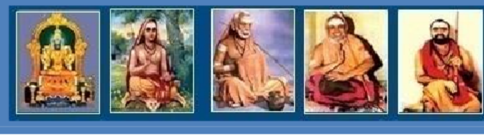


SRI CHANDRASEKHARENDRA SARASWATHI VISWA MAHAVIDYALAYA

(University established under section 3of UGC Act 1956)

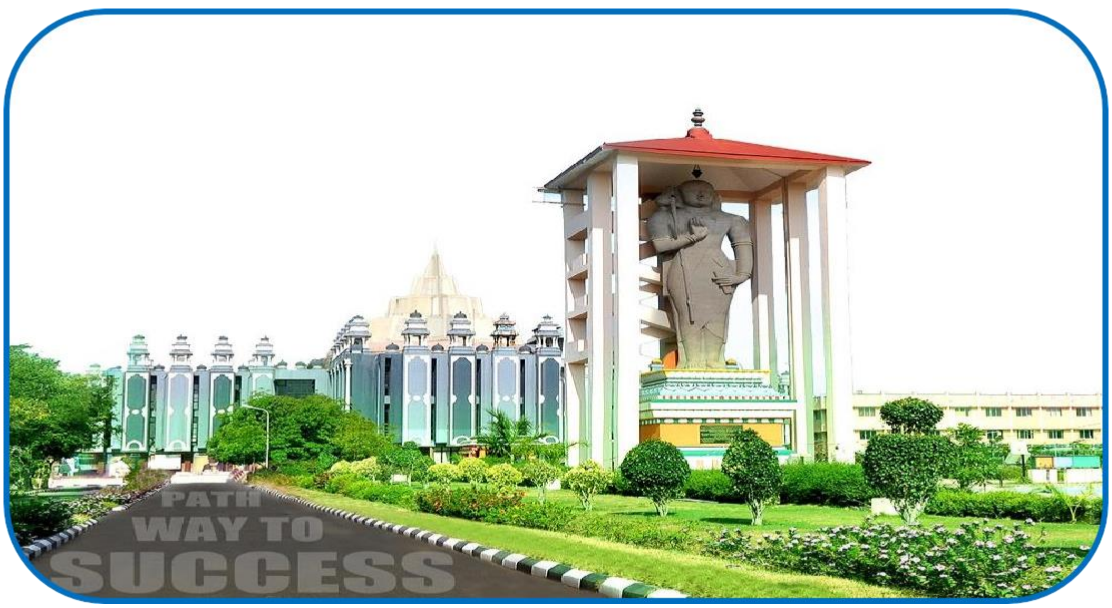
(Accredited with ‘A’ Grade by NAAC)

CURRICULUM FOR FULL TIME

BE - ELECTRONICS AND COMMUNICATION ENGINEERING

HONS./MINOR DEGREE IN EMERGING AREAS(OPTIONAL)

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING



B.E /B.TECH-Hons./Minor Degrees in Emerging Areas (Optional)

Emerging Areas	Offered as Hons., for the following Major Disciplines*	Offered as Minor Degrees for the following Major Disciplines**
5G COMMUNICATION SYSTEMS	Electronics and Communication Engineering / Computer Science and Engineering / Information Technology/ Electrical and Electronics Engineering	Electronics and Instrumentation Engineering/ Mechatronics / Mechanical Engineering / Civil Engineering
VLSI DESIGN	Electronics and Communication Engineering / Computer Science and Engineering / Information Technology/ Electrical and Electronics Engineering	Electronics and Instrumentation Engineering/ Mechatronics / Mechanical Engineering / Civil Engineering
IMAGE PROCESSING AND COMPUTER VISION	Electronics and Communication Engineering / Computer Science and Engineering / Information Technology	Electrical and Electronics Engineering /Electronics and Instrumentation Engineering/ Mechatronics/ Mechanical Engineering / Civil Engineering

Note: The “Minor Degree or Hons. will cumulatively require additional 18 to 20 credits in the specified area in addition to the credits essential for obtaining the Under Graduate Degree in Major Discipline.

* Under Graduate Degree Courses in EMERGING AREAS shall be allowed as specialization from the same Department. The minimum additional Credits for such Courses shall be in the range of 18-20 and the same shall be mentioned in the degree, as specialization in that particular area.

** Minor specialization in EMERGING AREAS in Under Graduate Degree Courses may be allowed where a student of another Department shall take the minimum additional Credits in the range of 18-20 and get a degree with minor from another Department.

ELECTRONICS AND COMMUNICATION ENGINEERING WITH HONS./MINOR DEGREES

5G COMMUNICATION SYSTEMS

CURRICULUM & SYLLABUS

For B.E. (Hons.) Electronics and Communication Engineering with Specialization in

5G COMMUNICATION SYSTEMS

S.No	Year	Sem	Course Code	Course Name	L	T	P	C	IA	EA	TM
1	II	IV		INTRODUCTION TO COMMUNICATION AND NETWORKING	3	0	0	3	40	60	100
2	III	V		ADVANCED WIRELESS COMMUNICATION	3	0	0	3	40	60	100
3	III	V		WIRELESS COMMUNICATION LAB	0	0	2	2	40	60	100
4	III	VI		WIRELESS BROADBAND NETWORKS	3	0	0	3	40	60	100
5	IV	VII		5G COMMUNICATIONS	3	0	0	3	40	60	100
6	IV	VII		5G COMMUNICATION LABORATORY	0	0	2	2	40	60	100
7	IV	VIII		SMART ANTENNAS FOR 5G COMMUNICATION	3	0	0	3	40	60	100
Total Credits					**19**						

Course Code		L	T	P	C	IA	EA	TM
Course Name	**INTRODUCTION TO COMMUNICATION AND NETWORKING**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital Communication							

Course Objectives:

The course should enable the students

1. To understand basic knowledge of networking.
2. To demonstrate knowledge of OSI and TCP Models.
3. To Evaluate and compare the performance of the various digital modulations schemes.
4. To understand the concept of Information Theory.
5. To Acquire the skills to generate and detect Wireless digital modulation schemes.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understanding of networking systems.	**K2**
CO2	Understanding the concept of different layers in the networks.	**K3**
CO3	Demonstrate proficiency in the generation and detection of digital modulated signals.	**K5**
CO4	Gain a comprehensive understanding of information theory and channel coding to improve communication reliability.	**K2**
CO5	Explore the practical applications of wireless digital modulation techniques.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	M	L	-	-	-	-	-	-	-	-	-	L	-	-
CO3	S	-	-	L	L	-	-	-	-	-	-	-	-	L	L
CO4	M	-	L	-	-	-	-	-	-	-	-	-	L	-	-
CO5	S	M	M	L	M	-	-	-	-	-	-	-	-	M	L

UNIT-I	INTRODUCTION TO DATA COMMUNICATION	9 Hours
Data Communication, Networks – Distributed Processing, Network Criteria, Applications; Protocols and Standards, Standard Organization, Line Configuration – Point to Point, Multi Point; Topology – Mesh, Star, Tree, Bus, Ring, Hybrid; Transmission mode, Categories of Network – LAN, MAN, WAN, Inter Networks.		
UNIT-II	**OSI AND TCP/IP MODEL**	**9 Hours**
ISO organization, The model – Layered architecture, functions of the layers -Physical layer, Data Link layer, Network layer, Transport layer, session layer, Presentation layer, Application layer. The TCP/IP reference model, comparison of TCP/IP & OSI, Introduction to Internet – ARPANET, Architecture of Internet, Client server model, www, IP Address Classes, Protocols: IP, HTTP, TCP. FTP, ARP.		
UNIT-III	**DIGITAL MODULATION TECHNIQUES**	**9 Hours**
Phase shift Keying techniques using coherent detection: generation, detection and error probabilities of BPSK and QPSK. Mary PSK. M-ary QAM . Frequency shift keying techniques using Coherent detection: BFSK generation, detection and error probability. Spread Spectrum Communication Systems - Direct Sequence Spread Spectrum Systems, Frequency Hopped Spread Spectrum.		
UNIT-IV	**INFORMATION THEORY**	**9 Hours**
Information-theoretic limits and Channel Coding, The capacity of AWGN Channel: modelling and geometry, Shannon theory basics: entropy, mutual information, and divergence, channel coding theorem, the capacity of standard constellations, parallel Gaussian channels and water filling Channel codes: Binary convolutional codes, Turbo codes and iterative coding, LDPC codes, bandwidth-efficient coded modulation.		
UNIT-V	**WIRELESS DIGITAL MODULATION**	**9 Hours**
Wireless Digital Modulation Physical modelling for wireless channels, Fading and diversity, OFDM, CDMA, MIMO- linear array, Beam-steering, MIMO-OFDM, Spatial Multiplexing,Space-time coding.		
	Total Hours	**45 Hours**

Text Book(s)

1.	Behrouz A. Forouzan , Data Communications And Networking, Mc Graw Hill, 2017.
2.	Upamanyu Madhow, Fundamentals of Digital Communication, Cambridge University Press, 2012
3	Sanjay Sharma, Communication Systems (Analog and Digital), SK Kataria Sons, 2013.

Reference Book(s)

1.	B. P. Lathi, Modern Digital and Analog Communication Systems, Oxford.
2.	J. R. Barry, E. A. Lee, and D. G. Messerschmitt, Digital Communication, Kluwer Academic Publishers, 2004.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**ADVANCED WIRELESS COMMUNICATION**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	**Wireless Communication Techniques**							

Course Objectives:

The course should enable the students

1. To understanding of the capacity limitations of wireless channels.
2. To Explore the principles of MIMO systems.
3. To Analyse the capacity of MIMO systems under different channel conditions.
4. To Study radio wave propagation and its effects on wireless communication.
5. To Investigate different space-time coding techniques.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Analyze channel capacity of wireless channels.	**K3**
CO2	Analyse MIMO system.	**K3**
CO3	Apply the principles of MIMO systems to enhance the capacity and reliability of wireless communication.	**K4**
CO4	Understand the principles of radio wave propagation.	**K2**
CO5	Design and decoding of various space-time coding techniques.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	L	L	-	-	-	-	-	-	-	-	-	L	-	-
CO2	M	L	L	-	M	-	-	-	-	-	-	-	-	L	-
CO3	S	M	M	-	M	-	-	-	-	-	-	-	M	-	-
CO4	L	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO5	L	M	M	S	S	-	-	-	-	-	-	-	S	L	-

UNIT-I	**CAPACITY OF WIRELESS CHANNELS**	**9 Hours**
The crowded spectrum, need for high data rate, MIMO systems – Array Gain, Diversity Gain, Data Pipes, Spatial MUX, MIMO System Model. MIMO System Capacity – channel known at the TX, Channel unknown to the TX – capacity of deterministic channels, Random channels and frequency selective channels.		
UNIT-II	**RADIO WAVE PROPAGATION**	**9 Hours**
Radio wave propagation – Macroscopic fading- free space and out door, small scale fading Fading measurements – Direct pulse measurements, spread spectrum correlation channel sounding frequency domain channel sounding, Antenna Diversity – Diversity combining methods.		
UNIT-III	**SPACE TIME BLOCK CODES**	**9 Hours**
Delay Diversity scheme, Alamoti space time code – Maximum likelihood decoding maximum ratio combining. Transmit diversity space time block codes for real signal constellation and complex signal constellation - decoding of STBC.		
UNIT-IV	**SPACE TIME TRELLIS CODES**	**9 Hours**
Space time coded systems, space time code word design criteria, design of space time T C on slow fading channels, design of STTC on Fast Fading channels, performance analysis in slow and fast fading channels, effect of imperfect channel estimation and Antenna correlation on performance, comparison of STBC & STTC.		
UNIT-V	**LAYERED SPACE TIME CODES**	**9 Hours**
LST transmitter – Horizontal and Vertical LST receiver – ML Rx, Zero forcing Rx; MMSE Rx, SIC Rx, ZF V-blast Rx- MMSE V-blast Rx, Iterative Rx - capacity of MIMO – OFDM systems – capacity of MIMO multi user systems.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Mohinder Jankiraman, "Space Time Codes and MIMO Systems", Artech House, Boston", London. www.artechhouse.com, 2004.
2.	Paulraj Rohit Nabar, Dhananjay Gore, "Introduction of Space Time Wireless Communication Systems", Cambridge University Press, 2003.
Reference Book(s)	
1.	David Tse and Pramod Viswanath, "Fundamentals of Wireless Communication", Cambridge University Press, 2005.
2.	Sergio Verdu "Multi User Detection", Cambridge University Press, 1998.
3.	Andre Viterbi, "Principles of Spread Spectrum Techniques", Addison Wesley 1995.
4.	Volker Kuhn, "Wireless communication over MIMO channels", John Wiley and Sons Ltd., 2006.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**WIRELESS COMMUNICATION LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital Communication							

Course Objectives:

1. To study & measure the performance of digital communication systems.
2. To study the practical aspects of baseband system design.
3. To provide a complete knowledge of Wireless Communication.
4. To design and conduct experiments, for digital communication.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Generate and detect digital communication signals	**K4**
CO2	Evaluate cellular mobile communication technology and propagation mode.	**K4**
CO3	Apply mathematical formulation to analyse spectrum estimation of a signal.	**K3**
CO4	Analyse the performance of optimization algorithms for equalizing the channel or noise/echo cancellation.	**K5**
CO5	Design synchronization algorithm for Digital Communication systems.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2	PSO3
CO1	S	S	-	-	S	-	-	-	S	S	M	M	L	L	-
CO2	S	S	L	M	S	-	-	-	S	S	M	M	-	L	-
CO3	S	S	M	M	S	-	-	-	S	S	M	M	L	-	-
CO4	S	S	M	M	S	M	M	L	S	S	M	M	-	L	M
CO5	S	S	L	M	S	L	M	L	S	S	M	M	M	M	M

	LIST OF EXPERIMENTS
1.	Communication link simulation
2.	Pseudo random binary sequence generation Baseband DSSS
3.	Performance analysis of simulated CDMA system
4.	OFDM design
5.	Channel equalizer design
6.	Design and Analysis of Spectrum Estimators
7.	BER performance Analysis of M-ary digital Modulation Techniques
8.	Noise / Echo cancellation
9.	Study of synchronization
10.	Wireless channel characterization.
Tools : MATLAB, LABVIEW	

Course Code		L	T	P	C	IA	EA	TM
Course Name	**WIRELESS BROADBAND NETWORKS**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Computer Networks, Wireless Communication							

Course Objectives:

The course should enable the students

1. To learn the basic architecture of a next generation network (NGN) with reference.
2. To understand next generation network services.
3. To learn the role of P Multimedia Sub-System (IMS), network attachment and admission control functions.
4. To learn and compare the various methods of providing connection-oriented services over NGN.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understand the evolution of wireless networks.	**K2**
CO2	Analyze the protocols used in wireless networks.	**K3**
CO3	Evaluate the features and components of 4G and beyond wireless networks.	**K4**
CO4	Analyze the LTE-A technology and network architecture.	**K3**
CO5	Analyze layer-level functions in wireless networks.	**K3**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	-	L	M	-	-	-	-	-	-	-	-	M	-
CO3	S	-	M	L	-	-	-	-	-	-	-	-	L	M	-
CO4	S	-	M	-	M	-	-	-	-	-	-	-	-	-	-
CO5	S	-	M	M	-	-	-	-	-	-	-	-	-	-	-

UNIT-I	**EVOLUTION OF WIRELESS NETWORKS**	**9 Hours**
Review of cellular standards, migration and advancement of GSM architecture and CDMA architecture, WLAN – IEEE 802.11and HIPERLAN, Bluetooth.		
UNIT-II	**WIRELESS PROTOCOLS**	**9 Hours**
Mobile network layer- Fundamentals of Mobile IP, data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing - DHCP, Mobile transport layer-Traditional TCP, congestion control, slow start, fast recovery/fast retransmission, classical TCP improvements- Indirect TCP, snooping TCP, Mobile TCP.		
UNIT-III	**3G EVOLUTIONS**	**9 Hours**
IMT-2000 - W-CDMA, CDMA 2000 – radio & network components, network structure, packet-data transport process flow, Channel Allocation, core network, interference-mitigation techniques, UMTS-services, air interface, network architecture of 3GPP, UTRAN – architecture, High Speed Packet Data-HSDPA, HSUPA.		
UNIT-IV	**4G AND BEYOND**	**9 Hours**
Introduction to LTE-A – Requirements and Challenges, network architectures – EPC, E-UTRAN architecture - mobility management, resource management, services, channel -logical and transport channel mapping, downlink/uplink data transfer, MAC control element, PDU packet formats, scheduling services, random access procedure.		
UNIT-V	**LAYER-LEVEL FUNCTIONS**	**9 Hours**
Characteristics of wireless channels - downlink physical layer, uplink physical layer, MAC scheme - frame structure, resource structure, mapping, synchronization, reference signals and channel estimation, SC-FDMA, interference cancellation –CoMP, Carrier aggregation, Services - multimedia broadcast/multicast, location-based services.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	KavehPahlavan, "Principles of wireless networks", Prentice-Hall of India, 2008.
2.	Vijay K.Garg, "Wireless Network Evolution- 2G & 3G" Pearson, 2013.
Reference Book(s)	
1.	Clint Smith,P.E, Dannel Collins, "3G Wireless Networks" 2nd edition, Tata McGraw-Hill, 2008.
2.	JochenH.Schiller, "Mobile Communications", 2/e, Pearson, 2014.
3.	Sassan Ahmadi, "LTE-Advanced – A practical systems approach to understanding the 3GPP LTE Releases 10 and 11 radio access technologies", Elsevier, 2014.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**5G COMMUNICATIONS**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital communications, Mobile Communication Systems, Wireless Networks							

Course Objectives:

The course should enable the students

1. To understand the requirements and regulations for 5G networks.
2. To Familiarize functional architecture of 5G networks.
3. To Understand the design principles 5G radio technology.
4. To analyse different network deployment types in 5G.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understand and explain the channel models of 5G and the use cases for 5G.	**K2**
CO2	Analyze use of MIMO in 5G and its techniques.	**K3**
CO3	Understand device to device (D2D) communication and standardization.	**K2**
CO4	Study the in-depth functioning of 5G radio access technologies.	**K3**
CO5	Understand interference management, mobility management and security issues in 5G.	**K2**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	M	-	-	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	L	L	-	-	-	-	-	-	-	-	-	L	-	-
CO3	M	-	-	-	-	-	-	-	-	-	-	-	-	L	-
CO4	M	L		-	-	-	-	-	-	-	-	-	-	-	-
CO5	M	-	-	-	-	-	-	-	-	-	-	-	-	-	-

UNIT-I	**5G BROADBAND WIRELESS COMMUNICATIONS**	**9 Hours**
. An Overview of 5G requirements, Regulations for 5G, Spectrum Analysis and Sharing for 5G. Channel modeling requirements, propagation scenarios and challenges in the 5G modeling, Channel Models for mmWave MIMO Systems.		
UNIT-II	**THE 5G ARCHITECTURE**	**9 Hours**
Introduction, NFV and SDN, Basics about RAN architecture, High-level requirements for the 5G architecture, Functional architecture and 5G flexibility, Functional split criteria, Functional split alternatives, Functional optimization for specific applications, Integration of LTE and new air interface to fulfill 5G Requirements, Enhanced Multi-RAT coordination features, Physical architecture and 5G deployment.		
UNIT-III	**DEVICE-TO-DEVICE (D2D) COMMUNICATIONS**	**9 Hours**
D2D: from 4G to 5G, D2D standardization: 4G LTE D2D, D2D in 5G: research challenges, Radio resource management for mobile broadband D2D, RRM techniques for mobile broadband D2D, RRM and system design for D2D, 5G D2D RRM concept: an example, Multi-hop D2D communications for proximity and emergency, services, National security and public safety requirements in 3GPP and METIS, Device discovery without and with network assistance.		
UNIT-IV	**5G RADIO-ACCESS TECHNOLOGIES**	**9 Hours**
Access design principles for multi-user communications, Orthogonal multiple-access systems, Spread spectrum multiple-access systems, Capacity limits of multiple-access methods, Sparse code multiple access (SCMA), Interleave division multiple access (IDMA), Radio access for dense deployments, OFDM numerology for small-cell deployments, Small-cell sub-frame structure, Radio access for V2X communication, Medium access control for nodes on the move, Radio access for massive machine-type communication.		
UNIT-V	**INTERFERENCE MANAGEMENT, MOBILITY MANAGEMENT, AND SECURITY FOR 5G**	**9 Hours**
Network deployment types, Ultra-dense network or densification, Moving networks, Heterogeneous networks, Interference management in 5G, Interference management in UDN, Interference management for moving relay nodes, Interference cancelation, mobility management in 5G, User equipment-controlled versus network-controlled handover, Mobility management in heterogeneous 5G networks.		
	Total Hours	**45 Hours**

Text Book(s)

1.	5G Mobile and Wireless Communications Technology, AfifOsseiran, Jose F. Monserrat, Patrick Marsch, Second Edition, 2011.
2.	5G NR: The Next Generation Wireless Access Technology, Erik Dahlman, Stefan Parkvall, Johan Skȯld, Elsevier, First Edition, 2016.

3.	Fundamentals of 5G Mobile Networks, Jonathan Rodriguez, Wiley, First Edition, 2010
Reference Book(s)	
1.	Theodore S.Rappaport, Robert W.Heath, Robert C.Danials, James N.Murdock "Millimeter Wave Wireless Communications", Prentice Hall Communications.
2.	Athanasios G.Kanatos, Konstantina S.Nikita, Panagiotis Mathiopoulos, "New Directions in Wireless Communication Systems from Mobile to 5G", CRC Press.
3.	Amitabha Ghosh and RapeepatRatasuk "Essentials of LTE and LTE-A", Cambridge University Press.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**5G COMMUNICATION LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	5G Communication							

Course Objectives:

The course should enable the students

1. To Understand the working of cellular networks.
2. To analyse the performance of LTE network.
3. To analyse the performance of 5G communication.
4. To design and analyse 5G waveform generation.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Design and analysis of cellular network.	**K4**
CO2	Design and analyse the 5G network.	**K4**
CO3	Understand the fundamentals of ray tracing as a simulation technique for analysing communication links in 5G networks.	**K3**
CO4	Evaluate the performance and capabilities of WLAN technologies in the context of 5G.	**K5**
CO5	Design and optimize beamforming algorithms and configurations for 5G systems.	**K5**

Z

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	S	-	-	S	-	-	-	S	S	M	M	-	L	-
CO2	S	S	L	M	S	-	-	-	S	S	M	M	-	L	-
CO3	S	S	M	M	S	-	-	-	S	S	M	M	L	-	-
CO4	S	S	M	M	S	L	M	-	S	S	M	M	-	L	-
CO5	S	S	L	M	S	L	M	-	S	S	M	M	M	M	M

LIST OF EXPERIMENTS

1. Call establishment in cellular network.
2. Handover in cellular network.
3. Throughput performance for various terrain models, transmission modes, loading, conditions, traffic profiles in LTE network.
4. 5G Communications Link Analysis with Ray Tracing.
5. Wireless Connectivity in the 5G Era for WLAN.
6. MIMO Wireless System Design for 5G.
7. 5G Waveforms generation.
8. 5G Beamforming Design.
9. Frame Structure of 5G technology.

Tools : MATLAB

Course Code		L	T	P	C	IA	EA	TM
Course Name	**SMART ANTENNAS FOR 5G COMMUNICATION**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Electromagnetic Field Theory, Antenna and Wave Propagation							

Course Objectives:

The course should enable the students

1. To Understand the fundamentals of smart antennas and their architecture.
2. To study the different smart antenna configurations.
3. To analyse various Angle of arrival estimation methods.
4. To analyse the MIMO and mmWave antenna design requirements for 5G communication.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	To Familiarize with smart and adaptive antennas.	**K2**
CO2	Apply different adaptive algorithms for 5G antenna.	**K3**
CO3	Understanding the concept of direction of arrival and angle of arrival.	**K2**
CO4	Design of antenna array architectures to meet 5G requirement.	**K4**
CO5	Discuss millimeter wave communication.	**K3**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	L	L	-	-	-	-	-	-	-	-	-	L	-	-
CO2	S	M	M	L	M	-	-	-	-	-	-	-	-	-	-
CO3	M	L	L	-	-	-	-	-	-	-	-	-	M	-	-
CO4	S	S	S	M	M	-	-	-	-	-	-	-	-	M	-
CO5	M	L	L	-	L	-	-	-	-	-	-	-	-	M	L

UNIT-I	**INTRODUCTION TO SMART ANTENNA**	**9 Hours**
Introduction to Smart Antennas, Architecture of a Smart Antenna System: Transmitter and Receiver, Types of Smart Antennas, Benefits and Drawbacks of Smart Antennas, Applications of Smart Antennas.		
UNIT-II	**SMART ANTENNA CONFIGURATIONS**	**9 Hours**
Fixed Sidelobe Cancelling, Retrodirective Arrays, Beamforming, Adaptive Arrays, Butler Matrix, Spatial Filtering with Beamformers, Switched Beam Systems, Multiple Fixed Beam System. Uplink Processing, Diversity Techniques, Angle Diversity, Maximum Ratio Combining, Adaptive Beamforming, Fixed Multiple Beams versus Adaptive Beamforming, Downlink Processing.		
UNIT-III	**ANGLE-OF-ARRIVAL ESTIMATION**	**9 Hours**
Fundamentals of Matrix Algebra, Array Correlation Matrix, AOA Estimation Methods: Bartlett AOA Estimate, Capon AOA Estimate, Linear Prediction AOA Estimate, Maximum Entropy AOA Estimate, Pisarenko Harmonic Decomposition AOA Estimate, Min-Norm AOA Estimate, MUSIC AOA Estimate, ESPRIT AOA Estimate.		
UNIT-IV	**MIMO ANTENNAS**	**9 Hours**
Introduction, Multiple-Antenna MS Design, RAKE Receiver Size, Mutual Coupling Effects, Dual-Antenna Performance Improvements, Downlink Capacity Gains, Principles of MIMO systems: SISO, SIMO, MISO, MIMO, Hybrid antenna array for mm Wave massive MIMO: Massive Hybrid Array Architectures, Hardware Design for Analog Subarray.		
UNIT-V	**mm WAVES**	**9 Hours**
Millimeter-wave Communications – spectrum regulations, deployment scenarios, beam-forming, physical layer techniques, interference and mobility management, Massive MIMO propagation channel models, Channel Estimation in Massive MIMO, Massive MIMO with Imperfect CSI, Multi-Cell Massive MIMO, Pilot Contamination, Spatial Modulation (SM).		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Ahmed El Zooghby, „Smart Antenna Engineering", ARTECH HOUSE, INC, 2005.
2.	Frank B. Gross, „Smart antenna with MATLAB", 2nd Edition, McGraw-Hill, 2015.
3.	Lal Chand Godara , "SMART ANTENNAS" , CRC PR ESS, 2004.
Reference Book(s)	
1.	ShahidMumtaz, Jonathan Rodriguez, Linglong Dai mmWave Massive MIMO: A Paradigm for 5G.

ELECTRONICS AND COMMUNICATION ENGINEERING WITH HONS./MINOR DEGREES

VLSI DESIGN

CURRICULUM & SYLLABUS

For B.E. (Hons.) Electronics and Communication Engineering with

Specialization inVLSI DESIGN

S.No	Year	Sem	Course Code	Course Name	L	T	P	C	IA	EA	TM
1	II	IV		ANALOG AND DIGITAL IC DESIGN	2	1	0	3	40	60	100
2	III	V		MIXED-SIGNAL AND ARCHITECTURE DESIGN	2	1	0	3	40	60	100
3	III	VI		VLSI SIGNAL PROCESSING	2	1	0	3	40	60	100
4	III	VI		VLSI SIGNAL PROCESSING LABORATORY	0	0	2	2	40	60	100
5	IV	VII		MACHINE LEARNING IN VLSI	2	1	0	3	40	60	100
6	IV	VIII		DEVELOPMENT OF MACHINE LEARNING ALGORITHMS IN VLSI	0	0	2	4	40	60	100
Total Credits					**18**						

Course Code		L	T	P	C	IA	EA	TM
Course Name	**ANALOG AND DIGITAL IC DESIGN**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**				V.1.0		
Pre-requisite	Digital System Design, Microprocessor & Microcontrollers							

Course Objectives:
The course should enable the students
1. To learn combinational and sequential circuits in CMOS design.
2. To learn and design using PLDs.
3. To understand the basics of various analog circuits in VLSI design.
4. To learn FPGA design flow.

Course Outcomes:
On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Design of the combinational and sequential building blocks used indigital CMOS VLSI circuits.	**K3**
CO2	Analyze and Implement the simple design with PLDs.	**K3**
CO3	Understand the significance of different analog devices and apply them aptly for different circuits.	**K3**
CO4	Design all basic building blocks like sources, sinks, mirrors, up to layout level.	**K3**
CO5	Understand FPGA design flow.	**K2**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	L	M	-	-	-	-	-	-	-	-	-	M	M	-
CO2	M	L	M	M	-	-	-	-	-	-	-	-	M	M	-
CO3	M	L	M	M	-	-	-	-	-	-	-	-	M	M	-
CO4	M	L	M	M	-	-	-	-	-	-	-	-	M	S	-
CO5	-	L	M	M	-	-	-	-	-	-	-	-	M	S	-

UNIT-I	**COMBINATIONAL AND SEQUENTIAL LOGIC CIRCUITS**	**9 Hours**
Dynamic Logic Gates, Pass Transistor Logic, Power Dissipation, Static Latches and Registers, Dynamic Latches and Registers.		
UNIT-II	**DESIGN EXAMPLES USING PLDs**	**9 Hours**
Design of Universal block, Memory, Floating point, multiplier, Barrel shifter.		
UNIT-III	**INTRODUCTION TO FPGAs**	**9 Hours**
Evolution of programmable devices, FPGA Design flow, Applications of FPGA.		
UNIT-IV	**MOS DEVICES**	**9 Hours**
MOS FET device I/V characteristics, second order effects, Capacitances, body bias effect, Biasing Styles, MOS small signal Model, NMOS verses PMOS devices.		
UNIT-V	**CURRENT MIRROR CIRCUITS**	**9 Hours**
Basic building blocks and basic cells-Switches, active resistors, Current sources and sinks,Current mirrors: Basic current mirror, cascode current mirror, low voltage current mirror,Wilson and Widlar current mirrors, voltage and current references.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Pr Gray and Rg Meyer, Analysis and Design of Analog Integrated Circuits, 5^{th} Edition, Wiley, 2009.
2.	Design of Analog CMOS Integrated Circuit, Behad Razavi McGraw Hill Education, 2nd Edition, 2017.
Reference Book(s)	
1.	John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.
2.	D.A, Patterson And J.L. Hennessy, Computer Organization and Design: Hardware /Software Interface, 4th Edition, Elsevier, 2011.
3.	Geiger, Allen and Stradder, VLSI Design Techniques for Analog and Digital Circuits, Tata McGraw-Hill Education, 2010.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**MIXED-SIGNAL AND ARCHITECTURE DESIGN**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Analog and Digital IC Design, Microprocessor & Microcontrollers							

Course Objectives:

The course should enable the students

1. To understand mixed signal specifications using op-amp.
2. To analyze the comparators circuits and its requirement in VLSI circuits.
3. To understand the basics of various architecture (RISC/FPGA).
4. To understand the building blocks of FPGA/CPLDs.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Design basic cells like OpAmp to meet the mixed signal specifications.	**K4**
CO2	Design comparators to meet the high speed requirements of digital circuitry.	**K4**
CO3	Design of RISC architecture and controller for a specific instruction set.	**K5**
CO4	Understand the building blocks of commercially available FPGA/CPLDs.	**K2**
CO5	Develop models and synthesize targeting for Vertex, Spartan FPGAs.	**K6**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	L	M	-	S	-	-	-	-	-	-	-	M	M	-
CO2	M	L	M	M	S	-	-	-	-	-	-	-	M	M	-
CO3	M	L	M	M	S	-	-	-	-	-	-	-	M	M	-
CO4	M	L	M	M	S	-	-	-	-	-	-	-	M	S	-
CO5	-	L	M	M	S	-	-	-	-	-	-	-	M	S	-

UNIT-I	**OP-AMP CIRCUITS**	**9 Hours**
Basic Building Blocks, OpAmp, Capacitors, Switches, Non-overlapping Clocks, BasicOperation and Analysis, Resistor Equivalence of a Switched Capacitor, Parasitic-SensitiveIntegrator , Parasitic-Insensitive Integrators, Signal-Flow-Graph Analysis, Noise in Switched-Capacitor Circuit.		
UNIT-II	**A/D CONVERTERS**	**9 Hours**
Multi-Bit Successive-Approximatio**n,** Algorithmic (or Cyclic) A/D Converter, Ratio Independent Algorithmic Converter, Pipelined A/D Converters, One-Bit-Per-Stage Pipelined Converter,1.5 Bit Per Stage Pipelined Converter, Pipelined Converter Circuits.		
UNIT-III	**RISC/CISC**	**9 Hours**
Overview of the features of Instruction set architectures of CISC, RISC processor- Building datapath and Control, multicycle implementation.		
UNIT-IV	**FPGAs/CPLDs**	**9 Hours**
Programming Technologies, Commercially available FPGAs: Xilinx‘s Vertex and Spartan, Actel‘s FPGA, Altera‘s FPGA/CPLD, Building blocks ofFPGAs/CPLDs, Configurable Logic block functionality, Routing structures, Input/outputBlock, Impact of logic block functionality on FPGA performance, Model for measuring delay.		
UNIT-V	**CASE STUDY**	**9 Hours**
Applications using Kintex-7, Virtex-7, Artix-7-Zynq7000 Architecture.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	David A Johns, Ken Martin: Analog IC design, Wiley 2008.
2.	John V. Old Field, Richrad C. Dorf, Field Programmable Gate Arrays, Wiley, 2008.
3.	D.A, Patterson And J.L. Hennessy, Computer Organization and Design: Hardware /Software Interface, 4th Edition, Elsevier, 2011.
Reference Book(s)	
1.	Amano, Hideharu, Principles and Structures of FPGAs, First Edition, Springer, 2018.
2.	Xilinx Inc, Vivado Design Suite User Guide, 2021.
3.	Data sheets of Artix-7, Kintex-7, Virtex-7.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**VLSI SIGNAL PROCESSING**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital Signal Processing, Mixed-Signal and architecture Design							

Course Objectives:

The course should enable the students

1. To analyze various VLSI- DSP algorithms in FIR and IIR filters.
2. To analyze algorithm for iteration.
3. To analyze the clocking concepts in DSP Architectures.
4. To implement DSP algorithms in VLSI.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Analyze the critical path, iteration bound using LPM and MCM algorithm.	**K4**
CO2	Analyze Digital filters.	**K4**
CO3	Apply Retiming, Folding and Unfolding Techniques and Synthesize systolic arrangements.	**K4**
CO4	Apply Cook Toom and Winograd algorithm and design lookahead and cluster pipelining.	**K4**
CO5	Ability to modify the existing or new DSP architectures suitable for VLSI.	**K6**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	M	M	S	S	-	-	-	-	-	-	-	S	S	-
CO2	S	M	M	S	S	-	-	-	-	-	-	-	S	S	-
CO3	S	M	M	S	S	-	-	-	-	-	-	-	S	S	-
CO4	S	M	M	S	S	-	-	-	-	-	-	-	S	S	-
CO5	S	M	M	S	S	-	-	-	-	-	-	-	S	S	-

UNIT-I	**INTRODUCTION TO DSP SYSTEMS**	**9 Hours**
Introduction; representation of DSP algorithms: Block Diagram, signal flow graph, data flow graph, dependence graph.		
UNIT-II	**ITERATION BOUND**	**9 Hours**
Introduction - Loop Bound and Iteration Bound - Algorithms for Computing Iteration Bound: Longest Path Matrix and Multiple Cycle Mean algorithms - Iteration Bound of Multi-rate Data Flow Graphs.		
UNIT-III	**PIPELINING AND PARALLEL PROCESSING**	**9 Hours**
Pipelining and parallel processing of FIR digital filters, pipeline interleaving in digital filters: signal and multichannel interleaving.		
UNIT-IV	**RETIMING, UNFOLDING AND FOLDING**	**9 Hours**
Retiming techniques; algorithm for unfolding, Folding transformation, systolic architecture design, systolic array design methodology.		
UNIT-V	**FAST CONVOLUTION, FILTERS AND TRANSFORMS**	**9 Hours**
Cook-toom algorithm, modified cook-toom algorithm, Winogard algorithm, iterated convolution Algorithm strength reduction in filters and transforms.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Keshab k. Parhi, "VLSI Digital Signal Processing Systems: Design and Implementation", Wiley, inter science.
Reference Book(s)	
1.	John G. Proakis, Dimitris K Manolakis, Digital Signal Processing: Principles, Algorithms and Applications, Prentice Hall, Fourth Edition, 2015.
2.	Mohammed Ismail and Terri Fiez, Analog VLSI Signal and Information Processing,McGraw-Hill, 2014.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**VLSI SIGNAL PROCESSING LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Digital Signal Processing Lab, CASD Lab							

Course Objectives:

The course should enable the students

1. To provide design concepts on implementation of DSP algorithms in FPGA.
2. To provide insights into design and implementation of image processing.
3. To provide insight on communication protocols used in FPGA domain.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Ability to interface external peripherals with a programmable platform.	**K5**
CO2	Ability to design and implement DSP algorithms into FPGA.	**K6**
CO3	Ability to analyze and optimize the HDL Code from MATLAB.	**K4**
CO4	Interpret the ethical principles in engineering practice.	**K3**
CO5	Express the Engineering activities with effective presentation and report.	**K5**
CO6	Analyse and develop innovative findings with appropriate technological / research citation.	**K6**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2	PSO 3
CO1	M	S	S	S	S	-	-	-	-	-	-	-	S	S	-
CO2	S	S	S	S	S	-	L	-	-	-	-	-	S	S	-
CO3	S	S	S	S	S	-	L	-	-	-	-	-	S	S	-
CO4	-	-	-	-	-	-	-	S	S	M	-	M	-	-	S
CO5	-	-	-	-	-	-	-	S	S	M	-	M	-	-	S
CO6	-	-	-	-	-	-	-	S	S	M	-	M	-	-	S

LIST OF EXPERIMENTS	
1.	Implementation of sampling of input signal and display in FPGA.
2.	Implement on DCT, FFT using FPGA.
3.	Synthesize and implement FIR filter and IIR filter Verilog /VHDL.
4.	Experiments on Multirate processing, Bus architectures using FPGA.
5.	Implementation of Application Platforms in FPGA boards.
6.	Image Processing – Image Enhancement, Edge detection.
Tools	
1	MATLAB/HDL

Course Code		L	T	P	C	IA	EA	TM
Course Name	**MACHINE LEARNING IN VLSI**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	Syllabus Revision					V.1.0	
Pre-requisite	VLSI Design							

Course Objectives:

The course should enable the students

1. To provide a concise introduction to the fundamental concepts of Machine Learning.
2. To explore the different Deep learning techniques including ensemble methods.
3. To gain the knowledge of machine learning to apply in VLSI design.
4. To focus on the backend design challenges, including mask synthesis and physical verification.
5. To study how machine learning can help in physical design.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Understand basic applications and issues of Machine Learning.	**K2**
CO2	Analyze various Machine Learning and Deep Learning techniques and algorithms.	**K4**
CO3	Apply the knowledge of machine learning in VLSI field.	**K4**
CO4	Apply the machine learning in physical verification and mask synthesis.	**K4**
CO5	Predict the machine learning model for physical design such as placement and routing.	**K4**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	S	M	M	S	-	-	-	-	-	-	-	S	S	-
CO2	L	S	S	S	S	-	-	-	-	-	-	-	S	S	-
CO3	L	S	S	S	S	-	-	-	-	-	-	-	S	S	-
CO4	M	M	M	M	S	-	-	-	-	-	-	-	S	S	-
CO5	M	M	M	M	S	-	-	-	-	-	-	-	S	S	-

UNIT-I	INTRODUCTION TO MACHINE LEARNING TECHNIQUES	9 Hours
Basics of machine learning Applications of Machine Learning, processes involved in Machine Learning, Supervised Learning, Unsupervised Learning and Reinforcement Learning, Evaluation Measures: confusion matrix, precision, recall, F-Score, ROC-Curve, Cross-Validation.		
UNIT-II	**DEEP LEARNING: CONVOLUTIONAL NEURAL NETWORKS**	**9 Hours**
Feed forward networks, Activation functions, back propagation in CNN, optimizers, batch normalization, convolution layers, pooling layers, fully connected layers, dropout, Examples of CNNs.		
UNIT-III	**MACHINE LEARNING IN VLSI DESIGN**	**9 Hours**
A Taxonomy for Machine Learning in VLSI Design Energy-Efficient Design of Advanced Machine Learning Hardware.		
UNIT-IV	**MACHINE LEARNING APPLICATIONS IN IC VERIFICATION**	**9 Hours**
ML in Physical Verification , Layout Feature Extraction and Hotspot Detection, ML in Mask Synthesis, Mask Synthesis Flow, Mask Synthesis and Verification , Machine Learning for Clock Optimization, Decision tree induction algorithm , Importance of Lithographic Patterning Process. Machine Learning for Lithography.		
UNIT-V	**MACHINE LEARNING APPLICATIONS IN IC PHYSICAL DESIGN**	**9 Hours**
Machine Learning for Physical Design: Modern VLSI Layouts, Placement and Routing Example, Correlation between Placement and Routing, Machine Learning for Placement, Routing, Mask Synthesis and Verification, VLSI Placement and Algorithm, Challenges for VLSI Design, Routability-Driven Placement, Prediction of Routing Congestion, Challenges of Routing Congestion, Application Specific ML.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Ethem Alpaydin, Introduction to Machine Learning, PHI.
2.	Elfadel, Ibrahim M., Duane S. Boning, and Xin Li, eds. Machine Learning in VLSI Computer-Aided Design. Springer, 2019.
Reference Book(s)	
1.	Bishop, C. (2006). Pattern Recognition and Machine Learning. Berlin: Springer-Verlag.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**DEVELOPMENT OF MACHINE LEARNING ALGORITHMS IN VLSI**	0	0	2	4	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite								

Course Objectives:

The course should enable the students

1. To carry out research / investigation and development work and to solve practical problems in the field of VLSI.
2. To Write and present a substantial technical report / document in the field of VLSI.
3. To Demonstrate the Research findings the VLSI area.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Synthesize knowledge and skills previously gained and apply to an in-depth study and execution of new technical problems in the area of VLSI.	**K3**
CO2	Define specification, adopt new VLSI methodologies and analyze to produce a suitable research design and justify the design.	**K5**
CO3	Demonstrate the research findings through hardware and software tools.	**K5**
CO4	Present the findings of their technical solution in a written report.	**K6**
CO5	Publish the work in reputed journals and International Conferences.	**K6**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	S	S	S	S	-	-	-	-	-	-	M	S	S	-
CO2	S	S	S	S	S	S	S	-	-	-	-	S	S	S	-
CO3	-	-	S	S	S	S	S	-	-	-	S	M	S	S	-
CO4	-	-	-	-	-	-	-	S	S	M	-	S	-	-	S
CO5	-	-	-	-	-	-	-	S	S	M	-	M	-	-	S

PRACTICAL SYLLABUS:	
The project topic should be selected to ensure the satisfaction need to establish a direct link between education, national development and productivity and reduce the gap between the world of work and the world of study. The project should have the following	
1.	Relevance to social needs of society.
2.	Relevance to value addition to existing facilities in the institute.
3.	Relevance to industry need.
4.	Problems of national importance.
5.	Research and development in various domain.
The student should complete the following for Mini Project	
1	Literature survey and Problem Definition.
2	Motivation for study and Objectives.
3	Preliminary design approaches.
4	Development and Verification.
5	Report and presentation.
6	Presenting the work in Reputed journals / International Conferences.
Examples	
1	Design and Development of a Bayes Classifier for Two-Class and Multi-Class Classification.
2	Design and Development of a Deep Learning Classifier Model.
3	Design and Development of Clustering Algorithms.
4	Develop the algorithms using Raspberry Pi.

ELECTRONICS AND COMMUNICATION ENGINEERING WITH HONS./MINOR DEGREES

IMAGE PROCESSING AND COMPUTER VISION

CURRICULUM & SYLLABUS

For B.E. (Hons.) Electronics and Communication Engineering with Specialization in IMAGE PROCESSING ANDCOMPUTER VISION

S.No	Year	Sem	Course Code	Course Name	L	T	P	C	IA	EA	TM
1	II	IV		MULTIDIMENSIONAL DIGITAL SIGNAL PROCESSING	3	0	0	3	40	60	100
2	III	V		DIGITAL IMAGE PROCESSING	3	0	0	3	40	60	100
3	III	V		COMPUTER VISION	3	0	0	3	40	60	100
4	III	VI		IMAGE ANALYSIS	3	0	0	3	40	60	100
5	IV	VI		DEVELOPMENT TOOLS FOR IMAGE AND VIDEO PROCESSING LABORATORY	0	0	2	2	40	60	100
6	IV	VII		PATTERN RECOGNITION AND MACHINE LEARNING	3	0	0	3	40	60	100
7	IV	VII		DIGITAL IMAGE PROCESSING LABORATORY	0	0	2	2	40	60	100
Total Credits					**19**						

Course Code		L	T	P	C	IA	EA	TM
Course Name	**MULTIDIMENSIONAL DIGITAL SIGNAL PROCESSING**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Basic Engineering Mathematics, Signals and System, Digital Signal processing							

Course Objectives:

The course should enable the students

1. To understand one-dimensional and two-dimensional signals.
2. To gain a better understanding of the sampling theorem and reconstruction, it's important to consider both down sampling and up sampling, which involve using different sampling techniques.
3. To gain knowledge of a discrete space transform for Fourier transform and fast Fourier transform.
4. To understand and analyze wavelet transformations and 2D Z transformations.
5. To acquire knowledge and comprehend the design of FIR and IIR filters.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Apply the knowledge of one dimensional and two dimensional signals.	**K2**
CO2	Apply concepts of sampling theorem and reconstruction.	**K3**
CO3	Explain the basic concepts of Fourier transform and fast Fourier transform.	**K2**
CO4	Describe different wavelet transform and Z transforms.	**K4**
CO5	Design and implementation of FIR and IIR filters.	**K4**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O 1	PS O2	PS O3
CO1	S	M	M	S	L	L	M	-	-	-	L	M	S	L	M
CO2	M	S	M	-	-	-	-	-	-	-	S	M	M	M	L

CO3	S	M	M	-	-	-	-	-	L	M	L	M	M	S	L
CO4	M	S	S	-	M	L	M	-	-	-	L	L	S	M	L
CO5	M	M	M	-	L	-	S	-	-	-	M	M	S	M	M

UNIT-I	**INTRODUCTION**	**9 Hours**
One Dimensional and Two Dimensional Signals and Systems- Separable Signals- Periodic Signals - General Periodicity - 1D & 2-D Discrete Space Systems. 1 D & 2D Convolution. Continuous Space Fourier Transform.		
UNIT-II	**SAMPLING IN ONE AND TWO DIMENSIONS**	**9 Hours**
Ideal Rectangular Sampling – Sampling Theorem. General Case – Change of Sampling Rate - Sampling Lattice – Reconstruction – Down sampling and Up sampling by integers.		
UNIT-III	**DISCRETE SPACE TRANSFORMS**	**9 Hours**
1D & 2D Discrete Fourier Series - 1D & 2-D Discrete Fourier transform- Properties – Discrete Time Fourier Transform- Short Time Fourier Transform – Fast Fourier Transform.		
UNIT-IV	**WAVELET TRANSFORM**	**9 Hours**
Gabor Transform. Two Dimensional Systems and Z-Transforms - 2D Spatial Systems – Z-Transforms - Regions of Convergence - Linear Mapping of Variables - Inverse Z-Transform.		
UNIT-V	**FILTER DESIGN FUNDAMENTALS**	**9 Hours**
Ideal and finite order Filters - Two Dimensional Filter Design - FIR and IIR filter design - Window Functions - Rectangular and Rotated windows.		
	Total Hours	**45 Hours**

Text Book(s)

1. Dan E. Dudgeon and Russell M. Mersereau, "Multidimensional Digital Signal Processing", Prentice-hall, 1984.
2. John W. Woods, “Multidimensional Signal, Image, and Video Processing and Coding”, Second Edition, Academic Press, Elsevier Inc. 2012.
3. Steven W. Smith, “Digital Signal Processing – A Practical Guide for Engineers and Scientists”, Newnes Elsevier Science, 2013.

Reference Book(s)

1. Alan V Oppenheim and Schafer Ronald W, “Digital Signal Processing”, Prentice Hall, 2008.
2. Sanjit K Mitra, “Digital Signal Processing: A Computer-Based Approach”, Third Edition, McGraw-Hill Companies, 2005.

Course Code		**L**	**T**	**P**	**C**	**IA**	**EA**	**TM**
Course Name	**DIGITAL IMAGE PROCESSING**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Basic Digital Electronics, Signals and System, Digital Signal Processing							

Course Objectives:

The course should enable the students

1. To acquire knowledge about image representation and image digitization.
2. Gain insight into the fundamental principles of image transformation, smoothing, and restoration.
3. To examine different image segmentation and graph cut algorithms.
4. To acquire knowledge and identify different types of color image processing.
5. To study various color transformations.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	**Description**	**Highest Bloom's Taxonomy**
CO1	Apply the knowledge of image representation, image digitization.	**K3**
CO2	Apply concepts of image transformation, smoothing and image restoration.	**K3**
CO3	Explain the basic concepts of image segmentation and graph cut algorithm.	**K2**
CO4	Apply and identify color image processing.	**K4**
CO5	Describe and implement color transformation.	**K4**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	**Program Outcomes (POs)**												**Program Specific Outcomes (PSOs)**		
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO2**	**PSO3**
CO1	M	S	M	-	-	-	-	L	L	-	L	M	M	L	M
CO2	M	L	L	M	-	L	M	-	M	-	M	M	M	L	S
CO3	M	M	M	-	L	-	-	L	-	-	S	L	S	M	S
CO4	S	S	L	-	M	-	M	-	M	-	L	L	S	M	L
CO5	S	L	M	-	L	-	L	-	L	-	L	M	M	M	L

UNIT-I	**IMAGE REPRESENTATION AND PROPERTIES**	**9 Hours**
Introduction - Image Representation - Image Digitization - Digital Image Properties – Discrete Fourier Transform - Image Pre-Processing in Spatial and Frequency Domain.		
UNIT-II	**IMAGE TRANSFORMATION**	**9 Hours**
Pixel Brightness Transformation - Geometric Transformations - Local Preprocessing - Image Smoothing – Edge Detectors - Corner Detectors – Image Restoration.		
UNIT-III	**IMAGE SEGMENTATION**	**9 Hours**
Thresholding – Edge- Based Segmentation – Region Based Segmentation, Mean shift segmentation, Graph cut algorithm– Matching – Evaluation Issues in Segmentation, Watersheds.		
UNIT-IV	**COLOR IMAGE PROCESSING**	**9 Hours**
Color Fundamentals – Color Models – Pseudocolor Image Processing – Basics of Full Color Image Processing.		
UNIT-V	**COLOR TRANSFORMATIONS**	**9 Hours**
Smoothing and Sharpening – Color Segmentation – Noise in Color Images.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Rafael C. Gonzalez and Richard E. Woods, “Digital Image Processing”, Third Edition, Pearson Education, 2009.
2.	Milan Sonka, Vaclav Hlavac and Roger Boyle, “Image Processing, Analysis and Machine Vision”, Third Edition, Cengage Learning, 2007.
Reference Book(s)	
1.	William K. Pratt, “Digital Image Processing”, Fourth Edition, Wiley Interscience, 2007
2.	Anil K Jain, “Fundamentals of Digital Image Processing”, Prentice Hall, 1989.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**COMPUTER VISION**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Engineering Mathematics, Knowledge, Digital Electronics, Digital Image Processing.							

Course Objectives:

The course should enable the students

1. To Gain knowledge on how images are formed requires understanding how they are formed.
2. To analyze the idea of camera models and calibration.
3. To learn and understand the different types of Local Feature Detectors and Descriptors.
4. To acquire knowledge of multiplane methods in pose Estimation.
5. To learn and understand the Stereo and Multi-view Geometry.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Apply the knowledge of image formation.	**K3**
CO2	Apply concepts of camera models and calibration.	**K2**
CO3	Apply the knowledge of Local Feature Detectors and Descriptors.	**K3**
CO4	Apply and identify calibration methods.	**K4**
CO5	Describe and implement for Stereo and Multi-view Geometry.	**K4**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	M	S	M	L	M	M	-	L	M	M	M	S	M	M
CO2	M	L	M	-	L	L	-	-	-	M	-	L	M	L	L
CO3	S	M	S	M	M	L	-	M	-	L	L	M	S	M	M
CO4	M	M	L	M	L	M	-	-	-	-	M	-	L	S	M
CO5	S	L	L	S	M	L	-	L	-	M	L	-	M	L	L

UNIT-I	**IMAGE FORMATION**	**9 Hours**
Geometric image formation, Photometric image formation.		
UNIT-II	**CAMERA MODELS AND CALIBRATION**	**9 Hours**
Camera Projection Models – Orthographic, Affine, Perspective, Projective models. Projective Geometry: Transformation of 2D and 3D, Internal Parameters, Lens Distortion Models.		
UNIT-III	**LOCAL FEATURE DETECTORS AND DESCRIPTORS**	**9 Hours**
Hessian corner detector, Harris Corner Detector, LOG detector, DOG detector, SIFT, PCA-SIFT, GLOH, SURF, HOG, Pyramidal HOG, PHOW.		
UNIT-IV	**CALIBRATION METHODS**	**9 Hours**
Linear, Direct, Indirect and Multiplane methods - Pose Estimation.		
UNIT-V	**STEREO AND MULTI-VIEW GEOMETRY**	**9 Hours**
Epipolar Geometry, Rectification and Issues related to Stereo, General Stereo with E Matrix Estimation, Stratification for 2 Cameras, Extensions to Multiple Cameras, Self-Calibration with Multiple Cameras, 3D reconstruction of cameras and structures, Three View Geometry.		
	Total Hours	**45 Hours**

Text Book(s)	
1.	Forsyth and Ponce, "Computer Vision – A Modern Approach", Second Edition, Prentice Hall, 2011.
2.	Emanuele Trucco and Alessandro Verri, "Introductory Techniques for 3-D Computer Vision", Prentice Hall, 1998.
Reference Book(s)	
1.	Olivier Faugeras, "Three Dimensional Computer Vision", MIT Press, 1993.
2.	Richard Szeliski, "Computer Vision: Algorithms and Applications", Springer, 2011.
3.	Milan Sonka, Vaclav Hlavac and Roger Boyle, "Image Processing, Analysis and Machine Vision", Third Edition, CL Engineering, 2013.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**IMAGE ANALYSIS**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Signals and System, Digital Signal Processing, Digital Image Processing.							

Course Objectives:

The course should enable the students

1. To learn and understand the image morphology and segmentation.
2. To analyze the performance of feature extraction and measurement.
3. To understand various image representations and descriptions.
4. To learn and understand the Texture representation and analysis
5. To become familiar image understanding.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Analyze given images and identify image morphology and segmentation.	**K3**
CO2	Apply the concepts of feature extraction and measurement.	**K2**
CO3	Describe various image representations and descriptions.	**K4**
CO4	Apply the concepts of texture description and recognition methods	**K3**
CO5	Analyze the point distribution models of image understanding.	**K4**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	S	M	M	L	-	M	-	L	M	M	L	S	M	M
CO2	M	M	S	S	M	L	-	L	M	-	M	M	M	S	L
CO3	S	M	L	M	L	-	-	M	-	L	L	L	M	L	S
CO4	M	S	L	M	L	M	M	-	L	-	L	M	L	M	M
CO5	M	M	L	S	M	-	L	-	L	-	M	L	S	M	M

UNIT-I	IMAGE MORPHOLOGY	9 Hours
Binary and gray scale Morphological analysis - Dilation and Erosion - Skeletons and Object Marking – Granulometry – Morphological Segmentation.		
UNIT-II	**FEATURE EXTRACTION**	**9 Hours**
Global image measurement, feature specific measurement, characterizing shapes, Hough Transform.		
UNIT-III	**REPRESENTATION AND DESCRIPTION**	**9 Hours**
Region Identification – Contour Based and Region Based Shape Representation and Description – Shape Classes. Flexible shape extraction: active contours, Flexible shape models: active shape and active appearance.		
UNIT-IV	**TEXTURE REPRESENTATION AND ANALYSIS**	**9 Hours**
Statistical Texture Description – Syntactic Texture Description Methods – Hybrid Texture description Methods – Texture Recognition Method Applications.		
UNIT-V	**IMAGE UNDERSTANDING**	**9 Hours**
Control Strategies –RANSAC – Point Distribution Models – Scene Labeling and Constraint Propagation. Image Data Compression: Predictive Compression Methods – Vector Quantization, DCT, Wavelet, JPEG.		
	Total Hours	**45 Hours**

Text Book(s)

1.	Milan Sonka, Vaclav Hlavac and Roger Boyle, “Image Processing, Analysis and Machine Vision”, Third Edition, Cengage Learning, 2007.
2.	Tinku Acharya, Ajoy K Ray,“Image Processing- Principles and Applications”, Wiley, 2005.
3.	John C. Russ, “The Image Processing Handbook”, Sixth Edition, CRC Press, 2007.

Reference Book(s)

1.	Mark S. Nixon, Alberto S. Aguado, “Feature Extraction and Image Processing”, Second Edition, Academic Press, 2008.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**DEVELOPMENT TOOLS FOR IMAGE AND VIDEO PROCESSING LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite								

Course Objectives:

1. To understand the importance of Open Source Tools for Image Processing and Computer Vision.
2. Familiarize the Beagle Board XM and Beagle Bone Black.
3. To study and implement NI Vision System Camera with LabView.
4. To learn and understand the iRobot for Matlab programming for Navigation scenario.
5. To Design and implement Lego Mindstorm Simple Robot Programming.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Able to understand OpenSource Tools for Image Processing and Computer Vision.	**K5**
CO2	Able to Implement and design NI Vision System Camera with LabView.	**K6**
CO3	Able to Implement and design of Lego Mindstorm Simple Robot Programming.	**K6**
CO4	Able to Implement and design of iRobot for Matlab programming for Navigation scenario.	**K6**
CO5	Able to Implement Lego Mindstorm Simple Robot Programming.	**K5**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	M	S	S	M	S	-	M	-	M	-	M	M	S	S	S
CO2	S	M	S	M	M	-	-	S	-	M	L	M	S	M	M
CO3	M	S	S	M	M	-	S	-	M	M	M	L	M	M	S
CO4	S	S	S	M	M	-	-	M	-	-	L	L	M	M	M
CO5	M	M	M	S	S	-	M	-	S	L	M	M	S	M	M

LIST OF EXPERIMENTS	
1	Open Source Tools for Image Processing and Computer Vision - OpenCV, OpenGL
2	BeagleBoard XM and BeagleBone Black - Application Development using OpenCV/Java for Image Processing concepts
3	NI Vision System Camera with LabView - Data Acquisition - Basic Image Processing concepts
4	iRobot - Matlab programming for Navigation scenario Lego Mindstorm
5	iRobot - Simple Robot Programming - Object

Course Code		L	T	P	C	IA	EA	TM
Course Name	**PATTERN RECOGNITION AND MACHINE LEARNING**	3	0	0	3	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite	Knowledge of Machine Learning Fundamentals, Digital Image Processing							

Course Objectives:

The course should enable the students

1. To learn and understand the concept of pattern recognition and classification.
2. Describe and analyze the kernel methods and support vector machines.
3. To learn and analyze the graphical models, mixture models.
4. To understand the applications of principal component analysis and Markov models.
5. To learn the concept of deep learning and Deep Architecture.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Apply the concept of pattern recognition and classification.(K3)	**K2**
CO2	Implements the kernel methods and support vector machines	**K4**
CO3	Manipulate the graphical models, mixture models.	**K4**
CO4	Apply the concepts of principal component analysis and Markov models.	**K3**
CO5	Categorizes deep learning and Deep Architecture.	**K4**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)												Program Specific Outcomes (PSOs)		
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	M	L	M	L	-	-	-	M	L	L	M	M	M	S
CO2	M	M	M	S	L	-	M	L	-	-	M	L	L	L	M
CO3	S	M	S	M	L	-	-	-	M	L	L	M	S	M	L
CO4	S	M	L	L	M	-	L	-	M	-	L	L	M	M	M
CO5	M	L	M	M	L	-	-	-	-	L	M	L	M	L	L

UNIT-I	**INTRODUCTION**	**9 Hours**
Pattern recognition systems - The design cycle - Learning and adaptation -Linear models for classification - Discriminant functions (Two and multiple classes) - Least squares classification functions - Fisher's discriminant analysis for two and multiple classes - Probabilistic generative models - Maximum likelihood solution.		
UNIT-II	**KERNEL METHODS**	**9 Hours**
Constructing kernels - Kernel density estimators - Nearest neighbor methods - Gaussian processes and classification - Sparse kernel machines - Support vector machines - Maximum margin classifiers - Multi-class support vector machines.		
UNIT-III	**GRAPHICAL MODELS**	**9 Hours**
Bayesian networks - Generative models - Linear Gaussian models - Conditional independence. Mixture models and Expectation maximization: K-means clustering - Mixtures of Gaussian - Expectation maximum for Gaussian mixtures.		
UNIT-IV	**CONTINUOUS LATENT VARIABLES**	**9 Hours**
Principal component analysis - Applications of principal component analysis - PCA for higher dimensional data - Factor analysis. Sequential data: Markov models - Hidden Markov models - Maximum likelihood for HMM - Forward-backward algorithm. Combining models - Tree based models - Decision trees - Classification and regression trees (CART).		
UNIT-V	**DEEP LEARNING FOR HIGH-LEVEL VISION**	**9 Hours**
Introduction to Deep Learning, main types of Deep Architectures, Application of Deep Learning Architecture to Computer Vision.		
	Total Hours	**45 Hours**

Text Book(s)

1.	Christopher M. Bishop, "Pattern Recognition and Machine Learning", Springer, 2006.
2.	Richard O. Duda, Peter E. Hart and David G. Stork, "Pattern Classification", Second Edition, John Wiley and Sons, 2003.

Reference Book(s)

1.	Earl Gose, Richard Johnsonbaugh and Steve Jost, "Pattern Recognition and Image Analysis", Prentice Hall of India, 2002.

Course Code		L	T	P	C	IA	EA	TM
Course Name	**DIGITAL IMAGE PROCESSING LABORATORY**	0	0	2	2	40	60	100
Course Category	PROFESSIONAL SPECIALIZED COURSE	**Syllabus Revision**					V.1.0	
Pre-requisite								

Course Objectives:

The course should enable the students

1. Study the image fundamentals, mathematical transforms necessary for image processing.
2. To understand the Display of an Image, Negative of an Image (Binary & Gray Scale).
3. To implement the various techniques of image enhancement, reconstruction, compression and segmentation.
4. To implement sampling and reconstruction procedures.
5. To design image processing systems.

Course Outcomes:

On completion of the course, the student will be able to

Course Outcomes	Description	Highest Bloom's Taxonomy
CO1	Able to understand the image fundamentals, mathematical transforms necessary for image processing.	**K4**
CO2	Demonstrate knowledge about the Contrast stretching of a low contrast image, Histogram, and Histogram Equalization.	**K6**
CO3	Able to identify, formulate and solve image smoothing and sharpening problems.	**K6**
CO4	Able to identify and formulate image Edge Detection and compression problems.	**K4**
CO5	Able to implement image restoration techniques.	**K3**

Correlation between Course Outcomes (COs) and Program Outcomes (POs):

COs	Program Outcomes (POs)											Program Specific Outcomes (PSOs)		
	PO 1	PO2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2	PSO3
CO1	S	S	-	M	S	-	M	-	M	-	M	M	S	M	M
CO2	S	S	S	-	M	-	-	S	-	M	-	M	S	S	M
CO3	M	S	S	M	M	-	S	-	M	M	M	-	M	S	S
CO4	S	M	M	S	M	-	-	M	-	-	-	-	M	M	M
CO5	M	S	S	M	S	-	M	-	S	-	M	M	S	M	S

LIST OF EXPERIMENTS	
1.	To study the Image Processing concept.
2.	Simulation and Display of an Image, Negative of an Image (Binary & Gray Scale).
3.	Implementation of Relationships between Pixels.
4.	Implementation of Transformations of an Image.
5.	Contrast stretching of a low contrast image, Histogram, and Histogram Equalization.
6.	Computation of Mean, Standard Deviation, Correlation coefficient of the given Image.
7.	Implementation of Image Smoothing Filters (Mean, Median filtering of an Image).
8.	Implementation of image sharpening filters and Edge Detection using Gradient Filters.
9.	Image Compression by DCT,DPCM, HUFFMAN coding.
10.	Implementation of image restoration techniques.