic Routing.	8
Module-IV	Topology Control, Clustering, Time Synchronization, Localization and Positioning, Sensor Tasking and Control.Sensor Node Hardware – Berkeley Motes, Programming Challenges, Node level software platforms, Node level Simulators, State centric programming.	12

Learning Resources:

Text Books:	1. Holger Karl & Andreas Willig, "Protocols and Architectures for Wireless Sensor Networks", John Wiley, 2005. 2. Feng Zhao & Leonidas J.Guibas, "Wireless Sensor Networks- An Information Processing Approach", Elsevier, 2007. 3. Waltenegus Dargie, Christian Poellabauer, "Fundamentals of Wireless Sensor Networks - Theory and Practice", John Wiley & Sons Publications, 2011 4. Kazem Sohraby, Daniel Minoli, &Taieb Znati, "Wireless Sensor Networks-Technology, Protocols, and Applications", John Wiley, 2007.
Reference Books:	
Other Suggested Readings:	

Course Title:	ADVANCED PHOTONIC DEVICES
Course Code:	ECEM 551
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the fundamentals of basic electronics, quantum mechanics, semiconductor physics, and band structures	Understand (Level II)
CO-2	Apply principles of quantum mechanics to analyze optical and electronic processes in semiconductors and nanostructures.	Apply (Level III)
CO-3	Analyze electronic transport, optical properties, and device behavior in low-dimensional systems and advanced optoelectronic materials.	Analyze (Level IV)
CO-4	Evaluate and design advanced optical and photonic devices (LEDs, lasers, solar cells, detectors, etc.) using semiconductor and nanostructured materials.	Evaluate (Level V)

Course Articulation Matrix:

Course Outcomes	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	–	–	–	–	3	2
CO-2	–	3	2	–	–	–	3	2
CO-3	–	2	3	2	–	–	3	3
CO-4	–	–	3	3	3	–	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basic Electronics and Quantum Mechanics: Maxwell's equations and boundary conditions Strain effects on band structures, Generation and Recombination in Semiconductors, Semiconductor *p-N* and Heterojunction, Metal-Semiconductor Junction, Schrodinger Equation, The Square Well, The Harmonic Oscillator, The Hydrogen Atom (3D and 2 0 Exciton Bound and Continuum States), Time-Independent and dependent Perturbation Theory	8
Module-II	Theory of Band Structures: The Bloch theorem and k.p method for simple bands, Strain effects on band structures, electronic states and Kronig- Penney model, Band structure for strained and un strained quantum wells.	4
Module-III	Optical Processes in Semiconductors: Fermi Golden rule, Spontaneous and stimulated emissions, Interband and intraband absorptions, Momentum Matrix elements for bulk and nano structures, Gain and Valence band mixing effects.	4
Module-IV	Low Dimensional nano structures: Fundamentals of Quantum mechanics, quantization and low dimensional electron gas,	4

	alloying, electrons in nanostructures- Quantum wells, wires and dots.	
Module V	Electronic Transport: Ohms' Law, mobility, Scattering mechanisms, Diffusion, Excess carriers, Transport in 1D and 2D systems, Resonant tunnelling, carrier lifetimes and recombination mechanisms, Statistics of electron	4
Module VI	Optical Properties: Basics of EM field, Photons, Scattering mechanisms, phonons, absorptions, spontaneous and stimulated emissions, Interband and intraband transitions, excitons, Franz-Keldysh effect, Exciton effect, Quantum confined Stark effect.	4
Module VII	Advanced Optical Devices: LEDs, Quantum Well and Multiple QW lasers, QD Lasers, Transistor laser, vertical cavity surface emitting lasers (VCSEL), Contemporary and advanced (Multi junction, intermediate band etc.) solar cells, Photonic crystals, surface plasmons, spintronic devices, photo detectors etc	4
Module VIII	Advanced Material for Photonic Devices: Introduction to Si devices, optical interconnects Opto-electronic Integrated circuits (OEICs), Si Ge based devices, Inorganic-organic materials, carbon-based materials, Sn based materials – their relative advantages and disadvantages.	4

Learning Resources:

Text Books:	1.Electronic and Optoelectronic Properties of Semiconductor Structures, Jasprit Singh, Cambridge University Press, 2003 2. Physics of Photonic Devices, S. L. Chuang, Wiley Series in Pure and Applied Optics, 2009. 3. Solid State Electronic Devices, Ben G Streetman and S. K. Banerjee, Global edition, Pearson 2018. 4. Semiconductor Physics and Devices, D. A. Neamen and D. Biswas Mcgraw Hill Education (India) Pvt. Ltd, Special Indian Edition. 5. Semiconductor Nanophotonics, P. K. Basu, B. Mukhopadhyay and R. Basu Oxford Science Publications, Oxford University Press 2022 6. Semiconductor Laser Theory P. K. Basu, B. Mukhopadhyay and R. Basu CRC Press, Taylor and Francis Group 2016.
Reference Books:	
Other Suggested Readings:	

Course Title:	**EMBEDDED CORE DESIGN**
Course Code:	**ECEM 552**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the abstraction levels and flow in embedded system design including hardware/software partitioning.	Understand (Level II)
CO-2	Develop Register Transfer Level (RTL) models using VHDL for digital design and simulation.	Apply (Level III)
CO-3	Analyze the structure, types, and applications of programmable logic devices (ROM, CPLD, FPGA).	Analyze (Level IV)
CO-4	Design embedded systems using microcontrollers and processors with specific hardware interfacing	Design (Level VI)
CO-5	Evaluate processor configurability and SOPC Builder systems using case study-based system design.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO1	3	2		1			3	
CO2	3	3	2	2			3	2
CO3	3	3	2	2			3	2
CO4	3	3	3	2		1	3	3
CO5	3	3	3	2		1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Elements of Embedded System-Abstraction levels — Transistors to Programs — Mixed level hardware — Design Specification — Embedded system design flow — Hardware / Software Partitioning — Hardware port — Software Port — Interconnection Specification — Common Hardware / Software Simulation — Hardware Synthesis — Software Compilation — Interconnection Hardware Generation — Design Integrator — Design Tools —Block Diagram Description —HDL and other hardware Simulators — Hardware synthesis tool —Compiler for Machine Language Generation — Software Builder and Debugger — Embedded System Integrator — Hardware design trends — Configurable processors — Standard Bus Structure — Software Programming — Software Utilities.	8
Module-II	RTL Design with VHDL-Basic Structures of VHDL — VHDL Overview and Concepts VHDL Types — VHDL Object Classes — VHDL Design Units — Basic Language Elements — Lexical Elements — Syntax — Types and Subtypes —Attributes — Control	8

	Structures — if statement — case statement — loop statement — Drivers —Resolution function — Drivers — Ports — VHDL Timing — Signal Attributes — Wait Statement — Modelingwith zero time delays — Inertial / Transport Delay —Elements of Entity / Architecture — Entity —Architecture — Process Statement — Concurrent Signal Assignment Statement — Component Instantiation Statement — Concurrent Procedure Call — Generate Statement — Concurrent Assertion Statement Block Statement — Subprograms — Subprogram Definition — Functions and Procedures —Packages.	
Module-III	Field Programmable Devices-Read Only Memories — Basic ROM Structure — NOR Implementation — Distributed Gates — Array Programmability — Memory View — ROM Variations — Programmable Logic Arrays — PAL Logic Structure — Product Term Expansion — Three State Outputs — Registered Outputs — Commercial Parts, Complex Programmable Logic Devices — Altera's MAX 70005 CPLD — Field Programmable Gate Arrays — Altera's Flex 10K FPGA Altera's Cyclone FPGA.	6
Module-IV	Design with Embedded Processors-Embedded Design Steps — Processor Selection — Processor Interfacing — Developing Softyare — Filter Design — Filter Concepts — FIR Filter Hardware Implementation — FIR Embedded Implementation — Building the FIR filter — Design of a Microcontroller — System Platform Microcontroller Architecture	6
Module-V	Design of an Embedded System-Designing an Embedded System — Nios II Processor — Configurability -Features of Nios II — Processor Architecture — Instruction Set — Nios II Alternative Cores — Avalon Switch Fabric — Avalon Specification — Address Decoding Logic — Data Path Multiplexing — Wait — state insertion — Pipelining Endian Conversion — Address Alignment and Dynamic Bus sizing — Arbitration for Multi-Mastersystems — Burst management — Clock Domain Crossing — Interrupt Controller—Reset Distribution —SOPC Builder Overview — Architecture of SOPC Builder Systems — Functions of SOPC Builder -Integrated Development Environment — OE Project Manager — Source Code Editor — C/C++ — Compiler Debugger — Flash Programmer- Case Study: Calculator — System Specification — Calculator 10 Interface — Design of Calculating Engine — Building Calculator Software — Calculator Program Completing the calculator System.	8

Learning Resources:

Text Books:	1. Embedded Core Design with FPGAs, ZainalabedinNavabi, Tata McGraw Hill, 2008 2. VHDL Coding Styles and Methodologies, Ben Cohen, Kluwer Academic Publishers, 2007
Reference Books:	
Other Suggested Readings:	

Course Title:	**ADVANCED WIRELESS COMMUNICATION NETWORKS**
Course Code:	**ECEM 553**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Explain wireless channel propagation phenomena, fading models, and link power budget analysis for understanding signal behaviour in different environments.	Understand (Level II)
CO-2	Analyze diversity techniques for enhancing the performance of wireless communication systems in the presence of fading and interference.	Analyze (Level IV)
CO-3	Evaluate MIMO system architectures, including capacity, diversity gain, and space-time coding techniques, to improve system reliability and efficiency.	Evaluate (Level V)
CO-4	Examine the evolution of wireless networks, including 3G, 4G, and IEEE 802.11 WLANs, with a focus on their architecture, air interfaces, and key technologies.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	2	2	1	1	3	2
CO-2	3	3	2	2	1	0	3	2
CO-3	3	3	3	2	1	0	3	3
CO-4	3	2	2	1	2	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Wireless channel propagation and model, Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading – shadowing Distributions, Link power budget Analysis.	7
Module-II	Diversity, Capacity of flat and frequency selective fading channels-Realization of independent fading paths, Receiver Diversity: selection combining, Threshold Combining, Maximum-ratio Combining, Equal gain combining. Transmitter Diversity: Channel known at transmitter, channel unknown at the transmitter	7
Module-III	MIMO communications, Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beam forming, Diversity-Multiplexing trade-offs, Space time Modulation and coding: STBC, STTC, Spatial Multiplexing and BLAST Architectures.	7
Module-IV	Wireless Networks: 3G Overview, Migration path to UMTS, UMTS Basics, Air Interface, 3GPP Network Architecture, 4G features and challenges, Technology path, IMS Architecture - Introduction to wireless LANs – IEEE 802.11 WLANs - Physical Layer- MAC sublayer.	7

Learning Resources:

Text Books:		
1.	Title	Wireless Communications, 2007
	Author	Andrea Goldsmith,
	Publisher	Cambridge University Press
	Edition	Cambridge University Press
2.	Title	Fixed Broadband Wireless System Design
	Author	HARRY R. ANDERSON
	Publisher	John Wiley – India
	Edition	2003
3.	Title	Wireless Communications
	Author	Andreas.F. Molisch
	Publisher	John Wiley – India
	Edition	2006
Reference Books:		
1.	Title	Modern Wireless Communications
	Author	Simon Haykin& Michael Moher
	Publisher	Pearson Education
	Edition	2007
Other Suggested Readings:		

Course Title:	**SOLID STATE MICROWAVE DEVICES**
Course Code:	**ECEM 554**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the characteristics and models of microwave semiconductor devices and amplifier design principles.	Understand (Level II)
CO-2	Analyze and design small signal, low-noise, and high-power amplifiers and oscillators for microwave systems.	Analyze (Level IV)
CO-3	Evaluate the working principles and applications of two-terminal microwave devices like PIN, varactor, IMPATT, and TRAPATT diodes.	Evaluate (Level V)
CO-4	Apply knowledge of GaAs FETs, microwave BJTs, and mixers for the design of microwave communication circuits.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	0	0	0	0	3	0
CO-2	3	3	0	2	0	0	3	0
CO-3	3	2	0	0	0	0	3	0
CO-4	3	3	2	2	0	0	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Microwave semiconductor devices and models; Power gain equations; Amplifier stability, impedance matching, constant gain and noise figure circles.	9
Module-II	Small signal, low-noise, high-power, and broadband amplifier design; One-port and two-port oscillators; YIG dielectric and Gunn-diode oscillators.	9
Module-III	Two-terminal microwave devices: PIN diode (switches, phase shifters, limiters); Varactor diodes, IMPATT, TRAPATT devices.	9
Module-IV	Examine the evolution of wireless networks, including 3G, 4G, and IEEE Microwave BJTs, GaAs FETs, low-noise and power GaAs FETs; Transferred electron devices; Microwave mixers and applications.	9

Learning Resources:

Text Books:		
1.	Title	Microwave Circuit Analysis and Amplifier Design
	Author	S.Y. Liao
	Publisher	Prentice Hall
	Edition	1987
	Title	Microwave Circuit Design, Using Linear and Non-linear Techniques
2.	Author	G.D. Vendelin, A.M. Pavio, U.L. Rohde
	Publisher	John Wiley
	Edition	1990
	Title	Microwave Circuit Analysis and Amplifier Design
	Author	S.Y. Liao

Course Title:	**STATISTICAL SIGNAL ANALYSIS**
Course Code:	**ECEM 555**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the transformation of random variables and conditional expectation in the context of stochastic processes.	Understand (Level II)
CO-2	Analyze different types of stochastic processes and evaluate their properties such as stationarity and orthogonality.	Analyze (Level IV)
CO-3	Apply KL expansion and analyze ergodicity and mean square characteristics of stochastic processes.	Apply (Level V)
CO-4	Design and evaluate the response of stochastic systems and implement optimal estimation techniques such as Wiener/Kalman filter.	Evaluate (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	1	0	3	2
CO-2	3	3	2	2	1	0	3	2
CO-3	3	3	2	2	1	0	3	2
CO-4	3	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Review of probability theory and random variables: Transformation (function) of random variables, Conditional expectation.	9
Module-II	Sequences of random variables: convergence of sequences of random variables; Stochastic processes: wide sense stationary processes, orthogonal increment processes, Wiener process, Poisson process.	7
Module-III	Karhunen–Loève (KL) expansion; Ergodicity, Mean square continuity, mean square derivative and mean square integral of stochastic processes.	11
Module-IV	Stochastic systems: response of linear dynamic systems (e.g. state space or ARMA systems) to stochastic inputs, Lyapunov equations, correlation function, power spectral density function, linear least square estimation, Wiener filtering, and Kalman filtering.	9

Learning Resources:

Text Books:		
1.	Title	Probability, Random Variables and stochastic processes,
	Author	A. Papoulis
	Publisher	McGraw Hill
	Edition	2nd Ed, 1983
2.	Title	Stochastic Processes
	Author	A. Larson and B.O. Schubert
	Publisher	Holden-Day
	Edition	Vol. I and II, 1979

Course Title:	MODELING AND SIMULATION
Course Code:	ECEM 556
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand mathematical foundations, types, and properties of partial differential equations (PDEs).	Understand (Level-II)
CO-2	Apply basic mechanics, tensor operations, and discretization strategies in solving physical problems.	Apply (Level -III)
CO-3	Implement numerical methods (FDM) and programming techniques in MATLAB to solve engineering problems.	Apply (Level -III)
CO-4	Analyze and evaluate FEM and BEM formulations for solving PDEs in practical applications.	Evaluate (Level -V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	1	1	0	3	1
CO-2	3	3	2	2	1	0	3	2
CO-3	3	3	2	3	2	1	3	3
CO-4	3	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basic mathematical definitions, norms, convergence of sequences, consistency; Classification of PDEs; Equation types and forms of nonlinearity; Well-posedness of PDE problems.	12
Module-II	Basics of continuum mechanics; Vectors and tensors; Introductory mechanics; Discretization techniques and gridding methods.	10
Module-III	Programming in MATLAB: basic calculations, writing scripts and functions, loops, conditionals, plotting; Finite Difference Methods (FDM): derivative approximations, truncation error, Poisson equations (1D & 2D).	12
Module-IV	Finite Element Methods (FEM): functional/variational formulation, weak form, triangulation, Galerkin method; Boundary Element Methods (BEM): Laplace, Helmholtz, diffusion equations, Green's function.	6

Learning Resources:

Text Books:		
1.	Title	Numerical Methods for Scientists and Engineers,
	Author	R.W. Hamming
	Publisher	Dover Publication
	Edition	(2nded.) 1987
2.	Title	Introduction to the Finite Element Method
	Author	R Reddy
	Publisher	McGraw Hill Education
	Edition	(3rd ed.) 2005
3.	Title	Numerical Methods for Scientific and Engineering Computation
	Author	M. K. Jain, S. R. K. Iyengar and R. K. Jain
	Publisher	
	Edition	(5th ed.) 2007
Reference Books:		
1.	Title	Design of Analog CMOS Integrated Circuits- Edition
	Author	BehzadRazavi
	Publisher	TMH
	Edition	
Other Suggested Readings:		

Course Title:	**ADVANCED NUMERICAL ANALYSIS**
Course Code:	**ECEM 557**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Apply iterative techniques like Jacobi, Gauss-Seidel, SOR, ADI, and conjugate gradient methods to solve linear systems.	Apply (Level III)
CO-2	Analyze finite difference schemes for PDEs with respect to consistency, stability, and convergence using analytical techniques.	Analyze (Level IV)
CO-3	Implement numerical schemes for solving initial and boundary value problems, and evaluate their stability using CFL conditions.	Apply (Level III)
CO-4	Formulate and solve one-dimensional differential equations using finite element and variational methods.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	2	3	2	0	3	2
CO-2	3	3	2	2	1	0	3	2
CO-3	3	3	3	3	2	1	3	3
CO-4	3	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Iterative methods for linear systems: Jacobi method, Gauss Seidel method, SOR method, ADI Method, Incomplete LU method, Conjugate gradient, method, Multigrid methods.	8
Module-II	Introduction and classification of PDEs. Finite difference schemes for partial, differential equations: Explicit and Implicit schemes; Consistency, stability, and convergence - Stability analysis by matrix method and von Neumann, method, Lax's equivalence theorem.	10
Module-III	Finite difference schemes for initial and boundary value problems: FTCS, backward Euler and Crank-Nicolson schemes, ADI methods, Lax-Wendroff, method, upwind scheme; CFL conditions.	10
Module-IV	Finite element method for ordinary differential equations: Variational methods, method of weighted residuals, finite element analysis of one-dimensional problems.	8

Learning Resources:

Text Books:		
1.	Title	Numerical Solutions to Partial Differential Equations
	Author	G. D. Smith
	Publisher	Oxford University Pres
	Edition	3rd Edn., 1986
2.	Title	Finite Difference Schemes and Partial Differential Equations, 2004.
	Author	J. C. Strikwerda,
	Publisher	SIAM
	Edition	SIAM
3.	Title	Numerical Solution of Partial Differential Equations in Science and Engineering,
	Author	L. Lapidus and G. F. Pinder,
	Publisher	John Wiley
	Edition	1982.
Reference Books:		
1.	Title	Numerical Solution of Partial Differential Equations in Science and Engineering
	Author	L. Lapidus and G. F. Pinder,
	Publisher	John Wiley,
	Edition	1982.
2.	Title	The finite Difference Methods in Partial Differential Equations
	Author	A. R. Mitchell and D. F. Griffiths
	Publisher	Wiley,
	Edition	1980
Other Suggested Readings:		

Course Title:	ADVANCED MATHEMATICS
Course Code:	ECEM 558
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Apply matrix decomposition techniques like QR and Singular Value Decomposition for eigenvalue problems and approximations.	Apply (Level III)
CO-2	Solve problems in the calculus of variations including Euler's equations and isoperimetric problems involving moving boundaries.	Evaluate (Level V)
CO-3	Apply Laplace and Fourier transform methods to solve PDEs related to wave and heat conduction problems.	Apply (Level III)
CO-4	Analyze and solve linear and nonlinear optimization problems using Simplex methods, duality, and Kuhn-Tucker conditions.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	2	2	1	1	3	2
CO-2	3	3	2	2	2	0	3	2
CO-3	3	3	2	1	2	0	3	3
CO-4	3	3	3	2	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	Detailed Syllabus	Contact Hours
Module-I	Matrix Theory and Decomposition: QR, Eigenvalue computation via shifted QR algorithm, Singular Value Decomposition (SVD) and approximations.	8
Module-II	Calculus of Variations: Functional concepts, Euler's equation, higher-order derivative functionals, isoperimetric problems, and moving boundary conditions.	10
Module-III	Transform Methods and PDEs: Laplace and Fourier transforms for solving 1D wave and heat equations, Laplace equation properties, harmonic functions.	9
Module-IV	Optimization Techniques: Linear and Nonlinear Programming – Simplex, Two-Phase, Big M methods, Duality, Dual Simplex, Lagrange multipliers, Kuhn-Tucker conditions.	9

Learning Resources:

Text Books:		
1.	Title	Schaum's Outlines of Theory and Problems of Matrix Operations
	Author	Richard Bronson,
	Publisher	McGraw-H
	Edition	
2.	Title	Higher Engineering Mathematics
	Author	Venkataraman M K
	Publisher	National Pub. Co
	Edition	1992
3.	Title	Differential Equations and Calculus of Variations
	Author	Elsgolts, L.,
	Publisher	Mir,
	Edition	1977.
Reference Books:		
1.	Title	Elements of Partial differential equations
	Author	Sneddon,I.N.
	Publisher	Dover Publications
	Edition	2006.
2.	Title	Introduction to partial differential equations
	Author	SankaraRao, K.,
	Publisher	Prentice – Hall of India
	Edition	1995

Course Title:	ORGANIC ELECTRONICS
Course Code:	ECEM 559
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the structure, properties, and charge transport mechanisms of organic and inorganic semiconductor materials.	Understand (Level II)
CO-2	Analyze the principles, operation, and modeling of Organic Field Effect Transistors (OFETs) and evaluate their performance parameters.	Analyze (Level IV)
CO-3	Apply fabrication techniques to design OLEDs, organic solar cells, and interpret their electrical and optical characteristics.	Apply (Level III)
CO-4	Design and implement organic electronic circuits like inverters, memory cells, and drivers for real-world applications using OTFTs.	Create (Level VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	2
CO-2	3	3	2	1	2	0	3	2
CO-3	3	3	2	1	3	1	3	3
CO-4	3	3	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	Detailed Syllabus	Contact Hours
Module-I	Organic and Inorganic Materials & Charge Transport: Introduction to organic materials, semiconductors (p-type, n-type, ambipolar), charge transport models, band diagrams; materials for electrodes, insulators, substrates. Comparison between organic and inorganic semiconductors.	9
Module-II	Device Physics and Modeling: OFET structures, operating principles, output/transfer characteristics, performance parameters; modeling of OTFTs, contact resistance, extraction and validation of electrical characteristics.	9
Module-III	Fabrication Techniques and Advanced Organic Devices: Fabrication of OFETs and organic devices, overview of OLEDs and Organic Solar Cells, materials, classifications, performance characteristics, advantages and limitations.	9
Module-IV	Applications and Circuits: OTFT-based circuits: organic inverters, complementary inverters (all-p-type, hybrid, organic CMOS), logic circuits, memory designs (OSRAM, DRAM, shift registers), OTFT drivers for OLEDs, and recent technology applications.	9

Learning Resources:

Text Books:		
1.	Title	Organic Electronics: Materials, Manufacturing and Applications
	Author	Hagen Klauk,
	Publisher	Wiley-VCH VerlagGmbh& Co. KGaA, Germany
	Edition	
2.	Title	OrganicElectronics: Materials, Manufacturing and Applications
	Author	Hagen Klauk
	Publisher	Wiley-VCH VerlagGmbh& Co. KGaA, Germany.
	Edition	
3.	Title	Organic Electronics II: More Materials and Applications
	Author	Hagen Klauk
	Publisher	Wiley-VCH VerlagGmbh & Co. KGaA, Weinheim, Germany
	Edition	2012

Course Title:	NANO MATERIALS
Course Code:	ECEM 560
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the fundamental concepts of nanotechnology, solid-state physics, and carbon nanostructures including CNTs and fullerenes.	Understand (Level II)
CO-2	Apply various techniques to measure and analyze the structural, electronic, and surface properties of nanoparticles and materials.	Analyze (Level IV)
CO-3	Analyze the physical, chemical, and magnetic properties of nanostructured materials and explain their unique behaviors and applications.	Evaluate (Level V)
CO-4	Evaluate synthesis, self-assembly, and fabrication techniques for quantum nanostructures and bulk nanomaterials for advanced applications.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	2
CO-2	3	3	2	1	2	1	3	3
CO-3	3	3	2	1	3	1	3	3
CO-4	3	3	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction to Nanotechnology: Nano technology, nano science, MEMS, CNT, fullerene, nano machines, semiconductor technology etc. Solid State Physics: Introduction, structure (physics of solid state), FCC nanoparticle, semiconductor structures lattice vibration, energy band, reciprocal space, fermi surfaces, localized particles, mobility, exciton, etc	8
Module-II	Methods of Measuring Properties: Measurement methods, structure – atomic, crystallography, particle size, mass spectroscopy, LEED, RHEED, surface structures, microscopy – TEM, SEM, FIM, AFM etc. Properties of Nanoparticles: Properties of nano-particles, metal nano-clusters, semi conducting nano-particles, semi-conducting nano-particles, rare gas & molecular clusters, methods of synthesis.	8
Module-III	Carbon Nanostructures: Carbon nano-structures, carbon-molecule, carbon clusters, C60, C20H20, C8H8, CNT, applications. Bulk Nanostructured Materials: Solid disordered nanostructures: synthesis, failure, mechanical properties, multilayers, electrical properties, other properties, composite	12

	glasses, porous silicon, nanostructured crystals: natural crystals, array in zeolites, metal nanoparticles, photonic crystals.	
Module-IV	Nanostructured Ferromagnetism: Basic, para, ferro, ferri, antiferro- magnetism, effect of bilk nanostructuring on magnetic properties, dynamics of nanomagnets, nanopore containment, nanocarbonferromagnets, giant and colossal magnetoresistance, ferrofluids. Quantum Nanostructure, Self-assembly and Deposition: Quantum wells, wires and dots, preparation, size effect, single electron tunneling, etc., monolayer, multiplayer, LB film deposition, CVD, PVD, sputtering etc.	12

Learning Resources:

Text Books:		
1.	Title	Introduction to Nanotechnology
	Author	C. P. Poole Jr. and F. J. Owens
	Publisher	Wiley Inter Science
	Edition	
2.	Title	Nano Structures and Nano Materials: Synthesis, Properties and Applications
	Author	Guozhong CaoImperial
	Publisher	College Press
	Edition	
3.	Title	Nanostructured Materials Processing, Properties and Applications,
	Author	Carl C Koch,
	Publisher	Jaico Publishing House.
	Edition	

Course Title:	**ADVANCED IMAGE PROCESSING**
Course Code:	**ECEM 561**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the fundamentals of digital images, visual perception, pixel relationships, and perform basic arithmetic, logical, and geometric operations.	Understand (Level II)
CO-2	Apply image transforms (DFT, DCT, Haar, KL, etc.) and spatial/frequency domain techniques for image enhancement.	Apply (Level III)
CO-3	Analyze degradation models and apply restoration techniques like Wiener filtering and SVD-based inversion.	Analyze (Level IV)
CO-4	Evaluate compression techniques (lossless/lossy), segmentation methods, and color/multispectral image processing approaches for various imaging applications.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	2
CO-2	3	3	2	1	2	1	3	3
CO-3	3	3	3	2	2	1	3	3
CO-4	3	3	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Digital image fundamentals Introduction: Digital Image- Steps of Digital Image Processing Systems-Elements of Visual Perception - Connectivity and Relations between Pixels. Simple Operations- Arithmetic, Logical, Geometric Operations. Mathematical Preliminaries - 2D Linear Space Invariant Systems - 2D Convolution - Correlation 2D Random Sequence - 2D Spectrum.	8
Module-II	Image transforms and enhancement Image Transforms: 2D Orthogonal and Unitary Transforms-Properties and Examples. 2D DFT- FFT – DCT - Hadamard Transform - Haar Transform - Slant Transform - KL Transform - Properties and Examples. Image Enhancement- Histogram Equalization Technique- Point Processing-Spatial Filtering-In Space and Frequency - Nonlinear Filtering-Use of Different Masks.	8
Module-III	Image restoration and construction Image Restoration: Image Observation and Degradation Model, Circulant and Block Circulant Matrices and Its Application in Degradation Model - Algebraic Approach to Restoration- Inverse by Wiener Filtering - Generalized Inverse-SVD and Interactive Methods.	12

Module-IV	Image compression & segmentation Image Compression: Redundancy and Compression Models -Loss Less and Lossy. Loss Less- Variable-Length, Huffman, Arithmetic Coding - Bit-Plane Coding, Loss Less Predictive Coding, Lossy Transform (DCT) Based Coding, JPEG Standard - Sub Band Coding. Image Segmentation: Edge Detection - Line Detection - Curve Detection - Edge Linking and Boundary Extraction, Boundary Representation. Color and multispectral image processing Color Image-Processing Fundamentals, RGB Models, HSI Models, Relationship Between Different Models. Multispectral Image Analysis - Color Image Processing, Three Dimensional Image Processing --Computerized Axial Tomography- Stereometry-Stereoscopic Image Display-Shaded Surface Display.	12

Learning Resources:

Text Books:		
1.	Title	Digital Image Processing, Gonzalez, R.E., 3rd edition, 2008.
	Author	R.C& Woods
	Publisher	Pearson Education
	Edition	3rd edition, 2008.
2.	Title	Digital Image Processing
	Author	Kenneth R Castleman
	Publisher	Pearson Education
	Edition	1995
3.	Title	Digital Image Procesing
	Author	S. Jayaraman, S. Esakkirajan, T. Veerakumar,
	Publisher	Tata McGraw Hill Education,.Pvt Ltd, NewDelhi
	Edition	2009
Reference Books:		
1.	Title	Fundamentals of Digital image Processing
	Author	Anil Jain.K
	Publisher	Prentice Hall of India
	Edition	1989.

Course Title:	**LASERS AND OPTO-ELECTRONICS**
Course Code:	**ECEM 562**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	To familiarize about the various opto-electronic properties.	Remember (Level - I)
CO-2	To bring out the basic principle of operation of semiconductor lasers.	Understand (Level - II)
CO-3	To implement the afore-mentioned opto-electronic properties in designing the structure of semiconductor lasers.	Analyze (Level IV)
CO-4	To discuss applications and specific properties of semiconductor lasers.	Apply (Level - III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	1	0	0	1	0	3	1
CO-2	3	2	1	0	1	0	3	2
CO-3	3	3	2	1	2	1	3	3
CO-4	3	3	2	1	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Quantum Theory of Atomic Energy Levels – Radiative and Nonradiative decay of excited state atoms – Emission Broadening and linewidth – Radiation and Thermal equilibrium – Conditions for laser action – Laser Oscillation above threshold - Laser Amplifiers – Requirements for obtaining population inversion – Rate Equations for three and four level systems – Laser pumping requirements – Laser Cavity modes – Stable resonators – Gaussian beams- Special Laser Cavities – Q-switching and Mode locking – Generation of ultra-fast Optical pulses- Pulse compression.	8
Module-II	Atomic Gas Lasers – He-Ne, Argon ion, He-Cd — Molecular Gas Lasers – CO2, Excimer, Nitrogen—X-Ray Plasma Laser — Free-Electron Laser — Organic Dye lasers — Solid-state lasers – Ruby, Nd: YAG, Alexandrite, Ti:Sapphire.	8
Module-III	Electronic and Optical properties of semiconductors- electron-hole pair formation, PN Junction, diffusion, injection efficiency, quantum efficiency, homojunction and heterojunction, Excitation absorption, donor-acceptor and impurity band absorption, LED, Semiconductor lasers, Heterojunction Lasers, quantum well lasers, VCSEL, DFB and DBR Lasers.	12
Module-IV	Detection of Optical radiations – Basic Principle, Thermal detectors, Photo multipliers, photoconductive detectors, Photo diodes, Avalanche photodiodes, CCDs, Image Intensifiers, Arrays, Solar Cells, noise considerations.	12

Learning Resources:

Text Books:		
1.	Title	Laser Fundamentals
	Author	W.T. Silfvast
	Publisher	Cambridge University Press
	Edition	Second Edition (2004)
2.	Title	Principles of Lasers
	Author	O. Svelto
	Publisher	Springer
	Edition	Fourth Edition (1998)
3.	Title	Photonics: Optical Electronics in Modern Communications
	Author	A. Yariv and P. Yeh
	Publisher	Oxford University Press
	Edition	Sixth Edition (2007)
4.	Title	Semiconductor Optoelectronic Devices
	Author	Pallab Bhattacharya
	Publisher	Prentice Hall of India
	Edition	First Edition (1995)
5.	Title	Semiconductor Optoelectronics
	Author	Jasprit Singh
	Publisher	Tata McGraw Hill
	Edition	First Edition (1995)
6.	Title	Optoelectronics – an Introduction
	Author	Wilson and Hawkes
	Publisher	Prentice Hall
	Edition	First Edition (1998)

Course Title:	BIO-IMAGING AND BIO-SIGNAL PROCESSING
Course Code:	ECEM 563
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Explain the concepts of data acquisition, including sampling, aliasing, interpolation, and quantization.	Understand (Level II)
CO-2	Analyze and design digital filters (FIR and IIR) for discrete-time systems.	Analyze (Level IV)
CO-3	Apply the discrete Fourier transform (DFT) and fast Fourier transform (FFT) for spectral analysis of signals.	Apply (Level III)
CO-4	Evaluate the effects of sampling and aliasing in time and frequency domains.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	2
CO-2	3	3	2	1	2	1	3	3
CO-3	3	3	2	1	3	1	3	3
CO-4	3	3	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	Detailed Syllabus	Contact Hours
Module-I	Fundamentals of Deterministic Signal and Image Processing: Data Acquisition: Sampling in time, aliasing, interpolation, and quantization. Digital Filtering: FIR and IIR filters, basic properties of discrete-time systems. FIR and IIR filter design. DFT: Sampling in frequency domain, the discrete Fourier transform and its properties, the fast Fourier transform (FFT).	8
Module-II	Bio-Signal acquisition: Basics of bio-signal acquisition systems like Electrocardiograph ECG: Cardiac electrophysiology, relation of electrocardiogram (ECG) components to cardiac events, clinical applications, Electroencephalograph (EEG), Electro astrograph (EGG), Speech Signals: The source-filter model of speech production, spectrographic analysis of speech. Speech Coding, Analysis-synthesis systems, linear prediction of speech.	8
Module-III	Image processing for bio-medical imaging: Basics of image processing, Extension of filtering and Fourier methods to 2-D signals and systems. Interpolation, noise reduction methods, image enhancement, image segmentation, edge detection, homomorphic filtering.	12
Module-IV	Survey of major modalities for medical imaging: Image acquisition systems like X-ray, CT, MRI, PET, and SPECT. MRI: signal processing for magnetic resonance imaging. Surgical Applications: A survey of surgical applications of medical image processing.	12

Learning Resources:

Text Books:		
1.	Title	Biomedical Signal Analysis (Vol. 33)
	Author	R.M. Rangayyan
	Publisher	John Wiley & Sons
	Edition	2015
2.	Title	Biomedical Signal Processing: Principles and Techniques
	Author	D.C. Reddy
	Publisher	McGraw-Hill
	Edition	2005
3.	Title	Digital Image Processing using MATLAB
	Author	Gonzalez, Woods, Eddins
	Publisher	Gatesmark Publishing
	Edition	
4.	Title	Biomedical Digital Signal Processing
	Author	W.J. Tompkins
	Publisher	Prentice Hall
	Edition	1993
5.	Title	Bioelectrical Signal Processing in Cardiac and Neurological Applications (Vol. 8)
	Author	L. Sörnmo and P. Laguna
	Publisher	Academic Press
	Edition	2005
6.	Title	Fundamentals of Digital Image Processing
	Author	Anil K Jain
	Publisher	PHI Publication
	Edition	

Course Title:	**MATHEMATICAL METHODS FOR SIGNAL PROCESSING**
Course Code:	**ECEM 564**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the basic concept of linear algebra.	Understand (Level II)
CO-2	Analyse linear models through linear algebra concept.	Analyze (Level IV)
CO-3	Applying linear algebra concept to distinct data analysis.	Apply (Level - III)
CO-4	Applying linear algebra concept to distinct system modelling.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	1
CO-2	3	3	2	1	2	1	3	2
CO-3	3	3	2	1	3	1	3	3
CO-4	3	3	2	1	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Vector spaces, subspaces and bases associated with a matrix, Orthogonal bases and orthogonal projections, Gram-Schmidt process, linear transformations, similarity transformations. Solution of linear system of equations, LU and QR decomposition, orthogonal and oblique projections, pseudo-inverse, singular value decomposition.	8
Module-II	Linear models and least-squares problems, Eigenvalues and Eigenvectors, Symmetric and positive definite matrices. Functions on Euclidean space: Subsets of Euclidean space, Norms and inner product, Functions and continuity, Sequences and convergence	8
Module-III	Applications to data analysis: Regression, Principal component analysis, factor analysis, linear discriminant analysis, compressed sensing. Application to modelling: System identification, dimensionality reduction of a system of differential equations, Krylov subspace techniques, data-driven modelling.	12
Module-IV	Application to modelling: System identification, dimensionality reduction of a system of differential equations, Krylov subspace techniques, data-driven modelling.	12

Learning Resources:

Text Books:		
1.	Title	Introductory Algebra: a real-world approach
	Author	Ignacio Bello
	Publisher	McGraw-Hill Higher Education
	Edition	4 edt
2.	Title	Linear Algebra and its Applications
	Author	Gilbert Strang
	Publisher	Cengage India Private Limited
	Edition	4th.
Reference Books:		
1.	Title	Linear Algebra and Its Applications
	Author	David C. Lay
	Publisher	Pearson Education
	Edition	5th

Course Title:	**VISUAL SIGNAL PROCESSING**
Course Code:	**ECEM 567**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understanding the basic of the imaging system.	Understand (Level II)
CO-2	Illustrate distinct image transformation approaches.	Analyze (Level IV)
CO-3	Analyzing and extracting relevant features of the concerned domain problem.	Apply (Level - III)
CO-4	Apply the knowledge in solving high-level Imaging problems like Image restoration and edge detection, etc.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	2
CO-2	3	3	2	1	2	1	3	3
CO-3	3	3	2	1	3	1	3	3
CO-4	3	3	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basics: Applications of image processing. notion of pixel, resolution, quantization, photon noise, Geometric transformations, source-to-target and target-to-source mapping, planar and rotational homography, RANSAC for homography estimation, image registration, change detection, and image mosaicing. Motion blur: Exposure time, weighted frame integration, depth aware warping, spatio-temporal averaging, dynamic scenes.	8
Module-II	Image Formation in Lens:Pin-hole versus real aperture lens model, lens as a 2D LSI system, blur circle, Doubly block circulant system matrix, pill box and Gaussian blur models, space invariant and space variant blurring.3D Shape from Focus: Depth of field, focal stack, focus operators, focus measure curve, Gaussian interpolation, 3D recovery, focused image recovery. Image Transforms: Data dependent and independent transforms, 1D Orthogonal transforms, Kronecker product, 2D orthogonal transforms from 1D, 2D DFT, 2D DFT for image matching, 2D DCT, Walsh-Haddamard transform, Karhunen-Loeve transform, eigen filters, PCA for face recognition, singular value decomposition, image denoising using SVD.	8
Module-III	Photometric stereo: Normal estimation, depth reconstruction, uncalibrated PS, Generalized bas relief ambiguity. Image Enhancement: Thresholding methods (peak-valley, Otsu, Chow-Kaneko), histogram equalization and modification, Noise models,	12

	mean, weighted mean, median, weighted median, non-local means filter, BM3D, frequency domain filtering, illumination compensation by homomorphic filtering, segmentation by k-means clustering, higher-order statistics-based clustering.	
Module-IV	Image Restoration: Well-posed and ill-posed problems, Fredholm-integral equation, condition number of matrix, conditional mean, Inverse filter, Wiener filter, ML and MAP restoration, image super-resolution. Edge Detection: Gradient operators, Prewitt, Sobel, Roberts, compass operators, LOG, DOG, Canny edge detectors, non-maxima suppression, hysteresis thresholding.	12

Learning Resources:

Text Books:		
1.	Title	Fundamentals of Digital Image Processing
	Author	A.K. Jain
	Publisher	Pearson Education India
	Edition	2015
2.	Title	Digital Image Processing and Analysis Computer Vision and Image Analysis
	Author	Scott E Umbaugh
	Publisher	CRC Press
	Edition	4 edt.
3.	Title	Introduction to Video and Image Processing: Building Real Systems
	Author	Thomas B. Moeslund
	Publisher	Springer-Verlag New York Inc
	Edition	2012

Course Title:	**WIRELESS AND ADHOC NETWORKS**
Course Code:	**ECEM 568**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	To understand the challenges and constraints of wireless sensor network and its subsystems	Understand (Level II)
CO-2	To examine the physical layer specification, modulation and transceiver design considerations	Analyze (Level IV)
CO-3	To adapt and analyse the protocols used at the MAC layer and scheduling mechanisms	Apply/Analyze (Level-III/Level-IV)
CO-4	To evaluate and synthesize the application areas and practical implementation issues.	Evaluate/Synthesis (Level-V/Level-VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	0	1	0	3	2
CO-2	3	3	2	1	2	1	3	3
CO-3	3	3	2	2	3	2	3	3
CO-4	3	2	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction to adhoc networks – definition, characteristics features, applications. Characteristics of Wireless channel, Adhoc Mobility Models: - Indoor and outdoor models.	6
Module-II	MAC Protocols: design issues, goals and classification. Contention based protocols- with reservation, scheduling algorithms, protocols using directional antennas. IEEE standards: 802.11a, 802.11b, 802.11g, 802.15. HIPERLAN.	9
Module-III	Routing Protocols: Design issues, goals and classification. Proactive Vs reactive routing, Unicast routing algorithms, Multicast routing algorithms, hybrid routing algorithm, Energy aware routing algorithm, Hierarchical Routing, QoS aware routing.	9
Module-IV	Transport layer: Issues in designing- Transport layer classification, adhoc transport protocols. Security issues in adhoc networks: issues and challenges, network security attacks, secure routing protocols. Cross layer Design: Need for cross layer design, cross layer optimization, parameter optimization techniques, Cross layer cautionary prespective. Integration of adhoc with Mobile IP networks.	9

Learning Resources:

Text Books:		
1.	Title	Ad hoc Networking
	Author	Charles E. Perkins
	Publisher	Pearson Education. 2007
	Edition	Wesley, 2000nd Edition
2.	Title	Adhoc Wireless Networks Architectures and Protocols
	Author	C.Siva Ram Murthy and B.S. Manoj
	Publisher	
	Edition	
Reference Books:		
1.	Title	Mobile Adhoc Networking
	Author	Stefano Basagni, Marco Conti, Silvia Giordano and Ivan Stojmenovic
	Publisher	Wiley-IEEE press
	Edition	2004
2.	Title	Cross Layer Design Optimization in Wireless Protocol Stacks
	Author	V.T. Raisinhani and S. Iyer
	Publisher	Comp. Communication
	Edition	Vol. 27 no. 8, 2004

Course Title:	**OPTICAL SIGNAL PROCESSING**
Course Code:	**ECEM 569**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand basic concepts of light propagation, spatial frequency and Spectral analysis.	Remember (Level-I)
CO-2	To study and design different domain filtering techniques.	Understand (Level - II)
CO-3	Apply the transform domain approach for study of light behaviors.	Apply (Level –III)
CO-4	Ability to develop optical filters, modulators and detectors for various applications of light processing	Analyze (Level –IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	2	1	1	3	2
CO-2	3	3	2	3	2	1	3	3
CO-3	3	3	2	3	3	1	3	3
CO-4	3	3	2	3	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Characterization of a General signal, examples of signals, Spatial signal. Basic laws of geometrical optics, Refractions by mirrors, the lens formulas, General Imaging conditions, the optical invariant, Optical Aberrations.	8
Module-II	Physical optics: The Fresnel Transforms, the Fourier transform, Examples of Fourier transforms, the inverse Fourier transform Extended Fourier transform analysis, Maximum information capacity and optimum packing density, System coherence.	8
Module-III	Spectrum Analysis and Spatial Filtering: Light sources, spatial light modulators, The detection process in Fourier domain, System performance parameters, and Dynamic range. Some fundamentals of signal processing, Spatial Filters.	12
Module-IV	Binary spatial filters: Magnitude Spatial Filters, Phase Spatial Filters, Real valued Spatial Filters, Interferometry techniques for constructing Spatial Filters. Optical signal processor and filter generator, Applications for optical signal processing. Acousto-optic cell spatial light modulators: Applications of acousto-optic devices. Basic Acousto-optic power spectrum analyzer. Heterodyne systems: Interference between two waves, the optical Radio. Lab based on the topics in Theory.	12

Learning Resources:

Text Books:		
1.	Title	Optical signal processing
	Author	Anthony Vanderlugt
	Publisher	Wiley-Interscience
	Edition	First Edition
2.	Title	Ultrafast All-Optical Signal Processing Devices
	Author	Hiroshi Ishikawa
	Publisher	Wiley
	Edition	First Edition, 2008
Reference Books:		
3.	Title	Optical data Processing-Applications
	Author	D. Casasent
	Publisher	Springer-Verlag, Berlin
	Edition	First Edition
4.	Title	Optical Signal Processing, Computing,and Neural Networks
	Author	Francis T. S. Yu, Suganda Jutamulia
	Publisher	Krieger Publishing Company
	Edition	2nd Edition

Laboratory Courses

Course Title:	COMMUNICATION LABORATORY -I
Course Code:	ECEM 515
L-T-P:	0-0-6
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Implement basic signal generation, manipulation, and analysis using MATLAB and verify fundamental DSP operations like convolution and correlation.	Apply (Level III)
CO-2	Analyze and realize signal processing algorithms such as DFT, IDFT, and FFT using both software (MATLAB) and hardware (DSP processors).	Analyze (Level-IV)
CO-3	Design and implement digital filters (FIR/IIR) and modulation techniques using DSP/FPGA kits for practical signal processing applications.	Create (Level-VI)
CO-4	Apply DSP techniques in real-world biomedical and audio applications, such as EEG noise removal using wavelets and speech pitch detection.	Analyze (Level-IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	1	2	1	3	2
CO-2	3	3	3	2	2	1	3	2
CO-3	3	3	3	2	3	2	3	3
CO-4	3	2	2	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:	
1.	Basics of MATLAB-Realisation of Unit Impulse, Unit Step & Unit Ramp signals.
2.	To create user function for performing signal operation: folding, Shifting, signal addition and continuous and discrete time scaling. Response of LTI Systems
3.	Linear & Circular Convolution of two Sequences, Correlation of two sequences.
4.	Study of Floating-Point Digital Signal Processor &Fixed-Point Digital Signal Processor.
5.	Realisation of Circular & Linear Convolution and Correlation of two sequences.
6.	DFT & IDFT Computation.
7.	Computation of DFT & IDFT of a given Sequence using DSP Processors.
8.	Radix-2 & Radix-4 algorithm FFT Calculation using DSP Processors.
9.	FIR & IIR Filter Implementation using the DSP Processors.
10.	Implementation of Digital modulation techniques using DSK/FPGA kits.
11.	Experiments on pitch detection schemes, speech analysis
12.	To remove various artifacts and noises in EEG signals using Discrete Wavelet thresholding techniques.

Learning Resources:

Textbooks:		
1.	Title	Digital Signal Processing: A Computer-Based Approach
	Author	S. K. Mitra
	Publisher	McGraw-Hill
	Edition	Third edition, 2006
2.	Title	Discrete-Time Signal Processing
	Author	A. Oppenheim and R. Schafer
	Publisher	Prentice Hall
	Edition	Second edition, 1999
3.	Title	Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK
	Author	RulphChassaing
	Publisher	Wiley
	Edition	2nd
4.	Title	Digital Signal Processing: Principles, Algorithms and Applications
	Author	J. Proakis, D. Manolakis
	Publisher	Prentice-Hall
	Edition	4th edition, 2006
5.	Title	Computer-Based Exercises for Signal Processing Using MATLAB 5
	Author	J. McClellan (Ed.)
	Publisher	Prentice Hall
	Edition	1997
Reference Books:		
1.	Title	Theory and Application of Digital Signal Processing
	Author	L.R. Rabiner and B. Gold
	Publisher	Phi Learning
	Edition	1st Edition, 2008
Other Suggested Readings:		

Course Title:	COMMUNICATION LABORATORY -II
Course Code:	ECEM 565
L-T-P:	0-0-6
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Apply MATLAB and DSP platforms to simulate basic signal processing operations and implement digital modulation techniques.	Apply (Level III)
CO-2	Analyze and design FIR/IIR filters and evaluate DFT/IDFT computations using DSP hardware (TMS320C6713 DSK).	Analyze (Level-IV)
CO-3	Perform image enhancement and EEG signal denoising using wavelet-based and time-frequency techniques.	Apply (Level-III)
CO-4	Classify EEG signals using machine learning classifiers and assess model performance using various metrics.	Evaluate (Level-V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	2	2	3	1	3	2
CO-2	3	3	3	2	3	1	3	3
CO-3	3	2	2	2	2	2	3	3
CO-4	3	2	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:	
1.	Basics of MATLAB-Realization of Unit Impulse, Unit Step & Unit Ramp signals.
2.	To create user function for performing signal operations for communication.
3.	Denoising of speech signals.
4.	Study of Floating-Point Digital Signal Processor & Fixed-Point Digital Signal Processor.
5.	Efficient computation of DFT &IDFT.
6.	FIR & IIR Filter Implementation using the using TMS320C6713 DSK.
7.	Implementation of Digital modulation techniques using TMS320C6713 DSK.
8.	Experiments on image enhancement, edge detection.
9.	Bio signal processing-based experiments.
10.	To extract various time domain features like sum, energy, standard deviation, and variance of EEG signals.
11.	To extract various hybrid time-frequency domain features of EEG signal using wavelet transform.
12.	To classify the EEG signals using various Machine learning classifiers like SVM, Logistic regression, Decision Trees, Random Forest and plot the performance metrics like Accuracy, Precision, Recall, Specificity, Sensitivity. ▪ RRM/BPM/HRM/Pulse Oximeter based experiments ▪ RRM, BIA based experiments ▪ Ultrasound HRM based experiments

Learning Resources:

Textbooks:		
1.	Title	A Course in Digital Signal Processing
	Author	B. Porat
	Publisher	J. Wiley and Sons
	Edition	1996
2.	Title	Computer-Based Exercises for Signal Processing Using MATLAB 5
	Author	J. McClellan (Ed.)
	Publisher	Prentice Hall
	Edition	1997
3.	Title	Understanding Digital Signal Processing
	Author	R. Lyons
	Publisher	Prentice-Hall
	Edition	1996
4.	Title	Digital Signal Processing and Applications with the TMS320C6713 and TMS320C6416 DSK
	Author	RulphChassaing
	Publisher	Wiley
	Edition	2nd
5.	Title	Digital Signal Processing: A Computer-Based Approach
	Author	S. K. Mitra
	Publisher	McGraw-Hill
	Edition	Third edition, 2006
6.	Title	Discrete-Time Signal Processing
	Author	A. Oppenheim and R. Schafer
	Publisher	Prentice Hall
	Edition	Second edition, 1999
7.	Title	Schaum's Outline of Digital Signal Processing
	Author	M. Hays
	Publisher	McGraw-Hill
	Edition	4th edition, 2006
Reference Books:		
1.	Title	Theory and Application of Digital Signal Processing
	Author	L.R. Rabiner and B. Gold
	Publisher	Phi Learning
	Edition	1st Edition, 2008
Other Suggested Readings:		

Course Title:	**FIBRE OPTICS LABORATORY**
Course Code:	**ECEM 516**
L-T-P:	**0-0-6**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Identify and explain the types, structures, and characteristics of optical fibers, sources, and detectors.	Apply (Level III)
CO-2	Measure numerical aperture, optical power, attenuation, and coupling loss in optical fiber systems.	Analyze (Level IV)
CO-3	Demonstrate the working of multiplexing techniques and analyze signal transmission characteristics of LEDs and lasers.	Apply (Level III)
CO-4	Design and evaluate a basic audio-video optical communication system using multiplexers, transmitters, and receivers.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	1	2	1	2	1
CO-2	3	3	2	2	3	2	3	2
CO-3	3	2	2	2	3	2	3	2
CO-4	3	3	3	2	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:	
1.	To study the basic structure and types of the optical fiber
2.	To measure the numerical aperture (NA) of the different cables provided
3.	To measure the optical power emitted by the LED.
4.	To observe the attenuation & coupling loss in optical fiber.
5.	Describe the operational characteristics and parameters of Photo diode used as photo detector in fiber optics ystem.
6.	To check the transmission characteristic of LED & laser source.
7.	To carry out measurement on digital communication systems.
8.	To become familiar with different types of multiplexing techniques.
9.	To carry out an audio +video communication system consisting of audio and video source; audio video multiplexer and de-multiplexer; analog transmitter and receiver on optical fiber.

Learning Resources:

Textbooks:		
1.	Title	Optical fiber communications: principles and practice
	Author	John. M. Senior
	Publisher	Prentice Hall
	Edition	Third edition, 2006
2.	Title	Optical fiber communications
	Author	Gerd Keiser
	Publisher	McGrawHill
	Edition	Third edition,
3.	Title	Fiber Optic Communication Systems
	Author	G. PAgrawal
	Publisher	Johannian and Sons
	Edition	1999

Course Title:	VLSI DESIGN LABORATORY
Course Code:	ECEM 517
L-T-P:	0-0-3
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Explain the fundamentals of basic electronics, semiconductor physics, and quantum mechanics relevant to nanostructures.	Understand (Level II)
CO-2	Apply quantum mechanical principles to analyze band structures and optical/electronic processes in semiconductors.	Apply (Level III)
CO-3	Analyze electronic transport mechanisms, optical properties, and device physics in low-dimensional and nanostructured materials.	Analyze (Level IV)
CO-4	Evaluate and design advanced photonic and optoelectronic devices using novel semiconductor and nanostructured materials.	Evaluate/Create (Level V/ VI)

Course Articulation Matrix:

Course Outcomes	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	–	–	–	3	2
CO-2	1	3	2	–	–	–	3	2
CO-3	–	2	3	2	1	–	3	3
CO-4	–	1	3	3	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:	
1.	Combinational and Sequential logic circuit design implementation.
2.	Frequency Response of CE, CB, CC and CS amplifiers, Darlington Amplifier, Differential Amplifiers - Transfer characteristic, CMRR Measurement, Cascode / Cascade amplifier.
3.	Two case studies and one minor project.

Learning Resources:

Textbooks:	1. SPICE manual, IRSIM manual, MAGIC manual 2. Xilinx Corporation, “FPGA Technology for Nineties”, Xilinx Handbook, 1992.
Reference Books:	
Other Suggested Readings:	

Course Title:	**VLSI DESIGN WITH CAD TOOLS**
Course Code:	**ECEM 566**
L-T-P:	**0-0-6**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Explain the relevance of VLSI design and semiconductor technologies with respect to national/international policies, socio-economic impact, and futuristic vision.	Understand (Level II)
CO-2	Apply fundamental principles of digital and analog VLSI circuit design to model and simulate circuits.	Apply (Level III)
CO-3	Analyze digital circuits using HDL (VHDL/Verilog) and evaluate performance through simulations.	Analyze (Level IV)
CO-4	Design and implement VLSI circuits using Cadence Virtuoso tool for advanced applications.	Evaluate/Create (Level V/ VI)

Course Articulation Matrix:

Course Outcomes	**PO-1**	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	3	2	1	–	–	1	3	2
CO-2	2	3	2	1	–	–	3	2
CO-3	–	2	3	2	2	–	3	3
CO-4	–	1	3	3	3	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

List of Experiments:	
1.	CMOS-inverter implementation.
2.	Half adder, full adder, half subtractor, and full subtractor implementation.
3.	Current mirror, differential amplifier, CE, CB, and CC amplifier circuit implementation.

Learning Resources:

Textbooks:	
Reference Books:	
Other Suggested Readings:	

Elective Courses

Course Title:	**ADVANCED ERROR CONTROL CODES**
Course Code:	**ECEM 520**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand and apply the fundamentals of information theory, including entropy, mutual information, and Shannon's theorems.	Understand (Level II)
CO-2	Design and analyze classical error-correcting codes such as block codes, cyclic codes, and Hamming codes.	Apply (Level III)
CO-3	Implement and evaluate advanced algebraic codes such as BCH and Reed-Solomon for reliable data transmission.	Evaluate (Level V)
CO-4	Analyze and apply modern coding schemes such as convolutional, Turbo, LDPC, and space-time codes for efficient communication in noisy environments.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	1	1	1	2	1
CO-2	3	3	2	2	2	1	3	2
CO-3	3	3	2	2	2	1	3	2
CO-4	3	3	3	3	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Modul-I	**Fundamentals of Information and Communication Theory** Introduction to Information and Coding Theory, Entropy and Information Rate, Mutual Information, Capacity of Discrete Channel, Channel Capacity, Shannon Theorems: Source Coding Theorem, Channel Coding Theorem, Capacity of a Gaussian Channel, Limits to Communication and Their Consequences	8
Module-II	**Classical Error-Correcting Codes** Generator and Parity Check Matrices, Encoding Circuits, Syndrome and Error Detection, Minimum Distance Considerations, Error Detecting and Error Correcting Capabilities, Standard Array and Syndrome Decoding, Decoding Circuits, Hamming Codes, Reed-Muller Codes, Golay Codes, Generator and Parity Check Polynomials, Encoding using Multiplication Circuits, Systematic Cyclic Codes, Feedback Shift Register Encoding, Generator Matrix for Cyclic Codes, Syndrome Computing and Error Detection	10
Module-III	**Advanced Algebraic Codes (BCH, RS)** Minimal Polynomials, Encoding and Decoding of BCH Codes, Error-Location and Error Evaluation Polynomials, Key Equation and Euclidean Algorithm, Encoding and Decoding Techniques, Applications in Error Correction	8
Module-IV	**Modern Coding Techniques (Convolutional, Turbo, LDPC, STBC)**	10

	Encoding and Distance Properties, Viterbi Algorithm, State Diagrams, Hard and Soft Decision Decoding, Error Probability Analysis, Introduction and Design Principles, Distance Properties, Decoding Algorithms, Regular and Irregular LDPC Codes, Tanner Graph Based Decoding, Alamouti Code, Encoding and Decoding Techniques	

Learning Resources:

Text Books:		
1.	Title	Essentials of Error Control Coding
	Author	Jorge Castineira Moreira and Patrik Guy Farrell
	Publisher	John Willy and Sons
	Edition	
2.	Title	Error Control Coding
	Author	Todd K. Moon
	Publisher	John Willy and Sons
	Edition	
Reference Books:		
Other Suggested Readings:		

Course Title:	INTRODUCTION TO MEMS
Course Code:	ECEM 521
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand MEMS fabrication techniques including surface and bulk micromachining.	Understand (Level II)
CO-2	Analyze mechanical behavior and energy modeling of MEMS structures.	Analyze (Level IV)
CO-3	Apply transduction and signal conditioning principles in MEMS design.	Apply (Level III)
CO-4	Evaluate the impact of noise, sensing configurations, and wireless communication in micromechanical circuit design.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	1	1	1	3	2
CO-2	3	3	2	3	2	1	3	2
CO-3	3	2	3	2	3	2	3	3
CO-4	3	3	2	3	3	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**MEMS Fabrication and Surface Micromachining** Administrative Information, MEMS Roadmaps, Benefits of Miniaturization and Scaling, Oxidation, Film Deposition, Lithography, Etching, Ion Implantation, Diffusion, Basic Process Flow, Release, Stiction, Material Choices, Residual Stress, Stringers, Planarization, MUMPS, Summit, Electroplating, 3D Out-of-Plane Structures	9
Module-II	**Bulk Micromachining, Process Integration, and MEMS Mechanics** Wet Etch-Based, Dissolved Wafer, SOI MEMS, SCREAM, HEXSiL, Deep RIE, Interleaved, MEMS-First, MEMS-Last, Bonded Integration, Wafer-to-Wafer Transfer, Stress, Strain, Material Properties, Measurement Techniques, Bending Moment, Flexural Rigidity, Residual Stress, Boundary Conditions, Springs, Clamped-Clamped Beam, Resonance Frequency, Free-Free Beam, Lumped Mechanical Models	9
Module-III	**MEMS Transduction and Signal Conditioning** Charge/Voltage Control, Pull-In, Linearization, Comb Drive, Levitation, Equivalent Circuits, Resonator, Thermal, and Fluidic Equivalent Circuits, Alternative Actuation Principles, Op-Amps, Transistor-Level Design	9
Module-IV	**MEMS Noise, Sensing, Wireless and Micromechanical Circuits**	9

	Electronic Noise, Brownian Motion, SNR, Dynamic Range, Configurations, Parasitics, Accelerometers, Gyroscopes, ront-End Architecture, Noise Figure, Filtering, High-Q Importance, Filters, Resonators, Couplers, Arrays, Oscillators, RF MEMS Switches	

Learning Resources:

Text Books:		
1.	Title	Introduction to Microelectronic Fabrication
	Author	Richard C. Jaeger,
	Publisher	Addison-Wesley
	Edition	1993
2.	Title	MEMS Handbook
	Author	Edited by Gad-El-Hak
	Publisher	CRC Press,
	Edition	2001
Reference Books:		
Other Suggested Readings:		

Course Title:	**INFORMATION AND NETWORK SECURITY**
Course Code:	**ECEM 522**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand security threats, services, and classical cryptographic methods	Understand (Level II)
CO-2	Apply modern encryption algorithms and authentication techniques for secure communication	Apply (Level III)
CO-3	Analyze system and network vulnerabilities and recommend countermeasures	Analyze (Level IV)
CO-4	Evaluate wireless and mobile security protocols and architectures.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	1	1	2	3	1
CO-2	3	3	3	2	3	2	3	2
CO-3	3	3	2	3	3	2	3	2
CO-4	3	3	2	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Foundations of Security and Classical Cryptography** Security issues in computing, types of attacks, security services and mechanisms, OSI security architecture, standards and standard-setting organizations, Basic encryption and decryption techniques, Substitution and transposition techniques, Block ciphers, Data Encryption Standard (DES), differential and linear cryptanalysis	9
Module-II	**Modern Cryptographic Algorithms and Authentication** Advanced Encryption Standard (AES) encryption and decryption, Block cipher modes, triple DES with two keys, Stream cipher using RC4, Public key cryptography using RSA, Diffie-Hellman, elliptic curve cryptography, Message authentication using HASH functions such as MD5 and SHA 512, Digital signature standards and authentication protocols	9
Module-III	**Network and System Security** IP security overview and architecture, Authentication header and encapsulating security payload, combining security associations and key management, Web security using SSL, TLS, and Secure Electronic Transaction (SET), Malicious software such as viruses, worms, and countermeasures, Intrusion detection systems, denial of service attacks, firewalls and trusted systems	9

Module-IV	**Wireless and Mobile Security** Security requirements and standards for wireless systems, Security mechanisms in IEEE 802.11, WiMAX security architecture, Security in North American and European cellular systems, Overview of wireless network vulnerabilities and secure communication	9

Learning Resources:

Text Books:		
1.	Title	Security in Computing
	Author	Charles P. Pleeger,
	Publisher	Prent ice Hall, New Delhi,
	Edition	2006
2.	Title	Network Security
	Author	Simands
	Publisher	McGraw Hill, New Delhi
	Edition	1998
Reference Books:		
Other Suggested Readings:		

Course Title:	PHOTONIC INTEGRATED DEVICES AND SYSTEMS
Course Code:	ECEM 523
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the principles of waveguide analysis and optical mode propagation	Understand (Level II)
CO-2	Apply fabrication processes and materials knowledge in the design of optical devices	Apply (Level III)
CO-3	Analyze the behavior and performance of dynamic integrated optical devices	Analyze (Level IV)
CO-4	Evaluate advanced photonic technologies and emerging integrated optical systems	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	2	2	1	3	2
CO-2	3	3	3	2	3	1	3	2
CO-3	3	3	2	3	3	2	3	2
CO-4	3	3	2	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	Detailed Syllabus	Contact Hours
Module-I	**Waveguide Theory and Analysis** Analysis of optical waveguides and devices, Planar waveguides and channel waveguides, Graded index waveguides, Coupled mode theory and its applications, Variational method, Beam propagation method	8
Module-II	**Materials and Fabrication Techniques** Overview of materials used in integrated optics, General fabrication steps for integrated optical devices, Photolithography techniques for patterning, Titanium diffused lithium niobate (Ti:$LiNbO_3$) process, Proton exchange process for waveguide formation, Silicon-based IC fabrication process, Compound semiconductor processes and their integration	10
Module-III	**Active and Dynamic Optical Devices** Electro-optic, acousto-optic, thermo-optic, and magneto-optic devices, Design and operation of integrated optical amplifiers, Optical communication components, Fiber optic sensors and their integration, Optical signal processing applications, Optical computing elements	9
Module-IV	**Advanced Topics in Integrated Optics** Nonlinear integrated optics and phenomena, Opto-electronic integrated circuits, Silicon-based photonic integrated circuits, Nanophotonic structures for light manipulation, Micro-opto-electro-mechanical systems (MOEMS), Recent trends and developments in photonic integrated circuits	9

Learning Resources:

Text Books:		
1.	Title	Integrated Optics- Theory and Technology,
	Author	Robert G. Hunsperger,
	Publisher	Springer
	Edition	6th edition
2.	Title	Integrated Photonics
	Author	C R Pollock and M Lipso
	Publisher	Kluwer Pub
	Edition	2003
3.	Title	Guided wave opto-electronics
	Author	T Tamir
	Publisher	Springer Verlag
	Edition	1990
Reference Books:		
Other Suggested Readings:		

Course Title:	SPEECH PROCESSING
Course Code:	ECEM 524
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the basics of speech production and representation using DSP techniques	Understand (Level II)
CO-2	Apply time and frequency domain methods to analyze speech signals	Apply (Level III)
CO-3	Analyze speech synthesis techniques and text-to-speech systems	Analyze (Level IV)
CO-4	Evaluate applications of speech technology including recognition and enhancement systems	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	1	2	1	3	2
CO-2	3	3	2	2	3	1	3	2
CO-3	3	3	3	3	3	2	3	2
CO-4	3	3	2	3	3	3	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Fundamentals of Speech and Signal Representation** Speech fundamentals including articulatory phonetics, Production and classification of speech sounds, Acoustic phonetics and the acoustics of speech production, Review of digital signal processing concepts, Short-Time Fourier Transform, Filter-bank and Linear Predictive Coding (LPC) methods	9
Module-II	**Speech Signal Analysis Techniques** Time domain techniques for speech analysis, Frequency domain analysis of speech, Pitch and formant estimation techniques, Cepstral analysis of speech signals, LPC analysis for feature extraction	9
Module-III	**Speech Synthesis Systems** Articulatory synthesis methods, Formant synthesis approaches, LPC-based speech synthesis, Voice response systems, Text-to-speech systems and architectures	9
Module-IV	**Applications of Speech Technology** Speech data compression and coding techniques, Vocoders and their working principles, Speech enhancement techniques, Applications in speech and speaker recognition, Assistive technologies for speech and hearing impairments	9

Learning Resources:

Text Books:		
1.	Title	Speech Communication: Human and Machine
	Author	D O'Shaughnessy
	Publisher	Addison Wesley
	Edition	1987
2.	Title	Digital Processing of Speech Signals, ,
	Author	L R Rabiner and RW Schafer,
	Publisher	Prentice Hall
	Edition	1978
3.	Title	Speech Analysis, Synthesis, and Perception
	Author	J.L Flanagan
	Publisher	Springer Verlag
	Edition	
Reference Books:		
Other Suggested Readings:		

Course Title:	**QUANTUM MECHANICS AND ITS APPLICATIONS TO ENGINEERING**
Course Code:	**ECEM 525**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Apply concepts of linear algebra and matrix theory to analyze engineering systems	Apply (Level III)
CO-2	Solve linear and nonlinear ordinary differential equations and use special functions in applications	Apply (Level III)
CO-3	Analyze and solve PDEs using separation of variables in curvilinear coordinates	Analyze (Level IV)
CO-4	Understand the foundational concepts of quantum theory and apply them to physical models	Understand (Level II) and Apply (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	1	2	1	3	2
CO-2	3	3	3	2	2	1	3	2
CO-3	3	3	3	3	2	2	3	3
CO-4	3	2	2	3	2	2	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Linear Algebra and Matrix Theory** Linear vector spaces, linear independence, basis, and dimension, Linear transformation and matrix representation, Diagonalizable matrices and singular value decomposition, Inner product spaces: Euclidean, Frobenius, and p-norms, Orthogonal and orthonormal vectors, Gram-Schmidt orthogonalization, Special matrices (unitary, Hermitian, skew-Hermitian, symmetric, skew-symmetric), Positive definite matrices and properties, Quadratic forms and canonical form reduction, Condition number of matrices	8
Module-II	**Differential Equations and Special Functions** Higher order linear ODEs: homogeneous and non-homogeneous, Methods (undetermined coefficients, variation of parameters, Euler-Cauchy), Power series solutions and Frobenius method, Classification of singular points, Special functions (Legendre, Bessel, Chebyshev, Hermite, Laguerre), Properties (generating functions, Rodrigue's formula, recurrence, orthogonality), Linear systems of ODEs (matrix methods, fundamental matrix, matrix exponential), Phase portraits and stability of planar systems, Intro to nonlinear ODEs	8
Module-III	**Partial Differential Equations and Vector Calculus** Coordinate systems (cylindrical and spherical polar), Transformation between Cartesian and curvilinear coordinates,	8

	Vector calculus: divergence, gradient, curl in curvilinear coordinates, Classification of PDEs, Dirichlet and Neumann boundary conditions, Method of separation of variables, Solution of Laplace, Poisson, Helmholtz, wave, and diffusion equations in curvilinear systems	
Module-IV	**Quantum Mechanics Foundations and Applications** Stern-Gerlach experiment and classical theory inadequacies, Wave-particle duality, wave packets, Fourier transforms, Time-dependent and time-independent Schrödinger equations, Physical interpretation of wave function, continuity equation, expectation values, Bound and scattering states, 1D quantum systems: Dirac-delta potential, infinite and finite square well, Quantum tunneling, potential barrier, Kronig-Penney model.	6

Learning Resources:

Text Books:		
1.	Title	Advanced Engineering Mathematics
	Author	R K Jain and S R K Iyengar
	Publisher	Narosa Publishing
	Edition	4 th Edition, 2010.
2.	Title	An Introduction to Theory and Applications of Quantum Mechanics
	Author	AmnonYariv
	Publisher	Dover Publications
	Edition	2012
Reference Books:		
Other Suggested Readings:		

Course Title:	**DIGITAL CMOS INTEGRATED CIRCUITS**
Course Code:	**ECEM 526**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand CMOS fabrication, device behavior, and inverter design fundamentals	Understand (Level II)
CO-2	Design and interpret CMOS layouts and combinational logic using various styles	Apply (Level III)
CO-3	Develop and analyze sequential digital circuits using static and dynamic logic	Analyze (Level IV)
CO-4	Evaluate timing, clocking, memory, and performance optimization using logical effort	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	1	1	3	2
CO-2	3	3	3	2	2	1	3	3
CO-3	3	3	3	3	2	1	3	3
CO-4	3	3	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**CMOS Technology and Inverter Design** Overview of MOSFET technology, Process flow and masking steps in MOS, CMOS fabrication technologies: n-well, p-well, twin-tub, SOI, and scaling, Latch-up in CMOS technology, NMOS inverter design (resistive, enhancement, and depletion load types), CMOS inverter (transfer characteristics, noise margins, transistor sizing, logic Levels), Delay analysis (rise/fall time, propagation delay, power consumption)	9
Module-II	**Layout Design, Design Rules and Combinational Logic Design** Stick diagrams and layout design rules (lambda & micron-based), Layer properties: diffusion, poly, metal, CMOS circuit layout design and area estimation, Design styles and practical design issues, CMOS logic styles (NAND, NOR, complex gates), Pass transistor logic, transmission gates, Dynamic logic (pseudo-NMOS logic, XOR/XNOR, multiplexers, half and full adders)	9
Module-III	**Sequential Logic Design and Advanced Dynamic Logic** Static and dynamic latches, flip-flops, and registers, CMOS Schmitt trigger, Monostable and astable circuits, Clocked CMOS (C2MOS), domino logic, NORA, TSPC, Advanced dynamic logic techniques and sequential circuit optimization	9
Module-IV	**Clocking, Memory, and Logical Effort** Clock distribution techniques and schemes in VLSI, Memory design fundamentals: ROM and RAM cells, Energy-efficient and	9

	adiabatic logic circuits, Logical effort concepts (input capacitance, logical/electrical effort, parasitic delay), Delay analysis (single/multi-stage circuits, branch networks), Optimization for minimum delay and best number of stages	

Learning Resources:

Text Books:		
1.	Title	CMOS Digital Integrated Circuits: Analysis and Design
	Author	Sung-Mo Kang , Yusuf Leblebici
	Publisher	McGraw-Hill Higher Education; 41st edition (1 December 2002)
	Edition	2002
2.	Title	Digital system design- A design perspective.
	Author	Rabaey, Chandrakasan and Milokic.
	Publisher	Pearson education, India.
	Edition	
3.	Title	Principles of CMOS VLSI Design, A System Perspective,
	Author	Neil H.E.Weste and Kamran Eshraghian
	Publisher	Pearson Education, India
	Edition	
Reference Books:		
1.	Title	CMOS Circuit Design, Layout and simulation
	Author	J. Baker, D.E. Boyce.,
	Publisher	wiely
	Edition	2009
Other Suggested Readings:		

Course Title:	**WIRELESS NETWORKS**
Course Code:	**ECEM 527**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand architecture, challenges, and protocols in Ad Hoc and WSNs	Understand (Level II)
CO-2	Analyze network design principles, routing, and data dissemination in WSNs	Analyze (Level IV)
CO-3	Evaluate MAC layer protocols and standards for WSNs and mobile nodes	Evaluate (Level V)
CO-4	Design and apply energy-efficient routing strategies and real-world WSN applications	Apply (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	1	1	2	2
CO-2	3	3	3	3	2	1	3	2
CO-3	3	3	3	3	3	2	3	3
CO-4	3	3	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Introduction to Ad Hoc and Wireless Sensor Networks** Introduction to Cellular and Ad Hoc Wireless Networks, Applications and issues in Ad Hoc Wireless Networks, Medium access schemes, routing, multicasting, Transport protocols, pricing schemes, Quality of service, self-organization, security, Addressing, service discovery, scalability, and deployment, Energy management and Ad Hoc Wireless Internet, Introduction and challenges in Wireless Sensor Networks (WSNs), Comparison with Ad Hoc networks, Applications of WSNs, enabling technologies, Single node architecture and energy consumption	9
Module-II	**Sensor Network Architecture and Design Principles** Issues in multicast routing for WSNs, Sensor network scenarios and requirements, Data dissemination techniques: Flooding and Gossiping, Data gathering strategies, Optimization goals and design principles, Gateway concepts and WSN–Internet communication, Tunneling techniques: WSN to Internet and vice versa	9
Module-III	**MAC Protocols and Standards in WSNs** MAC protocols for sensor networks, Location discovery and quality of service in WSNs, Low duty cycle concepts, wake-up mechanisms, The IEEE 802.15.4 MAC protocol, Energy efficiency considerations, Geographic routing basics for mobile nodes, Overview of evolving standards and remaining issues	9

Module-IV	**Routing Protocols and Applications in WSNs** Routing protocols: gossiping and agent-based forwarding, Unicast, broadcast, and multicast routing, Energy-efficient routing methods, Geographic routing with mobile nodes, Security concerns in WSNs, Application-specific support (Target detection and tracking, Contour/edge detection, Field sampling techniques)	9

Learning Resources:

Text Books:		
1.	Title	Protocols and Architectures for Wireless Sensor Networks
	Author	Holger Karl and Andreas Willig
	Publisher	John Wiley & Sons Limited
	Edition	2008.
2.	Title	Sensor Technology hand book
	Author	Wilson
	Publisher	Elsevier publications
	Edition	2005.
Reference Books:		
Other Suggested Readings:		

Course Title:	**DIGITAL IC DESIGN**
Course Code:	**ECEM 529**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand design strategies for custom, semi-custom, and IP-based digital ICs	Understand (Level II)
CO-2	Analyze interconnect effects and timing issues in synchronous and asynchronous systems	Analyze (Level IV)
CO-3	Design efficient arithmetic circuits such as adders, multipliers, and shifters	Apply (Level III)
CO-4	Evaluate memory architectures and peripheral circuit design in digital ICs	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	2	1	1	3	2
CO-2	3	3	3	3	2	1	3	3
CO-3	3	3	3	2	2	2	3	3
CO-4	3	3	3	3	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Implementation Strategies for Digital ICs** Overview of digital IC design approaches, From custom to semi-custom and structured array designs, Cell-based design methodology: standard, compiled, macro, mega cells, Intellectual Property (IP) cores, Semi-custom design flow, Array-based implementation approaches: mask-programmable arrays, prewired arrays, Implementation platforms of the future	9
Module-II	**Interconnects and Timing in Digital Circuits** Interconnect parasitic: capacitive and resistive, Cross talk, RC delay, ohmic voltage drop, electromigration, Timing in digital circuits (classification and types of interconnects), Synchronous, mesochronous, plesiochronous, asynchronous interconnects, Clock skew and jitter, clock distribution methods, Synchronizers and arbiters (design and implementation), Clock synthesis and synchronization using PLLs	9
Module-III	**Arithmetic Building Blocks Design** Design of adders (definitions, logic and circuit design), Full datapath in digital processors, Multipliers (partial product generation, accumulation, final addition), Shifters (barrel shifters and logarithmic shifters), Design trade-offs in arithmetic circuits,	9
Module-IV	**Memory and Array Structures** Memory types and architectures, ROM, RAM, non-volatile memory, CAM, Memory core and peripheral circuitry, Address	9

	decoders, sense amplifiers, voltage references, Drivers, buffers, timing and control circuits in memory	

Learning Resources:

Text Books:		
1.	Title	Fundamentals of Digital image Processing
	Author	Anil Jain.K
	Publisher	Prentice Hall of India
	Edition	1989.
2.	Title	Digital Integrated Circuits
	Author	Jan M. Rabaey,
	Publisher	Pearson Education
	Edition	2003
Reference Books:		
Other Suggested Readings:		

Course Title:	**ADVANCED MICROWAVE DEVICES**
Course Code:	**ECEM 530**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the structure, properties, and applications of waveguides and microwave components	Understand (Level II)
CO-2	Analyze and differentiate working principles of microwave tubes and solid-state microwave devices	Analyze (Level IV)
CO-3	Demonstrate the ability to measure microwave parameters using appropriate equipment	Apply (Level III)
CO-4	Evaluate radar system performance and interpret radar range and detection parameters	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	2	2	1	3	2
CO-2	3	3	3	3	2	2	3	3
CO-3	3	3	3	3	3	2	3	3
CO-4	3	2	3	3	3	3	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Waveguides and Microwave Components** Introduction to microwaves (definition, frequency bands, applications), Waveguides (advantages, comparison with coaxial cables), Rectangular waveguides (modes, cut-off frequency, dominant mode, parameters), Excitation and coupling methods (probe, slot, loop, re-entrant cavities), Microwave components (S-parameters, multi-port networks), Waveguide Tees (E, H, EH-plane), directional couplers, waveguide joints, bends, corners, Ferrite devices (circulators, isolators), Coaxial to waveguide transitions, matched terminations, tuners, slotted lines	9
Module-II	**Microwave Tubes and Solid-State Devices** Limitations of conventional tubes, Klystrons (multicavity, reflex, velocity modulation, bunching, applications), TWT (slow-wave structure, gain, wave modes, operation, Magnetron (construction, principle, analytical treatment), Microwave transistors, MOSFETs, PIN diodes, tunnel diodes, Schottky barrier diodes, Gunn diode, IMPATT, TRAPATT, Applications in amplifiers, oscillators, modulators, detectors	9
Module-III	**Microwave Measurements** Introduction to measurements, Techniques for measuring (Frequency, power, attenuation, VSWR, impedance, insertion loss, Phase shift, dielectric constant, noise factor, Q-factor), Use of X-band microwave bench, Network analyzers (block diagram,	9

	types, and applications), Overview of power meter, dB meter, VSWR meter	
Module-IV	**Radar Communication Systems** Fundamentals of radar (block diagram, classification), Radar range equation, performance factors, noise effects, Pulsed radar systems (block diagram, scanning, antennas, displays), Moving target indication, beacons, CW and FM-CW Doppler radar, phased array radars, Radar applications (navigation, military, surveillance)	9

Learning Resources:

Text Books:		
1.	Title	Microwave Devices and Circuits
	Author	S.Y. Liao
	Publisher	Prentice Hall India
	Edition	
2.	Title	Microwave Engineering
	Author	David M. Pozar
	Publisher	John Willey & Sons
	Edition	
3.	Title	Microwave Engineering
	Author	David M. Pozar
	Publisher	John Willey & Sons
	Edition	
Reference Books:		
Other Suggested Readings:		

Course Title:	**INTRODUCTION TO PLASMONIC AND META MATERIALS**
Course Code:	**ECEM 531**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the fundamental principles of nanophotonics, plasmonics, and metamaterials	Understand (Level II)
CO-2	Analyze light–matter interaction and interpret optical behavior in various dielectric structures	Analyze (Level IV)
CO-3	Examine photonic crystal structures and identify band structure engineering techniques	Apply (Level III)
CO-4	Evaluate metamaterials, their properties, and fabrication techniques for novel photonic devices	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	1	1	3	2
CO-2	3	3	3	2	2	1	3	3
CO-3	3	3	3	3	2	2	3	3
CO-4	3	3	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Introduction to Nanophotonics and Electromagnetic Theory** Motivation, introduction to nanophotonics, plasmonics, and metamaterials, Overview of research trends in academia and industry, Electromagnetic theory of light, Electromagnetic properties of materials, Constitutive relations and material parameters, Electromagnetic waves in dielectric media, Polarization of light, reflection and refraction, Fresnel equations, absorption, dispersion, and scattering	9
Module-II	**Photonic Crystal Structures** Matrix theory of dielectric layered media, Fabry–Perot Etalon, Bragg Grating, 1D Photonic crystals: Bloch modes, dispersion relation, photonic band structure, 2D and 3D photonic crystals, real and reciprocal lattices, Bandgap engineering and devices based on photonic crystals, Emerging applications of photonic crystals	9
Module-III	**Metamaterials and Applications** Concept of metamaterials, Effective medium theories (Maxwell–Garnett, Bruggeman, anisotropic mixtures), Negative permittivity and permeability materials, Double-negative materials, perfect absorbers, Superlens, hyperbolic metamaterials, and hyperlens, Tunable metamaterial-based photonic devices, Applications in high-resolution imaging	9
Module-IV	**Nanofabrication and Characterization**	9

	Thin-film fabrication methods (evaporation, sputtering, pulsed laser deposition, CVD, atomic layer deposition), Epitaxy (metal-organic CVD, molecular beam epitaxy), Lithography (photolithography, non-optical methods, pattern transfer), Nanophotonic characterization (near-field microscopy and related techniques)	

Learning Resources:

Text Books:		
1	Title	Plasmonics: Fundamentals and Applications
	Author	S. Maier
	Publisher	Springer
	Edition	2007
2	Title	Fundamentals of Photonics
	Author	Joseph W. Haus
	Publisher	
	Edition	2016
3	Title	Optical Metamaterials: Fundamentals and Applications
	Author	W. Cai and V. Shalaev
	Publisher	Springer
	Edition	2010
Reference Books:		
Other Suggested Readings:		

Course Title:	OPTICAL, ELECTRONIC & PHOTONIC PROPERTIES OF NANOSTRUCTURES
Course Code:	ECEM 532
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the fundamental principles of nanophotonics, plasmonics, and metamaterials	Understand (Level II)
CO-2	Analyze light–matter interaction and interpret optical behavior in various dielectric structures	Analyze (Level IV)
CO-3	Examine photonic crystal structures and identify band structure engineering techniques	Apply (Level III)
CO-4	Evaluate metamaterials, their properties, and fabrication techniques for novel photonic devices	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	1	1	1	3	2
CO-2	3	3	3	2	2	1	3	3
CO-3	3	3	3	3	2	1	3	3
CO-4	3	3	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Optical properties of semiconductors, Band edge energy and band gap, Dependence on nanocrystalline size, Quantum dots and quantum confinement, Optical transitions, Absorption and interband transitions, Introduction to photonic crystals	9
Module-II	Fluorescence and luminescence in nanostructures, Photoluminescence and electroluminescence, Laser emission from quantum dots, Photo fragmentation and Coulomb explosion, Phonons in nanostructures, Luminescent quantum dots for biological labeling	9
Module-III	Energy bands and bandgaps in semiconductors, Fermi surfaces, Donor and acceptor levels, Deep traps, Excitons, Carrier mobility, Size-dependent effects, Conduction electrons and dimensionality, Fermi gas, Density of states, Semiconducting nanoparticles, Electronic structure of Copper and Silicon, FCC lattices, Brillouin zones, Alloying, Silicon band structure	9
Module-IV	Photonic crystals and photonic bandgaps, Defects in photonic crystals, Localization of light, Dispersion control, Slowing and storage of light, High-efficiency optical sources, Photonic crystal waveguides and fibers	9

Learning Resources:

Text Books:		
1	Title	Introduction to Nano Technology
	Author	Charles. P. Poole Jr& Frank J. Owens.
	Publisher	Wiley India Pvt. Ltd
	Edition	
2	Title	Solid State physics
	Author	Pillai
	Publisher	Wiley Eastern Ltd
	Edition	
3	Title	Introduction to solid state physics
	Author	Kittel.
	Publisher	John Wiley & sons (Asia) Pvt Ltd.
	Edition	7th edition
Reference Books:		
Other Suggested Readings:		

Course Title:	**COMPUTER VISION FOR SIGNAL PROCESSING**
Course Code:	**ECEM 533**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Learn fundamentals of computer vision and its applications	Remember (Level I)
CO-2	Understand the basic image processing operations to enhance, segment the images.	Understand (Level II)
CO-3	Analyzing and extraction of relevant features of the concerned domain problem.	Analyze (Level IV)
CO-4	Understand and apply the motion concepts and its relevance in real time applications	Applying (Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	1	1	3	2
CO-2	3	2	3	2	2	1	3	3
CO-3	3	3	3	3	3	2	3	3
CO-4	3	3	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Essential mathematical tools: Least squares, RANSAC, Eigen-analysis, PCA, SVD, clustering, gradient-based optimization methods, Image Formation: Geometric image formation, Photometric image formation - Camera Calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; Camera Projection Models – Orthographic, Affine, Perspective, Projective models. Geometry, Camera models, Epipolar geometry, Stratified reconstruction, Applications: large scale reconstruction, single-view metrology Camera calibration: camera models; intrinsic and extrinsic parameters; radial lens distortion; direct parameter calibration; camera parameters from projection matrices; orthographic, weak perspective, affine, and perspective camera models.	7
Module-II	Image Processing: Pixel transforms, color transforms, histogram processing, histogram equalization, filtering, convolution, Fourier transformation and its applications in sharpening, blurring and noise removal. Feature detection: edge detection, corner detection, line and curve detection, active contours, SIFT and HOG descriptors, shape context descriptors, Morphological operations	7
Module-III	Segmentation: Low-level segmentation, energy minimization and clustering based methods, semantic segmentation, Active contours,	7

	split & merge, watershed, region splitting, region merging, graph-based segmentation, mean shift and model finding, Normalized cut. Stereo disparity estimation, Optical flow (Lucas Kanade and Horn Schunk approaches, contemporary energy minimization methods). Motion representation: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation	
Module-IV	Features detection and tracking: Harris corner detector, KL tracking, SIFT, Overview of other contemporary descriptors. Motion representation: the motion field of rigid objects; motion parallax; optical flow, the image brightness constancy equation, affine flow; differential techniques; feature-based techniques; regularization and robust estimation. Motion tracking: statistical filtering; iterated estimation; observability and linear systems; the Kalman filter. Object recognition and shape representation: alignment, appearance-based methods, invariants, image eigenspaces.	7

Learning Resources:

Text Books:		
1.	Title	Computer vision – A modern approach
	Author	D. Forsyth and J. Ponce
	Publisher	Pearson,
	Edition	Second edition, 2012.
2.	Title	Computer Vision: Algorithms and Applications
	Author	R. Szeliski
	Publisher	Springer,
	Edition	2011.
Reference Books:		
1.	Title	Computer vision – Models, learning and inference
	Author	S. Prince
	Publisher	Cambridge univ. press,
	Edition	2012.
Other Suggested Readings:		

Course Title:	**DEEP LEARNING AND AI FOR SIGNAL PROCESSING**
Course Code:	**ECEM 534**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the modern CNN-based architectures.	Understand (Level II)
CO-2	Describe relative merits of various deep learning architectures	Apply (Level III)
CO-3	Applying deep learning model in distinct applications.	Analyze (Level IV)
CO-4	Understand advanced deep learning model and its applications	Evaluate (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	3	3	2	1	3	2
CO-2	3	3	3	2	3	1	3	3
CO-3	3	3	3	3	3	2	3	3
CO-4	3	3	3	3	3	2	3	3

1 - Slightly; 2 - Moderately; 3 – Substantially

Syllabus:

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Deep feedforward neural networks (DFNNs), Optimization methods: Generalized delta rule, AdaGrad, RMSProp, Adadelta, AdaM, Second order methods; Regularization methods: Dropout, Dropconnect; Batch normalization. Autoencoders: Auto associative neural network, stacked autoencoder, Greedy layer-wise training, Pre-training of a DFNN using a stacked autoencoder, Fine tuning a DFNN, Regularization in autoencoders, Denoising autoencoder, Variational autoencoder	9
Module-II	CNN: Basic CNN architecture, Rectilinear Unit (ReLU), 2-D Deep CNNs: LeNet, AlexNet, VGGNet, GoogLeNet, ResNet; Image classification using 2-D CNNs; 3-D CNN for video classification; 1-D CNN for text and audio processing; Vector of Linearly Aggregated Descriptors (VLAD) method for aggregation – NetVLAD. Recurrent neural networks (RNNs): Architecture of an RNN, Unfolding an RNN, Backpropagation through time, Vanishing and exploding gradient problems in RNNs, Long short term memory (LSTM) units, Gated recurrent units, Bidirectional RNNs, Deep RNNs.	9
Module-III	Encoder-decoder paradigm, Image and video captioning models, Machine translation, Text processing models, Representation of words: Word2Vec, GloVe. Transformer models: Attention based models, Scaled dot product attention, Multi-head attention (MHA), Self-attention MHA, Cross-attention MHA, Position encoding, Encoder and Decoder modules in a transformer, Sequence to sequence mapping using transformer, Machine translation using	9

	transformer model, Vision transformer for image classification, Video captioning using transformer model, Bidirectional encoder representations from transformers (BERT) model for text processing, Pre-training a BERT model, Fine tuning a BERT model for text processing tasks, Vision-and-Language BERT (ViLBERT) for image and video processing tasks, Text and Visual question answering and reasoning using transformer models.	
Module-IV	Generative adversarial networks (GANs): mage generation models, Architecture and training of a GAN, Deep convolutional GAN, Cyclic GAN, Conditional GAN, Super-resolution GAN, Applications of GANs for image processing. Reinforcement Learning: Introduction to reinforcement learning, Markov decision processes, Policy gradients, Temporal difference learning, Q-learning, Deep reinforcement learning - Deep policy gradient, Deep Q learning; Text processing using deep reinforcement learning - Text classification, Text summarization.	9

Learning Resources:

Text Books:		
1.	Title	Deep learning for AI
	Author	Ian Goodfellow and Yoshua Bengio and Aaron Courville
	Publisher	MIT Press
	Edition	2016
2.	Title	Dive into Deep Learning
	Author	Aston Zhang, Zachary C. Lipton, Mu Li, Alexander J. Smola
	Publisher	Cambridge Univ Press
	Edition	2023
Reference Books:		
1.	Title	Understanding Deep Learning
	Author	Simon J. D. Prince
	Publisher	MIT Press
	Edition	2023
Other Suggested Readings:		

Course Title:	**DEEP LEARNING FOR IMAGING**
Course Code:	**ECEM 535**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Explain wireless channel propagation phenomena, fading models, and link power budget analysis for understanding signal behavior in different environments.	Understand (Level II)
CO-2	Analyze diversity techniques for enhancing the performance of wireless communication systems in the presence of fading and interference.	Analyze (Level IV)
CO-3	Evaluate MIMO system architectures, including capacity, diversity gain, and space-time coding techniques, to improve system reliability and efficiency.	Evaluate (Level V)
CO-4	Examine the evolution of wireless networks, including 3G, 4G, and IEEE 802.11 WLANs, with a focus on their architecture, air interfaces, and key technologies.	Analyze (Level IV)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	2	1	3	2
CO-2	2	3	3	3	2	1	3	3
CO-3	3	3	3	3	3	2	3	3
CO-4	2	2	2	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Wireless channel propagation and model, Propagation of EM signals in wireless channel – Reflection, diffraction and Scattering-Small scale fading- channel classification- channel models – COST -231 Hata model, Longley-Rice Model, NLOS Multipath Fading Models: Rayleigh, Rician, Nakagami, Composite Fading –shadowing Distributions, Link power budget Analysis.	7
Module-II	Diversity, Capacity of flat and frequency selective fading channels-Realization of independent fading paths, Receiver Diversity: selection combining, Threshold Combining, Maximum-ratio Combining, Equal gain combining. Transmitter Diversity: Channel known at transmitter, channel unknown at the transmitter.	7
Module-III	MIMO communications, Narrowband MIMO model, Parallel decomposition of the MIMO channel, MIMO channel capacity, MIMO Diversity Gain: Beam forming, Diversity-Multiplexing trade-offs, Space time Modulation and coding: STBC, STTC, Spatial Multiplexing and BLAST Architectures.	7

Module-IV	Wireless Networks: 3G Overview, Migration path to UMTS, UMTS Basics, Air Interface, 3GPP Network Architecture, 4G features and challenges, Technology path, IMS Architecture - Introduction to wireless LANs – IEEE 802.11 WLANs - Physical Layer- MAC sublayer.	7

Learning Resources:

Text Books:		
1.	Title	Wireless Communications, , 2007
	Author	Andrea Goldsmith,
	Publisher	Cambridge University Press
	Edition	Cambridge University Press
2.	Title	Fixed Broadband Wireless System Design
	Author	HARRY R. ANDERSON
	Publisher	John Wiley – India
	Edition	2003
3.	Title	Wireless Communications
	Author	Andreas.F. Molisch
	Publisher	John Wiley – India
	Edition	2006
Reference Books:		
1.	Title	Modern Wireless Communications
	Author	Simon Haykin& Michael Moher
	Publisher	Pearson Education
	Edition	2007
Other Suggested Readings:		

Course Title:	**TESTING AND VERIFICATION OF VLSI CIRCUITS**
Course Code:	**ECEM 570**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the scope, challenges and need for testing and verification in modern VLSI design	Understand (Level II)
CO-2	Apply fault models and automatic test generation techniques to develop testable VLSI circuits,	Apply (Level III)
CO-3	Analyze various system and SoC testing methods including BIST and test automation	Analyze (Level IV)
CO-4	Evaluate verification techniques such as simulation, formal methods and hardware emulation	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	1	1	2	1	3	2
CO-2	2	3	3	2	3	1	3	3
CO-3	2	3	3	2	2	2	3	3
CO-4	2	2	2	3	3	2	2	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Syllabus:		
Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction to Testing and Verification,Scope of testing and verification in VLSI design process; Issues in test and verification of complex chips, embedded cores and SOCs	9
Module-II	VLSI Testing and Fault Modeling, Fundamentals of VLSI testing; Fault models; Automatic test pattern generation (ATPG); Design for testability; Scan design; Test interface and boundary scan	9
Module-III	System and SoC Testing, Iddq testing; Delay fault testing; Built-In Self Test (BIST) for logic and memories; System testing and test for SOCs; Test automation	9
Module-IV	Verification Techniques, Design verification based on simulation, analytical, and formal methods; Functional and timing verification; Basics of equivalence checking and model checking; Hardware emulation	9

Learning Resources:

Text Books:		
1.	Title	Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers
	Author	M. Bushnell and V. D. Agrawal
	Publisher	M. Bushnell and V. D. Agrawal
	Edition	2000
2.	Title	Digital Systems Testing and Testable Design
	Author	M. Abramovici, M. A. Breuer and A. D. Friedman
	Publisher	IEEE Press
	Edition	1990
3.	Title	Introduction to Formal Hardware Verification
	Author	T. Kropf
	Publisher	Springer Verlag
	Edition	2000
Reference Books:		
Other Suggested Readings:		

Course Title:	NANO MAGNETICS AND SPINTRONICS
Course Code:	ECEM 571
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the fundamental concepts of magnetism at the nanoscale and quantum mechanics in spin-based devices	Understand (Level II)
CO-2	Analyze magnetic phenomena such as exchange interaction, magnetic anisotropy, and domain wall dynamics in nanostructures.	(Analyze Level IV)
CO-3	Evaluate materials and structures used in spintronic devices like GMR, TMR, spin valves, and magnetic tunnel junctions.	(Evaluate Level V)
CO-4	Apply spintronic principles in the design of logic, memory, and sensing applications in nanoscale electronics.	(Apply Level III)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	1	-	-	2	2
CO-2	3	3	2	2	1	-	3	2
CO-3	2	3	3	2	1	1	3	3
CO-4	2	3	2	3	2	1	3	2

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction to spin, quantum mechanics of spin, spin-orbit interaction, spins and magnetism in confined structures, spin relaxation, passive Spintronic devices.	12
Module-II	Spin valve, magnetic tunnel junctions (MTJ), spin transfer torque based MTJ, micromagnetics, Magnetic RAM (MRAM) technology.	12
Module-III	Active Spintronics devices: spin transistors, advanced topics: spin currents, magneto-optic effects, spin caloritronic devices, spin-Hall devices, all spin logic and spin based quantum computing.	12

Learning Resources:

Text Books:	1. Introduction to spintronics, S. Bandyopadhyay and M. Cahay, CRC Press, 2008. 2. Spin Current, Ed. S. Maekawaet. al., Oxford Science Publications, 2011. 3. Nanomagnetism and spintronics, Ed. T. Shinjo, Elsevier.
Other Suggested Readings:	

Course Title:	COMPUTER AIDED DESIGN OF VLSI CIRCUITS
Course Code:	ECEM 572
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand VLSI design methodologies, fabrication processes, and their influence on physical design.	Understand (Level II)
CO-2	Apply algorithmic graph theory and data structures to design automation tools in VLSI.	Apply (Level III)
CO-3	Analyze general-purpose combinatorial optimization methods for floorplanning, placement, and routing in VLSI CAD.	Analyze (Level IV)
CO-4	Evaluate logic synthesis, high-level synthesis, and layout compaction techniques used in modern chip design.	Evaluate (Level V)
CO-5	Implement simple VLSI designs using physical design automation for FPGA and VHDL-based systems.	Apply (Level III)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	2	2	1	3	3
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3
CO-5	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Design Methodologies Introduction to VLSI Methodologies – VLSI Physical Design Automation - Design and Fabrication of VLSI Devices - Fabrication process and its impact on Physical Design.	8
Module-II	Introduction to Graph Theory and Computational Complexity A Quick Tour of VLSI Design Automation Tools - Data structures and Basic Algorithms - Algorithmic Graph theory and computational complexity - Tractable and Intractable problems	8
Module-III	General Purpose Methods for Combinatorial Optimization General purpose methods for combinational optimization — Circuit representation -Wire length estimation - Placement algorithms - Partitioning algorithms -Floor planning floor planning concepts - Shape functions and floor planning sizing - Pin assignment - Routing - Local routing - Area routing -Channel routing - global routing and its algorithms.	6
Module IV	VLSI Simulation, Logic Synthesis and Verification Simulation-logic synthesis - gate level and switch level	8

	modeling and simulation - Introduction to combinational logic synthesis - ROBDD principles, implementation, construction and manipulation -Two level logic synthesis - High-level synthesis- hardware model for high level synthesis - Internal representation of input algorithms - Allocation, assignment and scheduling - Scheduling algorithms— Aspects of assignment - High level transformations - Verification-High level synthesis = Layout Compaction - Design rules - symbolic layout - Applications of compaction - Formulation methods - Algorithms for constrained graph compaction.	
Module V	Physical Design of FPGA and VHDL Implementation Physical Design Automation of FPGAs, MCIV1S-VHDL-Implementation of Simple circuits using VHDL	6

Learning Resources:

Text Books:	1. Algorithms for VLSI Physical Design Automation, NI .A. Sherwani, Kluwer Academic Publisher, 2007. 2. Algorithms for VLSI Design Automation, S. H. Gerez., John Wiley & Sons, 2007.
Other Suggested Readings:	

Course Title:	ARTIFICIAL NEURAL NETWORKS
Course Code:	ECEM 573
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the structure and functioning of biological and artificial neurons, and foundational concepts of neural networks.	Understand (Level II)
CO-2	Apply supervised learning algorithms, including perceptron's, multilayer networks, and backpropagation, to real-world problems.	Apply (Level III)
CO-3	Analyze unsupervised learning architectures and self-organizing maps used in clustering and feature extraction.	Analyze (Level IV)
CO-4	Evaluate associative neural models and global optimization methods like Hopfield networks and genetic algorithms.	Evaluate, (Level V)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	3	2	1	3	3
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction: Biological neurons and memory: Structure and function of a single neuron; Artificial Neural Networks (ANN); Typical applications of ANNs: Classification, Clustering, Vector Quantization, Pattern Recognition, Function Approximation, Forecasting, Control, Optimization; Basic Approach of the working of ANN - Training, Learning and Generalization.	10
Module-II	Supervised Learning: Single-layer networks; Perceptron-Linear separability, Training algorithm, Limitations; Multi-layer networks-Architecture, Back Propagation Algorithm (BTA) and other training algorithms, Applications. Adaptive Multi-layer networks-Architecture, training algorithms; Recurrent Networks; Feed-forward networks; Radial-Basis-Function (RBF) networks.	10
Module-III	Unsupervised Learning: Winner-takes-all networks; Hamming networks; Maxnet; Simple competitive learning;	8

	Vector-Quantization; Counter propagation networks; Adaptive Resonance Theory; Kohonen's Self- organizing Maps; Principal Component Analysis.	
Module IV	Associated Models: Hopfield Networks, Brain-in-a-Box network; Boltzmann machine.; Optimization Methods: Hopfield Networks for-TSP, Solution of simultaneous linear equations; Iterated Gradient Descent; Simulate, Annealing; Genetic Algorithm.	8

Learning Resources:

Text Books:	1. Elements of Artificial Neural Networks, K. Mehrotra, C.K. Mohan and Sanjay Ranka, MIT Press, 1997 - [Indian Reprint Penram International Publishing (India), 1997. 2. Neural Networks - A Comprehensive Foundation, Simon Haykin., Macmillan Publishing Co., New York, 1994. 3. Neural Networks for Optimization and Signal Processing, ACichocki and R. Unbehauen, John Wiley and Sons, 1993.
Other Suggested Readings:	

Course Title:	COMPUTATIONAL ELECTROMAGNETICS
Course Code:	ECEM 574
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the fundamentals of computational electromagnetics and numerical ODE solvers like Euler and Runge-Kutta..	Understand (Level II)
CO-2	Analyze various electromagnetic structures and apply numerical techniques such as MoM, FEM, FDTD	Analyze (Level IV)
CO-3	Apply FDTD and wavelet-based multi-resolution methods for time-varying field simulations and MEMS applications.	Apply (Level III)
CO-4	Evaluate complex systems like MMICs, antennas, optics, and memory devices under electromagnetic radiation.	Evaluate (Level V)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	2	1	1	3	3
CO-3	2	3	2	3	2	-	3	3
CO-4	2	3	3	2	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	**Introduction.** Applications of Electromagnetics in the 21st century. Historical development of Computational Methods. Numerical Methods. ODE solvers. Euler. Runge – Kutta method, Boundary conditions. Propagation of errors. Survey of numerical packages. Scientific programming with Python and Matlab.	8
Module-II	Review of Basic Electromagnetics Electrostatics. Magnetostatics. Wave equations. TE, TM and Hybrid modes. Guided wave structures Metallic waveguides. Dielectric waveguides. Radiating structures. Numerical Techniques. Method of Curvilinear Squares. Method of Moments. Finite Element Method. Finite Difference Method. Monte Carlo Method. Understanding boundary conditions.	12
Module-III	Time-varying Electromagnetic Fields. FDTD simulations with the Yee cell. Courant's stability condition. Eddy currents and skin depth. Multi-resolution Time Domain Methods. Introduction to wavelets. Families of wavelets and	8

	orthogonality conditions. Motors. Micro Electro Mechanical Systems. Ferro-fluids. Electromagnetic Acoustic Transducer. Effects of stress in an optical waveguide.	
Module IV	Microwaves. Waveguides. MMICs. Antennas. Scattering Optics. Fiber optics. Integrated optics. Plasmonic. Micro magnetics. Hysteresis. Non-volatile memory, Spin waves Effects of EM radiation.	8

Learning Resources:

Text Books:	1. Fundamentals of Electromagnetics with MATLAB 2e Karl E. Lonngren, Sava V. Savov, Randy J, Jost, SciTech Publishing, Inc., 2007. 2. Wavelets in Electromagnetics and Device Modeling, George W.Pan Wiley. 3. Numerical Methods in Engineering with Python JaanKiusalaas, Cambridge, Fundamentals of Electromagnetics with MATLAB
Other Suggested Readings:	

Course Title:	WAVELETS
Course Code:	ECEM 575
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the fundamental concepts of time-frequency analysis and wavelet theory including STFT and Wigner-Ville.	Understand (Level II)
CO-2	Analyze continuous and discrete wavelet transforms, and their role in time-frequency tiling and signal decomposition.	Analyze (Level IV)
CO-3	Apply multiresolution analysis, biorthogonal wavelets, and multirate signal processing for signal transformation.	Apply (Level III)
CO-4	Evaluate wavelet-based techniques in applications like denoising, compression, transient detection, and communication.	Evaluate (Level V)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	1	1	-	2	2
CO-2	3	3	3	2	1	-	3	2
CO-3	2	3	2	3	1	-	3	3
CO-4	2	3	3	2	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction to time frequency analysis; the how, what, and why about wavelets. Short-time Fourier transform, Wigner-Ville transforms.	9
Module-II	Continuous time wavelet transforms, Discrete wavelet transform, tiling of the time-frequency plane and wave packet analysis.	9
Module-III	Construction of wavelets. Multiresolution analysis. Introduction to frames and biorthogonal wavelets. Multirate signal processing and filter bank theory.	9
Module IV	Application of wavelet theory to signal denoising, image and video compression, multi-tone digital communication, transient detection.	9

Learning Resources:

Text Books:	1. Wavelet Basics, Y.T. Chan, Kluwer Publishers, Boston, 1993. 2. Ten Lectures on Wavelets, Society for Industrial and Applied Mathematics, Daubechies, Philadelphia, PA 1992. 3. An Introduction to Wavelets, C. K. Chui, Academic Press Inc., New York, 1992.
Reference Books:	1. A Friendly Guide to Wavelets, Gerald Kaiser, Birkhauser, New York, 1995. 2. Multirate Systems and Filter Banks, P. P. Vaidyanathan, Prentice Hall, New Jersey
Other Suggested Readings:	

Course Title:	**MICROELECTRONICS CHIP DESIGN**
Course Code:	**ECEM 576**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand RF and wireless technology fundamentals, including nonlinearity, noise, sensitivity, and design trade-offs.	Understand (Level II)
CO-2	Analyze RF modulation techniques, transceiver architectures, and mobile communication systems.	Analyze (Level IV)
CO-3	Model and evaluate high-frequency behavior of BJT/MOSFET devices and parasitic effects in RF circuits.	Evaluate (Level V)
CO-4	Design and implement core RF building blocks including LNAs, mixers, oscillators, VCOs, and quadrature generators.	Apply (Level III)
CO-5	Design RF synthesizers, PAs, filters, and explore CAD tools used in RF VLSI design.	Apply (Level III)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	1	1	-	2	2
CO-2	3	3	2	2	1	-	3	2
CO-3	2	3	3	2	1	1	3	3
CO-4	2	3	3	3	2	1	3	3
CO-5	2	3	3	2	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction to RF and Wireless Technology: Complexity, design and applications. Choice of Technology. Basic concepts in RF Design: Nonlinearly and Time Variance, inter-symbol Interference, random processes and Noise. Definitions of sensitivity and dynamic range, conversion Gains and Distortion.	7
Module-II	Analog and Digital Modulation for RF circuits: Comparison of various techniques for power efficiency. Coherent and Non coherent defection. Mobile RF Communication systems and basics of Multiple Access techniques. Receiver and Transmitter Architectures and Testing heterodyne, Homodyne, Image-reject, Direct-IF and sub- sampled receivers. Direct Conversion and two steps transmitters.	8
Module-III	BJT and MOSFET behavior at RF frequencies Modeling of the	6

	transistors and SPICE models. Noise performance and limitation of devices. Integrated Parasitic elements at high frequencies and their monolithic implementation.	
Module IV	Basic blocks in RF systems and their VLSI implementation: Low Noise Amplifiers design in various technologies, Design of Mixers at GHz frequency range. Various Mixers, their working and implementations, Oscillators: Basic topologies VCO and definition of phase noise. Noise-Power trade-off. Resonator less VCO design. Quadrature and single-sideband generators.	8
Module V	Radio Frequency Synthesizes: PLLS, Various RF synthesizer architectures and frequency dividers, Power Amplifiers design. Linearization techniques, Design issues in integrated RF filters. Some discussion on available CAD tools for RF VLSI designs.	7

Learning Resources:

Text Books:	1. CMOS Circuit Design, Layout and Simulation, R.JacobBaker, H.W.Li Prentice-Hall of India,1998. 2. Mixed Analog and Digital VLSI Devices and Technology, Y.P. Tsividis McGraw Hill,1996.
Other Suggested Readings:	

Course Title:	**TELEMATICS**
Course Code:	**ECEM 577**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the fundamentals of telephony systems, signaling, ISDN, BISDN, and ATM technologies.	Understand (Level II)
CO-2	Analyze different circuit switching mechanisms including Clos networks, crossbar switches, and blocking analysis.	Analyze (Level IV)
CO-3	Evaluate switch architectures and routing techniques in high-speed networks such as Banyan, Knockout, and self-routing.	Evaluate (Level V)
CO-4	Apply traffic models and dynamic routing techniques to optimize performance in circuit-switched and packet-switched networks.	Apply (Level III)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	1	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basics of Telephony: Telephone Network overview; Subscriber Loop; Signaling in the Telephone Network; Overview of ISDN, BISDN and ATM Technologies.	9
Module-II	Circuit Switching in Telephone Networks: Crossbar switch; Clos networks; Clos and Slepian-Duguid theorems; Recursive construction of Clos Networks; Time switching, TMS and TST switches; Lee and Jacobeus blocking analysis.	9
Module-III	Routing in R-NB network; Switch processor, Call processing and overload control; Example telephone switches.; Cell Switching: Generic Switch; Input and output queued switches; Shared memory and Shared medium switches, Crossbar switch, Complexity and scaling disadvantage of output queued switches, Knockout principle; Interconnections for large switches, Self-routing architectures, Batcher-banyan networks; Un buffered banyan switches, Buffered banyan, Tandem banyan, Speedup, Parallelism and Channel grouping toenhance	9

	input queued switches; Concentrators super concentrators and Copy networks,	
Module IV	Examples of ATM switches, IP Switching from VC based fixed length packet switches.; Multiplexing and Routing in Circuit Switched Networks: Abstract System Models Erlang Blocking Models; Overflow Models, Equivalent Random Theory, Haywards Approxmn and Introductory Non-Poisson Arrival Processes; Product form solution; Erlang Fixed Point Solution; Techniques to choose good routes; Alternate Routing; Dynamic Routing, Least Busy Alternate Routing.	9

Learning Resources:

Text Books:	1. Switching and Traffic Theory for Integrated Broadband Networks, Joseph Y. Hui, Kluwer Academic Publishers,1990. 2. Mathematical Theory of Connecting Networks and Telephone Traffic, V.E. Benes, Academic Press, 1965.
Other Suggested Readings:	

Course Title:	**FREE SPACE OPTICAL NETWORKS**
Course Code:	**ECEM 578**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand light propagation in unguided media and analyze atmospheric effects, LIDAR, and coding techniques.	Understand (Level II)
CO-2	Analyze and design FSO transceivers, including optical sources, detectors, amplifiers, and optical tracking systems	Analyze (Level IV)
CO-3	Evaluate topologies and performance of Point-to-Point, Ring, and hybrid FSO systems.	Evaluate (Level V)
CO-4	Apply WDM and mesh-based FSO networking principles for resilient, high-capacity communication networks.	Apply, (Level III)
CO-5	Understand and evaluate FSO-specific security issues and explore real-world applications like disaster-area connectivity.	Evaluate (Level V)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	1	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	2	2	1	3	3
CO-5	2	2	3	2	2	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Introduction: Propagation of light in unguided media - laser beam characteristics - atmospheric effects on optical signals - coding for atmospheric optical propagation - LIDAR.	7
Module-II	FSO Transceiver Design, Light Sources: Modulators - photo detectors and receivers-optical amplification - optical signal to noise ratio - acquisition, pointing and tracking - adaptive and active optics - laser safety - node housing and mounting.	7
Module-III	Point to Point FSO Systems, Simple PtP Design: Transponder nodes - hybrid FSO and RF - FSO point to multipoint - FSO point to mobile; Ring FSO Systems: Ring topologies and service protection - ring nodes with add drop - concatenated rings - ring to network connectivity.	8
Module IV	Mesh FSO Systems, FSO Nodes for Mesh Topology: Hybrid mesh	8

	FSO with RF - hybrid FSO fiber networks; WDM Mesh FSO: DWDM and CWDM optical channels - WDM FSO links - WDM mesh FSO networks - service protection in mesh FSO networks.	
Module V	FSO Network Security and Applications, Cryptography: Security levels - security layers - FSO inherent security features; FSO Specific Applications: FSO networks for highway assisted communications - mesh FSO in disaster areas - visual light communication.	6

Learning Resources:

Text Books:	1. Free Space Optical Networks for Ultra-Broad Band Services, Stamatios V. Kartalopoulos, IEEE Press 2011. 2. Free-Space Optics: Propagation and Communication, Olivier Bouchet, HerveSizun, Christian Boisrobert and Frederique De Fornel, John Wiley and Sons, 2010.
Other Suggested Readings:	

Course Title:	**SEMICONDUCTOR OPTOELECTRONICS**
Course Code:	**ECEM 579**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand optical processes in semiconductors, including absorption, recombination, quantum effects, and time-resolved emission.	Understand (Level II)
CO-2	Analyze the growth techniques and fabrication processes of optoelectronic thin films and heterostructures.	Analyze (Level IV)
CO-3	Evaluate the charge transport mechanisms and material characteristics in organic semiconductors.	Evaluate (Level V)
CO-4	Apply principles of organic optoelectronic devices such as OLEDs and OPVDs for light emission and solar energy conversion.	Apply (Level III)
CO-5	Apply numerical methods and transport models for simulating semiconductor device characteristics.	Apply (Level III)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	2	2	1	3	3
CO-5	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Optical process in Semiconductors Electron hole pair formation and recombination, absorption in semiconductor, effect of electric field on Absorption, Franz-keldysh and stark effects, Absorption in Quantum wells and Quantum confined stark effect, relation between Absorption and emission spectra, Stokes shift in optical transition, Deep level transitions, Measurement of absorption and luminescence Spectra, Time resolved Photoluminescence	8
Module-II	Materials Growth & Fabrication Growth of optoelectronics materials by MBE, MOCVD, Plasma CVD, photochemical deposition. Epitaxy, interfaces and junctions (advantages/disadvantages of growth methods on interface	8

	quality, interdiffusion and doping. Quantum wells and band gap engineering Equipments for Thin Film Deposition: Working principle of Vacuum Coating Unit, Spin Coating Unit and Spray pyrolysis apparatus and their specifications and features.	
Module-III	Organic Electronics Molecular materials, Electronic state in conjugated molecules, Optical spectra of molecules, Electronic vibration transitions, the Franck Condon principle hydrocarbons, conjugated polymer, Organic Semiconductors: Conductivity and Mobility of nearly-fee Charge Carriers, Charge Carriers in Organic Semiconductors: Polarons, Shallow Traps and Deep Traps, Generation of Charge Carriers and Charge Transport: Experimental Methods. The TOF Method: Gaussian Transport. Space-Charge Limited Currents. Band or Hopping Conductivity, Electric-field Approved by joint Board of Studies in Electronics & Physics on 20th September 2013 Page 9 Dependence, Charge Transport in Disordered Organic Semiconductors. The Bassler Model.	8
Module IV	Organic Optoelectronic Devices: Organic Light-Emitting Diodes (OLEDs). The Principle of the OLED, Multilayer OLEDs. Structure, Fundamental processes Efficiency, Characterization of OLEDs Organic photovoltaic diodes (OPVDs): Fundamental process, Exciton absorption, Exciton dissociation, Charge collection characterization of OPVDs, Relevant performance parameters	6
Module V	Introduction to Semiconductor Device Simulation: Need of Simulation, Process Simulation, Device Simulation device simulation sequence, hierarchy of transport models, DD Model, Relationship between various transport regimes and significant length-scales. Numerical Solution Methods - finite difference scheme, discretization of Poisson's and current continuity equations.	6

Learning Resources:

Text Books:	1. Organic Electronics: Materials, Manufacturing, and Applications, Hagen Klauk, Wiley-VCH, 1 edition. 2. Organic Molecular Solids Markus Schwoerer (Author), Wiley-VCH; Hans Christoph Wolf, 1 edition (March 27, 2007). 3. Semiconductor Devices Modeling and Technology, Nandita Das Gupta and Amitava Das Gupta, Prentice Hall of India Pvt. Ltd. Organic Electronics: Materials, Manufacturing, and Applications.
Reference Books:	1. Computational Electronics, DragicaVasileska and Stephen M. Goodnick, CRC Press. 2. Semiconductor Optoelectronics Devices: Pallab Bhattacharya, Pearson Education.
Other Suggested Readings:	

Course Title:	LOW POWER VLSI DESIGN
Course Code:	ECEM 580
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand sources of power dissipation in digital VLSI circuits and the impact of scaling, device, and technology.	Understand (Level II)
CO-2	Analyze simulation-based and probabilistic power analysis techniques, including entropy modeling and Monte Carlo simulations.	Analyze Level IV)
CO-3	Apply low-power design methods such as circuit/logic-level techniques, reorganization, encoding, and architectural strategies	Apply (Level III)
CO-4	Evaluate clock distribution techniques, low-power bus balancing, and SRAM-specific optimizations.	Evaluate (Level V)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	3	2	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction: Low-power VLSI chips are needed. Sources of power dissipation on Digital Integrated circuits. Emerging Low power approaches. Device& Technology Impact on Low Power: Dynamic dissipation in CMOS, Transistor sizing& gate oxide thickness, Impact of technology Scaling, Technology & Device innovation. Simulation Power analysis: SPICE circuit simulators, gate-level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis, Monte Carlo simulation.	12
Module-II	Probabilistic power analysis: Random logic signals, probability & frequency, probabilistic power analysis techniques, signal entropy. Low Power Circuit's: Transistor and gate sizing, network restructuring and Reorganization. Special Flip Flops & Latches design, high capacitance nodes, low power digital cells library.	8
Module-III	Logic level: Gate reorganization, signal gating, logic encoding, state machine encoding, pre-computation logic. Low power Architecture & Systems: Power & performance management,	8

	switching activity reduction, parallel architecture with voltage reduction, flow graph transformation, low power arithmetic components	
Module-IV	Low power Clock Distribution: Power dissipation in clock distribution, single driver Vs. distributed buffers, Zero skew Vs tolerable skew, Special Techniques: Power Reduction in Clock networks, CMOS Floating Node, Low Power Bus Delay balancing, and Low Power Techniques for SRAM.	8

Learning Resources:

Text Books:	1. Practical Low Power Digital VLSI Design, Gary K. Yeap, KAP 2002. 2. Low Power Design Methodologies, Rabey, Pedram, Kluwer Academic. 3. Low-Power CMOS VLSI Circuit Design, Kaushik Roy, Sharat Prasad, Wiley, 2000.
Reference Books:	1. Design of Low Power CMOS Circuits, Anantha Chandrakasan and Robert W. Brodersen, IEEE Press, 1998. 2. Research papers from IEEE Transactions on VLSI Systems and IEEE Solid-State Circuits on low power design.
Other Suggested Readings:	

Course Title:	**OFDM FOR WIRELESS COMMUNICATION**
Course Code:	**ECEM 581**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the fundamentals of OFDM systems, including subcarrier generation, guard intervals, and parameter selection.	Understand, (Level II)
CO-2	Analyze Peak-to-Average Power Ratio (PAPR) problems and evaluate various techniques for its reduction.	Analyze (Level IV)
CO-3	Apply synchronization methods to minimize timing and frequency domain impairments in OFDM systems.	Apply (Level III)
CO-4	Analyze adaptive modulation and multiuser OFDM systems for performance enhancement.	Analyze (Level IV)
CO-5	Evaluate MIMO-OFDM and space-time processing techniques for multiuser communication scenarios	Evaluate (Level V)

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CO-1	3	2	2	1	1	-	2	2
CO-2	3	3	3	2	1	-	3	2
CO-3	2	3	3	3	2	-	3	3
CO-4	2	3	3	3	2	1	3	3
CO-5	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	OFDM Principles, System Model: Generation of sub carrier using IFFT - guard time - cyclic extensions - windowing - choice of OFDM parameters - signal processing - OFDM bandwidth.	7
Module-II	PAPR Reduction Techniques, Peak to Average Power Ratio (PAPR): Peak power problem - distribution of PAPR - clipping and peak windowing - peak cancellation - PAPR reduction codes - symbol scrambling.	7
Module-III	OFDM Time and Frequency Domain Synchronization, System performance with frequency and timing errors; Synchronization algorithms - comparison of frequency acquisition algorithms - BER performance with frequency synchronization.	7
Module-IV	Adaptive Single and Multiuser OFDM Techniques, Adaptive Modulation for OFDM: Adaptive OFDM speech system - pre-equalization; Comparison of adaptive techniques - near optimum power and bit allocation in OFDM - multiuser AOFDM	7

Module-V	Multiuser OFDM Systems, Multiuser Systems: Maximum likelihood enhanced sphere decoding of MIMO OFDM - classification of smart antennas; Introduction to Space Time Processing: SDM OFDM system model - optimized hierarchy reduced search algorithm - aided SDM detection.	8

Learning Resources:

Text Books:	1. OFDM for Wireless Communication Systems, Ramjee Prasad, Artech House, 2004. 2. OFDM for Wireless Multimedia Communication, Richard D. J. Van Nee and Ramjee Prasad, Artech House, 1999
Other Suggested Readings:	

Course Title:	CARBON NANOTUBES AND CARBON NANO STRUCTURES
Course Code:	ECEM 582
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the structure and formation of carbon-based nanostructures, including fullerenes and carbon nanotubes (CNTs)	Understand (Level II)
CO-2	Analyze the morphological types of CNTs, including chiral, armchair, and zigzag configurations, and their structural principles	Analyze (Level IV)
CO-3	Evaluate different synthesis methods of CNTs and the factors affecting their purity, alignment, and scalability.	Evaluate (Level V)
CO-4	Examine the structural, electronic, mechanical, and optical properties of CNTs and their relation to material behaviour.	Analyze (Level IV)
CO-5	Apply CNTs in emerging technologies such as drug delivery, field emission, displays, and nanocomposites.	Apply (Level III)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3
CO-5	2	3	3	2	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Introduction to Carbon Nanostructure: Carbon molecule, carbon small clusters, carbon big clusters, fullerenes, discovery of C60, synthesis of C60, properties of C60, other buckeyballs, CNT.	7
Module-II	CNT Morphology: From a graphene sheet to a nanotube, structure - archiral and chiral nanotubes, singlewall, multiwall and bundled nanotubes, zigzag and armchair nanotubes, Euler's Theorem in cylindrical and defective nanotubes.	7
Module-III	Production Techniques of Nanotubes: Growth of single-wall/multiwall nanotubes, carbon arc bulk synthesis in presence and absence of catalysts, high purity material (bucky paper) production using pulsed laser vaporization (PLV) of pure and doped graphite, high-pressure co-conversion (HIPCO), nanotube synthesis based on Boudoir reaction-chemical vapor deposition (CVD), laser ablation, synthesis of	8

	aligned nanotube films.	
Module-IV	Structural, Electronic Properties: Structural changes in free standing and interacting nanotubes – librations, rotations, twistons, effect of inter tube interactions on the electronic structure, electronic structure of graphite as building block of nanotubes, effect of chirality and discrete atoms, conducting versus insulating nanotubes, band structure of metallic carbon nanotubes, effect of doping on conductivity, electrical properties, vibrational properties, chemical properties, mechanical properties, physical properties, optical properties.	8
Module-V	Applications of Nanotubes Harnessing field enhancement, flat panel displays, Hydrogen storage, carbon nanotubes & drug delivery, structural application of CNTs, CNT nanocomposites.	6

Learning Resources:

Text Books:	1. Carbon Nanotubes, M. Endo, S. Iijima, M. S. Dresselhaus, Pergamon. 2. Carbon Nanotubes: Advanced Topics in the Synthesis, Structure, Properties and Applications, Ado Jorio, Mildred S. Dresselhaus, and Gene Dresselhaus, Springer. 3. Physics of Carbon Nanostructures, Stefano Bellucci, Alexander Malesevic, Springer.
Reference Books:	
Other Suggested Readings:	

Course Title:	**DEEP LEARNING FOR COMPUTER VISION**
Course Code:	**ECEM 583**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand foundational neural networks and CNN architectures for feature extraction and visual representation.	Understand (Level II)
CO-2	Analyze advanced CNN techniques for image classification, verification, detection, and segmentation	Analyze (Level IV)
CO-3	Apply hybrid deep learning models like CNN + RNN and attention mechanisms in video and visual-language understanding.	Apply (Level III)
CO-4	Evaluate and implement generative models (GANs, VAEs) for computer vision tasks and analyze their applications.	Evaluate (Level V)

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	2	1	1	3	3
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Neural Network Review- Neural Network model, Multi-layer Perceptrons, Backpropagation. Convolutional Neural Networks (CNNs)- Introduction to CNNs; Evolution of CNN Architectures: AlexNet, ZFNet, VGG, InceptionNets, ResNets, DenseNets. Imaging system: Image Formation, Capture and Representation; Linear Filtering, Correlation, Convolution. Visual Features and Representations: Edge, Blobs, Corner Detection; Scale Space and Scale Selection; SIFT, SURF; HoG, LBP, etc. Visual Matching: Bag-of-words, VLAD; RANSAC, Hough transform; Pyramid Matching; Optical Flow.	9
Module-II	Visualization and Understanding CNNs: Visualization of Kernels; Backprop-to- image/Deconvolution Methods; Deep Dream, Hallucination, Neural Style Transfer; CAM,Grad-CAM, Grad-CAM++; Recent Methods (IG, Segment-IG, SmoothGrad), CNNs for Recognition, Verification, Detection, Segmentation: CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss); CNNs forDetection: Background of Object Detection, R-CNN, Fast R-	9

	CNN, Faster R-CNN, YOLO, SSD, RetinaNet; CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN	
Module-III	CNN + RNN Models for Video Understanding: Spatio-temporal Models, Action/Activity Recognition. Attention Models: Introduction to Attention Models in Vision; Vision and Language: Image Captioning, Visual QA, Visual Dialog; Spatial Transformers; Transformer Networks.	9
Module-IV	Deep Generative Models: Review of (Popular) Deep Generative Models: GANs, VAEs; Other Generative Models: PixelRNNs, NADE, Normalizing Flows, etc Variants and Applications of Generative Models in Vision: Applications: Image Editing, Inpainting, Superresolution, 3D Object Generation, Security; Variants: CycleGANs, Progressive GANs, StackGANs, Pix2Pix, etc, Recent Trends: Zero- shot, One-shot, Few-shot Learning; Self-supervised Learning; Reinforcement Learning in Vision; Other Recent Topics and Applications.	9

Learning Resources:

Text Books:	1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016 2. Computer Vision: Algorithms and Applications, R. Szeliski Springer, 2011. 3. Neural Networks and Deep Learning, Michael Nielsen, Determination Press, 2016.
Reference Books:	1. Computer vision – Models, learning and inference, S. Prince, Cambridge univ. press, 2012. 2. Computer Vision: Models, Learning, and Inference, Simon Prince Cambridge Univ. Press, 2012.
Other Suggested Readings:	

Course Title:	**PHOTONICS MATERIALS & DEVICES FOR COMMUNICATIONS**
Course Code:	**ECEM 584**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	To develop an understanding of photonic components and optical fiber technology.	Remember & Understand (Level I & II)
CO-2	To classify the material systems/technologies along with their fabrication processes to design efficient photonic devices for communication.	Analyze (Level IV)
CO-3	To Design and analyze different types of Photonic/Nano-photonic devices and components.	Apply, (Level III)
CO-4	Analytically evaluate the various photonic devices	Evaluate (Level V)

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basics of Photonics, Optical fibers and Communication: Photonics, integrated photonics and their brief history, Basic photonic technologies and components, Brief introduction to Maxwell's equations, wave equation, Electromagnetic waves at different dielectric interfaces. Overview of Optical fibers, types (step-index and graded index), single-mode and multimode, along with their condition, birefringent fiber, numerical aperture, Optical fiber communications, Dispersion and scattering losses in fiber, and budget analysis.	9
Module-II	Optical waveguides and Photonic Devices: Optical waveguides classification, Guided modes in optical waveguides, Dispersion of guided modes, Single-mode 3-D optical waveguides. Basic integrated-optic devices: Optical power splitter, Directional	9

	coupler, thermo-optic switches, Mach-Zehnder interferometer, Arrayed Waveguide Grating (AWG)-based MUX/DEMUX, Add-drop multiplexer, Design of photonic devices: Beam Propagation Method and Marcatili's Method.	
Module-III	Fundamental of Nano-Photonic Devices and Components: Nano-photonics: Photonic crystal (PhC) technology, PhC waveguide, PhC resonator, PhC MUX/DEMUX, PhC Filters, PhC fibers, Nano-wires, Packaging of photonic devices. Recent studies on PhC based devices for communication applications.	9
Module-IV	Photonic Materials and Fabrication Technologies: Photonic materials, selection of materials like silicon, silica, Lithium Niobate, Compound Semiconductor and Polymers. Fabrication and process techniques like Lithography, Deposition, and Diffusion etc. Parameter measurement and techniques, recent studies on photonic materials.	9

Leaning Resources:

Text Books:	1. Gerd Keiser, Optical Fiber Communications, 3rd Edition, McGraw-Hill International edition, 2000. 2. John M. Senior, Optical Fiber Communications, 2nd Edition, PHI, 2002. 3. H Nishihara, M Haruna and T Suhara, Optical integrated Circuits, McGraw-hill, 1989.
Reference Books:	1. C. R. Pollock and M. Lip Son, Integrated Photonics, Kluwer Pub., 2003. 2. D.K. Mynbaev, S.C. Gupta and Lowell L. Scheiner, Fiber Optic Communications, Pearson Education, 2005.
Other Suggested Readings:	

Course Title:	**BIOMEDICAL SIGNAL ANALYSIS**
Course Code:	**ECEM 585**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Explain the principles of human physiology and the generation and propagation of bioelectric signals.	Understand (Level II)
CO-2	Analyze the origin, characteristics, and challenges in the interpretation of various biomedical signals such as ECG, EEG, and EMG.	Analyze (Level IV)
CO-3	Apply filtering techniques to remove noise and artifacts from biomedical signals in the time and frequency domains.	Apply (Level III)
CO-4	Utilize advanced analytical methods for event detection, feature extraction, and signal interpretation in applications like ECG and EEG analysis.	Apply (Level III)

Course Articulation Matrix:

	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	2	1	-	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	**Introduction to Biomedical Signals:** Introduction to human physiology, Basic components of Biomedical signal processing, bioelectric signals. Action Potential and Its Generation: The propagation of action potentials in nerves.	6
Module-II	**Biomedical Signals and Characteristics:** Origin and Waveform Characteristics of Basic Biomedical Signals, Like: Electrocardiogram (ECG), Electroencephalogram (EEG), Electromyogram (EMG), Phonocardiogram (PCG), Electroneurogram (ENG), Event-Related Potentials (ERPS), Electrogastrogram (EGG), Biomedical Signal Analysis, Difficulties in Biomedical Signal Analysis, Computer-Aided Diagnosis.	7
Module-III	**Removal of Noise and Artifacts from Biomedical Signal**: Noise, Physiological Interference, Noises and Artifacts Present in ECG and EEG Time and Frequency Domain Filtering.	7

Module-IV	**EEG and ECG Signal Analysis and Event Detection in Biomedical Signals**: EEG signal Analysis, Linear Prediction Theory, Autoregressive Method, Sleep EEG, Application of Adaptive Filter for Noise Cancellation in ECG and EEG Signals; Detection of P, Q, R, S and T Waves in ECG, EEG Rhythms, Waves and Transients, Detection of Waves and Transients, Correlation Analysis Ad Coherence Analysis of EEG Channels.	7

Learning Resources:

Text Books:	1. Rangayyan, R.M., 2015. Biomedical signal analysis (Vol. 33). John Wiley & Sons. 2. Reddy, D.C., 2005. Biomedical signal processing: principles and techniques. McGraw-Hill
Reference Books:	1. Tompkins, W.J., 1993. Biomedical digital signal processing. Editorial Prentice Hall. 2. Sörnmo, L. and Laguna, P., 2005. Bioelectrical signal processing in cardiac and neurological applications (Vol. 8). Academic Press.
Other Suggested Readings:	

Course Title:	DEEP LEARNING FOR COMPUTER VISION
Course Code:	ECEM 586
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the modern CNN-based architectures	Remember & Understand (Level I & II)
CO-2	Describe the relative merits of various deep learning architectures	Analyze (Level IV)
CO-3	Analyzing and extracting relevant features of the concerned domain problem.	Apply (Level III)
CO-4	Understand and apply the computer vision concepts and their relevance in real-time applications	Analyze & Evaluate (Level IV & V)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	**Neural Network Review:** Neural Network model, Multi-layer Perceptron's, Backpropagation. **Convolutional Neural Networks (CNNs):** Introduction to CNNs; Evolution of CNN Architectures: Alex Net, ZNet, VGG, Inception Nets, ResNets, DenseNets. **Imaging system:** Image Formation, Capture and Representation; Linear Filtering, Correlation, Convolution. **Visual Features and Representations:** Edge, Blobs, Corner Detection; Scale Space and Scale Selection; SIFT, SURF; HoG, LBP, etc. **Visual Matching:** Bag-of-words, VLAD; RANSAC, Hough transform; Pyramid Matching; Optical Flow.	10
Module-II	**Visualization and Understanding CNNs:** Visualization of Kernels; Backprop-to-image/Deconvolution Methods; Deep Dream, Hallucination, Neural Style Transfer; CAM,Grad-	10

	CAM, Grad-CAM++; Recent Methods (IG, Segment-IG, SmoothGrad) **CNNs for Recognition, Verification, Detection, Segmentation:** CNNs for Recognition and Verification (Siamese Networks, Triplet Loss, Contrastive Loss, Ranking Loss); CNNs for Detection: Background of Object Detection, R-CNN, Fast R-CNN, Faster R-CNN, YOLO, SSD, RetinaNet; CNNs for Segmentation: FCN, SegNet, U-Net, Mask-RCNN	
Module-III	CNN + RNN Models for Video Understanding: Spatio-temporal Models, Action/Activity Recognition. **Attention Models:** Introduction to Attention Models in Vision; Vision and Language: Image Captioning, Visual QA, Visual Dialog; Spatial Transformers; Transformer Networks.	8
Module-IV	**Deep Generative Models:** Review of (Popular) Deep Generative Models: GANs, VAEs; Other Generative Models: PixelRNNs, NADE, Normalizing Flows, etc **Variants and Applications of Generative Models in Vision:** Applications: Image Editing, Inpainting, Superresolution, 3D Object Generation, Security; Variants: CycleGANs, Progressive GANs, StackGANs, Pix2Pix, etc **Recent Trends:** Zero-shot, One-shot, Few-shot Learning; Self-supervised Learning; Reinforcement Learning in Vision; Other Recent Topics and Applications	10

Learning Resources:

Text Books:	1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016. 2. Computer Vision: Algorithms and Applications, R. Szeliski, 2011. 3. Neural Networks and Deep Learning, Michael Nielsen, Determination Press 2016.
Reference Books:	1. Computer Vision - Models, learning and inference, S. Prince Cambridge univ. press, 2012.
Other Suggested Readings:	

Course Title:	**DEEP LEARNING FOR IMAGING**
Course Code:	**ECEM 587**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Understand the basic NN-based architectures.	Remember (Level I)
CO-2	Describe the relative merits of various NN-based architectures	Understand (Level II)
CO-3	Analyzing and extracting relevant features of the advanced deep learning architectures.	Analyze (Level IV)
CO-4	Applying various deep learning models to real applications	Apply (Level III)

Course Articulation Matrix:

Course Outcomes ↓ / POs →	**PO1**	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PSO1**	**PSO2**
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	2	2	1	1	3	2
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	**Detailed Syllabus**	**Contact Hours**
Module-I	Basic Neural Network: Perceptron; Multi-layer Perceptron; Back propagation; Stochastic gradient descent; Universal approximation theorem; Applications in imaging such as for denoising. Convolutional Neural Networks (CNN): CNN Architecture (Convolutional layer, Pooling layer, ReLu layer, fully connected layer, loss layer); Regularization methods such as dropout; Fine-tuning; Understanding and Visualizing CNN; Applications of CNN in imaging such as object/scene recognition.	12
Module-II	Image reconstruction and enhancement: Deep learning-based reconstruction, denoising autoencoders, super-resolution using CNNs.	12
Module-III	Deep Generative Models: Restricted Boltzmann machine; Deep Boltzmann machine; Recurrent Image Density Estimators (RIDE); Pixel RNN and Pixel CNN; Plug-and-Play generative	12

	networks. Generative Adversarial Network (GAN): GAN; Deep Convolutional GAN; Conditional GAN; Applications.	
Module-IV	Deep Learning for Image Processing and Computational Imaging Denoising, Deblurring, Super-resolution, Color Filter Array design.	12

Learning Resources:

Text Books:	1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016. 2. Understanding Deep Learning, Simon J.D. Prince, MIT Press, 2023
Reference Books:	1. Deep learning with PyTorch, Eli Stevens, Luca Antiga, and Thomas Viehmann, Manning, 2020
Other Suggested Readings:	

Course Title:	MACHINE LEARNING FOR COMPUTER VISION
Course Code:	ECEM 588
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Understand the Basic concepts of Machine Learning Approaches to the Computer Vision Task.	Remember (Level I)
CO-2	Analyzing and extracting relevant features of the concerned domain problem.	Understand (Level II)
CO-3	Deduce the distinct representation and Learning.	Analyze (Level IV)
CO-4	Understand and apply the computer vision domain for real-life applications	Apply (Level III)

Course Articulation Matrix:

	PO1	PO2	PO3	PO4	PO5	PO6	PSO1	PSO2
CO-1	3	2	2	2	1	-	2	2
CO-2	3	3	3	3	2	1	3	3
CO-3	2	3	3	3	2	1	3	3
CO-4	2	3	3	3	2	1	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Module	Detailed Syllabus	Contact Hours
Module-I	Practical aspects of model training. Regularization, optimizers, training recipes. Attention and vision transformers. Image classification architectures based on Transformers (ViT, SWiN). ConvNeXt. Object detection. Introduction to ensemble learning via boosting. The Viola-Jones detector and its applications. Specialized NN architectures for object detection. Two-stages, one-stage, and anchor-free detectors. RoI Pooling operator, Feature Pyramid Networks. Imbalanced learning and the focal loss. Hands-on session on object detection.	12
Module-II	Dense prediction problems: semantic/instance segmentation and depth from mono/stereo. Ensemble learning via bagging and random forests. The algorithm behind the Kinect body part segmentation. Fully Convolutional Networks. Transposed and dilated convolutions. RoI Align operator. Specialized NN architectures for semantic, instance, and panoptic segmentation. Deep networks for depth estimation: DispNet, GCNet, RAFT Stereo, Mono depth.	12
Module-III	**Metric and representation learning**. Deep metric learning and its applications to face recognition/identification and	12

	beyond. Locally connected layers. Contrastive and triplet loss. Unsupervised representation learning. Hands-on session on face recognition.	
Module-IV	**3D computer vision:** data structures (point clouds, mesh, voxel grids). Specialized neural networks for point clouds and voxels. Hands-on session on point cloud classification. **Image generation with diffusion models:** denoising diffusion probabilistic models and score-matching models. Stable diffusion and text-guided image generation. Hands-on session on textual inversion.	12

Learning Resources:

Text Books:	1. Deep Learning, Ian Goodfellow and Yoshua Bengio and Aaron Courville, MIT Press, 2016. 2. Understanding Deep Learning, Simon J.D. Prince, MIT Press, 2023
Reference Books:	1. Deep Learning for Coders with fastai and PyTorch, Jeremy Howard and Sylvain Gugger, 2020
Other Suggested Readings:	

Dissertation/ Seminar Courses

Course Title:	**DISSERTATION I**
Course Code:	**ECEM 604**
L-T-P:	**0-0-32**
Credits:	**16**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Level**
CO-1	Refine the research problem and extend literature survey with updated findings.	Understanding (Level II)
CO-2	Implement the proposed methodology to full extent including testing/validation.	Applying (Level III)
CO-3	Critically analyze experimental/simulation results and evaluate performance against existing methods.	Evaluating (Level V)
CO-4	Prepare and present a complete dissertation with clarity, adhering to academic writing standards.	Creating (Level VI)

Course Articulation Matrix:

	PO-1	**PO-2**	**PO-3**	**PO-4**	**PO-5**	**PO-6**	**PSO-1**	**PSO-2**
CO-1	3	3	2	1			3	2
CO-2	2	3	3	3	1		3	3
CO-3	2	2	3	3			3	3
CO-4	3	3	3	2		2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description: Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project.

The Dissertation I will be evaluated for 100 marks, with the following weightages:

Component	**Weightages**
Periodic evaluation by Guide	40 Marks
Mid-term review	20 Marks
End Semester viva-voce examination	40 Marks
Total	100 Marks

The midterm review and the end semester viva-voce examination will be conducted by a committee constituted by the Head of the Department. If the performance of a student is not satisfactory, he/ she can be awarded ‘F’ grade. Such a student will be given a maximum time of three months to improve his/her performance. If the performance of such a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

Course Title:	INDEPENDENT STUDY COURSE - I
Course Code:	ECEM 602
L-T-P:	3-0-0
Credits:	3
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Levels
CO-1	Identify and review recent research or technological trends in a specific domain of interest.	Remember /Understand (Level I/II)
CO-2	Analyze technical literature, synthesize key ideas, and critically evaluate existing solutions or approaches.	Analyze (Level IV)
CO-3	Formulate a coherent presentation or report with logical flow and proper technical documentation.	Apply/Create (Level III /Level VI)
CO-4	Demonstrate effective oral communication and defend viewpoints through seminars and discussions.	Apply/Create (Level III/Level VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	0	0	0	0	0	0
CO-2	2	3	2	2	0	0	0	0
CO-3	0	2	2	0	3	0	0	0
CO-4	0	0	0	0	2	0	0	0

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project .

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Identification of Problem Domain	10
II	Study of Existing Systems and establishing clear objectives	20
III	Planning of project and work distribution within the team	30
IV	Proper Documentation and Technical Writing	25
V	Presentation and Response to questions	15

Evaluation Criteria-CO Mapping

CO / Criteria	CO-1	CO-2	CO-3	CO-4
I	✔			
II	✔	✔		
III		✔	✔	✔
IV		✔	✔	
V			✔	✔

Course Title:	**SEMINAR - I**
Course Code:	**ECEM 603**
L-T-P:	**0-0-2**
Credits:	**1**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Identify and review recent research or technological trends in a specific domain of interest	Remember/ Understand (Level I/II)
CO-2	Analyze technical literature, synthesize key ideas, and critically evaluate existing solutions or approaches.	Analyze (Level IV)
CO-3	Formulate a coherent presentation or report with logical flow and proper technical documentation.	Apply/Create (Level III/ Level VI)
CO-4	Demonstrate effective oral communication and defend viewpoints through seminars and discussions.	Apply/Create (Level III/ Level VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	0	0	0	0	0	0
CO-2	2	3	2	2	0	0	0	0
CO-3	0	2	2	0	3	0	0	0
CO-4	0	0	0	0	2	0	0	0

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project.

Evaluation Criteria:

The student will be evaluated by the panel based on the below criteria. Weightage for each criterion will be determined by the panel and will be informed to the students.

Criteria	Description	Weightages
I	Identification of Problem Domain	10
II	Study of Existing Systems and establishing clear objectives	20
III	Planning of project and work distribution within the team	30
IV	Proper Documentation and Technical Writing	25
V	Presentation and Response to questions	15

Evaluation Criteria-CO Mapping

CO / Criteria	CO-1	CO-2	CO-3	CO-4
I	✔			
II	✔	✔		
III		✔	✔	
IV			✔	✔
V				✔

Course Title:	DISSERTATION II
Course Code:	ECEM 654
L-T-P:	0-0-32
Credits:	16
Pre-requisites:	

Course Outcomes:

Course Outcomes		Cognitive Level
CO-1	Refine the research problem and update the literature review with recent developments.	Understanding (Level II)
CO-2	Apply and execute the proposed methodology to achieve complete implementation.	Applying (Level III)
CO-3	Critically evaluate the performance of the system using experiments/simulations and benchmarking.	Evaluating (Level V)
CO-4	Prepare a well-structured dissertation and deliver an effective viva presentation of the research outcomes.	Creating (Level VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	3	2	2			3	2
CO-2	2	3	3	3	2		3	3
CO-3	2	2	3	3			3	3
CO-4	3	3	3	2	1	2	3	3

1 - Slightly; 2 - Moderately; 3 - Substantially

Description: Students are expected to choose real-world contemporary problem and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel will decide the suitability and worthiness of the project.

Dissertation II will be evaluated for 100 marks, with the following weightages:

Component	Weightages
Periodic evaluation by Guide	40 Marks
Mid-term review	20 Marks
End Semester viva-voce examination	40 Marks
Total	100 marks

The midterm review and the end semester viva-voce examination will be conducted by a committee constituted by the Head of the Department. If the performance of a student is not satisfactory, he/ she can be awarded 'F' grade. Such a student will be given a maximum time of three months to improve his/her performance. If the performance of such a student is not satisfactory even after the extended time period, he/ she will have to repeat the project work in the next academic year.

Course Title:	**INDEPENDENT STUDY COURSE - II**
Course Code:	**ECEM 652**
L-T-P:	**3-0-0**
Credits:	**3**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Identify and review recent research or technological trends in a specific domain of interest.	Remember/ Understand (Level I/Level II)
CO-2	Analyze technical literature, synthesize key ideas, and critically evaluate existing solutions or approaches.	Analyze (Level IV)
CO-3	Formulate a coherent presentation or report with logical flow and proper technical documentation.	Apply/Create (Level III/Level VI)
CO-4	Demonstrate effective oral communication and defend viewpoints through seminars and discussions.	Apply/Create (Level III/ Level VI)

Course Articulation Matrix:

	PO-1	PO-2	PO-3	PO-4	PO-5	PO-6	PSO-1	PSO-2
CO-1	3	2	0	0	0	0	0	0
CO-2	2	3	2	2	0	0	0	0
CO-3	0	2	2	0	3	0	0	0
CO-4	0	0	0	0	2	0	0	0

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

Students are expected to choose real world or relevant problems and apply the engineering principles learned, to solve the problem through building prototypes or simulations or writing codes or establishing processes/synthesis/correlations etc. The department constituted panel can decide the suitability and worthiness of the project.

Evaluation Criteria:

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Criteria	**Description**	**Weightages**
I	Identification of Problem Domain	10
II	Study of Existing Systems and establishing clear objectives	20
III	Planning of project and work distribution within the team	30
IV	Proper Documentation and Technical Writing	25
V	Presentation and Response to questions	15

Evaluation Criteria-CO Mapping

CO / Criteria	CO-1	CO-2	CO-3	CO-4
I	✔			
II	✔	✔		
III		✔	✔	✔
IV		✔	✔	
V			✔	✔

Course Title:	**SEMINAR - II**
Course Code:	**ECEM 653**
L-T-P:	**0-0-2**
Credits:	**1**
Pre-requisites:	

Course Outcomes:

Course Outcomes		**Cognitive Levels**
CO-1	Identify and review recent research or technological trends in a specific domain of interest	Remember/ Understand (Level I/II)
CO-2	Analyze technical literature, synthesize key ideas, and critically evaluate existing solutions or approaches.	Analyze (Level IV)
CO-3	Formulate a coherent presentation or report with logical flow and proper technical documentation.	Apply/Create (Level III/ Level VI)
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CO-2	2	3	2	2	0	0	0	0
CO-3	0	2	2	0	3	0	0	0
CO-4	0	0	0	0	2	0	0	0

1 - Slightly; 2 - Moderately; 3 - Substantially

Description:

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Evaluation Criteria-CO Mapping

CO / Criteria	CO-1	CO-2	CO-3	CO-4
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II	✔	✔		
III		✔	✔	
IV			✔	✔
V				✔