PHD4001EC	RESEARCH METHODOLOGIES IN ECE					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	100Marks	CIE		-	

UNIT-I

Introduction to Research Methodology: Objectives and Motivation of Research, Types of Research, Research Approaches, Significance of Research, Research and Scientific Method, Importance of Research Methodology, Research Process, Criteria and characteristics of good research, challenges encountered by researchers and benefits of research.

Defining the Research Problem: Defining Research Problem, Problem Formulation, necessity of defining the Problem, Techniques involved in defining a Problem.

Literature Review: Importance of Literature review, sources of Information, Assessment of quality of Journals and research Articles, Critical appraisal of Literature Review, arriving final problem

UNIT-II

Research Design: Meaning of Research Design, need of Research Design, Important concepts related to Research Design, Different Research Designs, Basic Principles of Experimental Design, Developing a Research Plan, Design of Experimental Set-up, Use of Standards and Codes.

Research Tools: Methods to search required information effectively, citation styles, reference management, software's (Zotero/ Mendeley /Endnote).

Plagiarism: Plagiarism & self-plagiarism consequence of plagiarism, unintentional plagiarism, copyright infringement. Software's for detection of plagiarism (Turnitin/iThenticate).

UNIT-III

Data Collection: data types, collection of primary data, secondary data, Data organization, data validation, methods of data grouping, diagrammatic representation of data, Graphical representation of data. Sample design and population.

Data Analysis: Mathematical modeling: definition of model, types of models, mathematical model and modeling of engineering systems, Probability and its distribution, hypothesis testing, Test for significance: Chi-square, Student t-test, Regression modeling, ANOVA, F-test, Time Series analysis. Analysis of Data, role of Statistics in Data Analysis, Parametric v/s non-Parametric methods, Descriptive Statistics. Concept of simulation and simulation methods etc.

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UNIT-IV

Research Report Writing: Format of the research report, preparation of Synopsis in an effective manner, thesis writing, arrangements of chapters and finalization of chapter names. Ethics and moral issues related to research and publishing, References/Bibliography, Patents etc

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Technical paper writing: Layout of a research paper, impact factor of journals, research quality indicators (citations/h-index/i10 index/cite score, etc.), research profile building (Orcid-id/Google Scholar id/PubMed/Scopus id, etc.) **Research Proposal Preparation:** Funding agencies in India and across the Globe, writing research proposal, Writing Research Grant Proposal: Minor and Major Research proposals (UGC, DST and AICTE).

UNIT-V
Advancements and scope in Research Trends and challenges in Signal and Image processing, SoC design in VLSI/Embedded Systems, IoT and Cyber Security, Research Challenges in Remote sensing and GNSS, 5G and beyond communications, Concepts of data analysis and visualization with AI/ML, Applied Electromagnetics and RF Circuits

Suggested Reading:

1	C.R Kothari, Research Methodology, Methods & Technique; New Age International Publishers, 2004
2	R. Ganesan, Research Methodology for Engineers, MJP Publishers, 2011
3	Vijay Upagade and Aravind Shende, Research Methodology, S. Chand & Company Ltd., New Delhi, 2009
4	P. Ramdas and Wilson Aruni; Research and Writing across the disciplines; MJP Publishers, Chennai, 2009
5	Margaret Cargill and Patrick O'Connor: Writing Scientific Research Articles Strategy and Steps, A John Wiley & Sons, Ltd., Publication, 2009
6	MLA Handbook for Writers of Research Papers, The modern language association of America, New York 2009

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PHD4002EC	Hardware Acceleration of Machine Learning					
Pre-requisites	Computer Organization, Micro Processors		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To introduce the fundamentals of parallel computing and explore different parallel architectures
2	To impart practical knowledge of MPI and CUDA programming
3	To develop an understanding of deep learning models
4	To analyze and compare accelerator architectures
5	To provide hands-on experience with optimization techniques

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Explain key concepts in parallel computing including speedup, efficiency, scalability, and memory models
CO-2	Develop parallel programs using MPI for message-passing systems, utilizing point-to-point and collective communication effectively.
CO-3	Write CUDA programs that use thread hierarchies and memory management techniques to accelerate image-processing tasks.
CO-4	Compare and evaluate different accelerator architectures (CPU, GPU, TPU, FPGA) for deploying and training deep neural networks.
CO-5	Understand optimization techniques such as pruning, and batching to improve the performance of CNNs on various platforms.

UNIT–I
Introduction to Parallel Computing: Motivation and Concepts, Types of Parallel Architectures: SIMD, MIMD, Shared vs. Distributed Memory, Speedup, Efficiency, Scalability, Introduction to MPI & Cluster Setup (local or cloud-based), MPI Basics: MPI Unit, MPI Comm_rank, MPI_Comm_size, MPI_Finalize, Point-to-Point Communication: MPI_Send, MPI_Recv, Collective Communication: MPI_Bcast, MPI_Reduce, MPI_Scatter, MPI_Gather, Synchronization and Barriers, Problem Decomposition: Domain vs. Functional, Load Balancing Techniques, Introduction to Parallel Matrix Multiplication using MPI, Debugging and Profiling MPI Programs

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UNIT–II
Overview of CUDA Architecture: CUDA cores and the GPU structure, SIMD (Single Instruction, Multiple Data) concept, **Efficient Memory Management,** Managing device memory, memory allocation strategies, Memory coalescing and data alignment, **Optimizing Performance with Shared Memory,** Shared memory usage for fast data access, Optimizing computational kernels using shared memory, **Reducing Latency,** Asynchronous memory copy, Overlapping computation and communication **CUDA Programming Basics:** Threads, blocks, and grids, Memory hierarchy (Global, Shared, Local, Constant, Texture memory), CUDA execution model (kernels and thread synchronization), Writing simple CUDA programs, Case Study: CUDA Program for Processing for Image Processing

UNIT–III
Overview of Machine and Deep Learning: Basics of Deep Neural Network (DNN), Training and Inference of DNNs, Forward and Backward propagation Different types, **Networks:** Fully Connected Networks, Convolutional Neural Networks, Matrix Multiplication, Applications in different domains: Computer Vision, Image Classification.

UNIT-IV
Accelerator architectures for DNNs: Introduction to Systolic Array for Matrix-Multiplication, Distinct Characteristics Of Training And Inference, Architectures of TPU v1, v2, v3 and v4; comparison between their architectures, Comparison of CPU, TPU and GPU, Deep Learning techniques on FPGA; efficacy of FPGAs for binarized neural networks (BNNs), Deep Learning on CPU, Deep Learning on GPU

UNIT – V
Case Study: Computer Vision problem example on CPU, GPU, CUDA & FPGA Optimizations techniques: Memory and Compute Optimizations to CNNs such as tiling, loop optimizations, batching, quantization, pruning, Catch Blocking

SUGGESTED READING:

1	Michael J. Quinn, "Parallel Programming in C with MPI and Open MP", McGraw-Hill Science Engineering, 2003
2	NVDIA- CUDA C Programming Guide – Design Guide, NVIDIA Corporation, 2018.
3	Masoud Daneshtalab, Mehdi Modarressi , "Hardware Architectures for Deep Learning", Institution of Engineering and Technology (IET), 2020

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PHD4003EC	DIGITAL VLSI DESIGN					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To learn the basics of MOS Circuits, its process and understand the operation of MOS devices.
2	To impart in-depth knowledge on digital logic design.
3	To understand and design the High-speed CMOS logic circuits and acquaint the students with the fundamental concepts of memory and interconnects.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Able to understand the fabrication process of IC technology
CO-2	Able to analysis of the operation of MOS transistor
CO-3	Able to design layout of the logic function
CO-4	Student can able to design Adders, Multipliers and memories etc.
CO-5	Getting the idea of design approach

UNIT–I

Review of MOSFET: MOS operation and CMOS process flow, MOS Threshold voltage, Sub threshold conduction. MOSFETI-V characteristics: Long and short channel effects, MOSFET capacitances, lumped and distributed RC model for interconnects, transmission lines, CMOS inverter: Static characteristics, power consumption, dynamic behavior, buffer design. Design rules, Layouts and stick diagram.

UNIT–II

Combinational logic: Transistor sizing in static CMOS logic gates, static CMOS logic gate sizing considering method of logical effort, dynamic logic, pass-transistor logic and Transmission Gate logic. Sequential logic: Static latches and flip-flops (FFs), dynamic latches and FFs, sense-amplifier based FFs, NORA-CMOS, Schmitt trigger circuit.

UNIT–III

High Speed CMOS Logic Design: Switching Time Analysis, Detailed Load capacitance Calculation, Improving Delay calculation with input slope, Gate sizing for optimal path Delay, Optimizing paths with Logical Effort. Scaling MOS Transistors.

UNIT-IV

Data path Design: Adder, Multiplier, Barrel Shifter, Logarithmic Shifter, Semiconductor Memory Design: Core Memory structure, MOS Decoder, Static RAM cell Design and Content-Addressable Memories (CAM).

UNIT – V

Interconnect Design: Introduction, Interconnect RC Delays, Buffer Insertion very long wires,Interconnect coupling capacitance: Components of Coupling capacitance, Coupling effects

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on Delay, Crosstalk, Interconnect Inductance. Timing issues: Timing fundamentals, clock distribution and jitter.

SUGGESTED READING:

1	David A Hodges, Horace G Jackson ResveASaleg "*Analysis and Design of Digital Integrated circuits*" The McGraw Hill Companies 3rd edition, 2006
2	Jan M Rabaey, A Chandrakasan, Borvioje N "*Digital Integrated Circuits Design Perspective*" PHI2nd edition, 2005.
3	Neil H E Weste, David Harris, Ayan Banerjee "*CMOS VLSI Design a circuit's and system perspective*" Pearson 3nd Edition 2009.
4	Wayne Wolf, "*Modern VLSI Design*" 3rd ed:, Pearson Education, 1997

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PHD4004EC	IOT AND APPLICATIONS					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To understand the concepts of the Internet of Things and be able to build IoT Applications
2	To learn the programming and use of Arduino and Raspberry Pi boards Design and detail the deep beams.
3	To know about data handling and analytics in SDN

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Known basic protocols in sensor networks.
CO-2	Program and configure Arduino boards for various designs
CO-3	Python programming and interfacing for Raspberry Pi.
CO-4	Design IoT applications in different domains.
CO-5	Study the basics of Cloud Computing and different applications.

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UNIT – I

Introduction to the Internet of Things, Characteristics of IoT, Physical design of IoT, Functional blocks of IoT, Sensing, Actuation, Basics of Networking, Communication Protocols, Sensor Networks.

UNIT – II

Machine-to-Machine Communications, Difference between IoT and M2M, Interoperability in IoT, Introduction to Arduino Programming, Integration of Sensors and Actuators with Arduino.

UNIT – III

Introduction to Python programming, Introduction to Raspberry Pi, Interfacing Raspberry Pi with basic peripherals, Implementation of IoT with Raspberry Pi .

UNIT – IV

Implementation of IoT with Raspberry Pi, Introduction to Software-defined Network (SDN), SDN for IoT, Data Handling and Analytics

UNIT – V

Cloud Computing, Sensor-Cloud, Smart Cities and Smart Homes, Connected Vehicles, Smart Grid, Industrial IoT, Case Study: Agriculture, Healthcare, Activity Monitoring.

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Suggested Reading:

1	PethuruRaj and Anupama C. Raman "The Internet 'of Things: Enabling Technologies, Platforms, and Use Cases", CRC Press, 2017.
2	Terokarvinen, kemo, karvinen and villeyvaltokari, "Make sensors", 1st edition, Maker media, 2014.
3	Arshdeep Bahga and VijayMadisetti ,"Internet of Things: A Hands-on Approach", by , Universitiespress, India(I) Pvt Ltd., 2014
4	Waltenegus Dargie,Christian Poellabauer, "Fundamentals of Wireless Sensor Networks: Theory and Practice, John Wiley & Sons, 2010.
5	Charles Bell , "Beginning Sensor networks with Arduino and Raspberry Pi", Apress, 2013

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PHD4005EC	DIGITAL IMAGE AND VIDEO PROCESSING					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	This course offers fundamentals of digital image and video processing and algorithms for most of the work currently underway in this field.
2	Beyond the obvious applications in entertainment and scientific visualization, digital images, and video have become a central component of human/computer interfacesand databases.
3	Through this course, students will get a clear impression of the breadth and practical scope of digital image and video processing and develop a conceptual understanding which will enable them to undertake further study, research, and/or implementation workin this area.

Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	Define digital image, digital image representation, the importance of image resolution, applications in image processing, and application of various image transforms.
CO-2	Select and apply appropriate enhancement and restoration techniques to real problems in image analysis
CO-3	Understand techniques for image segmentation and techniques for image compression
CO-4	Develop familiarity with video technology from analog color TV systems to digital video systems, and implement filtering operations in basic video processing.
CO-5	Understand general methodologies for 2D motion estimation, and various coding used in video processing

UNIT – I
Fundamentals of Image Processing and Image Transforms: Basic steps of Image Processing System, Image acquisition and display, Sampling and Quantization of an image, the basic relationship between pixels image **Image Transforms:** 2-D Discrete Fourier Transform, Discrete Cosine Transform (DCT), Haar transform, slant transform, KL transform, singular value decomposition, Radon

transform, Wavelet Transforms: Continuous Wavelet Transform, Discrete Wavelet Transforms comparison of different image transforms.

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UNIT – II
Image Processing Techniques **Image Enhancement:** Spatial domain methods: Histogram processing, Fundamentals of Spatial filtering, smoothing spatial filters, Sharpening spatial filters. Frequency domain methods: Basics of filtering in the frequency domain, image smoothing, image sharpening, Selective filtering. Laplacian of Gaussian (LOG) filters. **Image Restoration:** Introduction to Image restoration, Image degradation, Types of image blur, Classification of image restoration techniques, Image restoration model, Linear and Nonlinear image restoration techniques, Blind de convolution.

UNIT – III
Image Segmentation: Segmentation concepts, Point, Line, Edge Detection, Thresholding, and Region-Based segmentation. Edge detection and linking, Hough Transform, boundary detection, chain coding. **Image Compression:** Image compression fundamentals - Coding Redundancy, Spatial and Temporal redundancy, Compression models: Lossy & Lossless, Huffman coding, Arithmetic coding, LZW coding, Run-length coding, Bit plane coding, Transform coding, Predictive coding, Wavelet coding, JPEG standards.

UNIT – IV
Basic steps of Video Processing: Analog Video, Digital Video. Principles of Colour video processing, composite versus component video, Time-Varying Image Formation models Three-Dimensional Motion Models, Geometric Image Formation, Photometric Image Formation, Sampling of Video signals, and Filtering operations.

UNIT – V
2-D Motion Estimation: Optical flow, General Methodologies, Pixel Based Motion Estimation, Block- Matching Algorithm, Mesh-based Motion Estimation, Global Motion Estimation, Region-based motion Estimation, Multi-resolution motion estimation, Waveform based coding, Block based transform coding, Predictive coding, Application of motion estimation in Video coding, MPEGs and H.26x standards.

Suggested Reading:

1	Gonzalez and Woods, "Digital Image Processing", 3rd ed., Pearson, 2008.
2	Yao Wang, Joem Ostermann and Ya–quin Zhang, "Video processing and communication", 1 st Ed., PH Int., 2002.
3	M. Tekalp, "Digital Video Processing", Prentice-Hall International, 1995

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PHD4006EC	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	Study the concepts of Artificial Intelligence.
2	Learn the methods of solving problems using Artificial Intelligence.
3	Introduce the concepts of Expert Systems and machine learning.
Course Outcomes :	
On completion of this course, the student will be able to do :	
CO-1	To identify problems that are amenable to solutions by AI methods.
CO-2	To identify appropriate AI methods to solve a given problem & implement basic AI algorithms.
CO-3	To formalize a given problem in the language/framework of different AI methods.
CO-4	To study the basics of Machine learning. Usage of Python packages for Machine Learning.
CO-5	To evaluate the performance of various Machine Learning algorithms on a dataset.

UNIT – I

Introduction: Machine learning, Terminologies in machine learning, Types of machine learning: supervised, unsupervised, semi-supervised learning.

UNIT – II

Discriminate Models: Least Square Regression, Gradient Descent Algorithm, Univariate and Multivariate Linear Regression, Prediction Model, probabilistic interpretation, Regularization, Logistic regression, multi-class classification, Support Vector Machines-Large margin classifiers, Nonlinear SVM, kernel functions, SMO algorithm. Model evaluation and improvement, Regularization, Bias Variance, Hyper parameter Tuning. Computational Learning theory- Sample complexity, exhausted version space, PAC Learning, agnostic learner, VC dimensions, Sample complexity - Mistake bounds.

UNIT – III

Gaussian Models: Multivariate Gaussian distributions, Maximum Likelihood Estimate, inferring parameters, Mixture models, EM algorithm for clustering and learning with latent variables.

UNIT – IV

Generative Models: Linear Discriminative Analysis, Nave Bayes classifier, Decision trees, Ensemble models – Bagging and Boosting. Unsupervised Learning .

UNIT – V

Algorithms: Dimensionality Reduction Principal Component Analysis (PCA), Singular Value Decomposition (SVD). Clustering – Hierarchical, Partitioned clustering: K-means, PAM, explainable AI (XAI), Approaching an ML problem.

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Suggested Reading:

1	Tom Mitchell, "Machine Learning", McGraw Hill, 1997.
2	E. Alpaydin, "Introduction to Machine Learning", PHI, 2005.
3	Andrew Ng, Machine learning yearning, https://www.deeplearning.ai/machine-learningyearning/ .
4	Aurolien Geron , "Hands-On Machine Learning with Scikit-Learn and TensorFlow, Shroff/O'Reilly",2017.
5	Andreas Muller and Sarah Guido, "Introduction to Machine Learning with Python: A Guide for Data Scientists", Shroff/O'Reilly, 2016 .

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PHD4007EC	ADVANCED DIGITAL SIGNAL PROCESSING					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives :	
The course is taught with the objective of enabling the student to:	
1	To make students familiar with the most important methods in DSP, including digital filter design, transform-domain processing, and the importance of Signal Processors
2	Create efficient realizations for up-sampling and down-sampling of signals using the poly phase decomposition
3	To introduce some practical aspects of signal processing and in particular adaptive systems

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Design, implementation, analysis, and comparison of digital filters for processing of Discrete-time signals
CO-2	Acquire the basics of multi-rate digital signal processing.
CO-3	Comprehend design criteria and modeling adaptive systems and theoretical Performance evaluation
CO-4	Analyze the power spectrum estimation
CO-5	Apply the algorithms for a wide area of recent applications.

UNIT – I
Overview of DSP, Characterization in time and frequency, FFT Algorithms, Digital filter design, and structures: Basic FIR/IIR filter design &structures, design techniques of linear phase FIR filters, IIR filters by impulse invariance, bilinear transformation, FIR/IIR Cascaded lattice structures, and parallel all pass realization of IIR.

UNIT – II
Multi-rate DSP, Decimators and Interpolators, Sampling rate conversion, multistage decimator &interpolator, poly phase filters, QMF, digital filter banks, and Applications in sub-band coding.

UNIT – III
Linear prediction & optimum linear filters, stationary random process, forward-backward linear prediction filters, solution of normal equations, AR Lattice and ARMA Lattice-Ladder Filters, Wiener Filters for Filtering and Prediction.

UNIT – IV
Estimation of Spectra from Finite-Duration Observations of Signals. Nonparametric Methods for power Spectrum Estimation, Parametric Methods for Power Spectrum Estimation, Minimum-Variance Spectral Estimation, Eigen analysis Algorithms for Spectrum Estimation.

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UNIT –V
Application of DSP & Multi-rate DSP, Application to RADAR, introduction to wavelets, application to image processing, design of phase shifters, DSP in speech processing & other applications

Suggested Reading:

1	J.G.Proakis and D.G.Manolakis, "Digital signal processing: Principles, Algorithm and Applications", 4th Edition, Prentice-Hall, 2007.
2	S.Haykin, "Adaptive Filter Theory", 4th Edition, Prentice-Hall, 2001.

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PHD4008EC	MICROWAVE ANTENNAS					
Pre-requisites			L	T	P	C
			3	-	-	3
Evaluation	SEE	100Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the basic concepts of antenna parameters and radiation mechanism.
2	To analyze aperture antennas with the knowledge of various theorems and study the principles of frequency independent antenna design.
3	To understand, analyze and synthesize printed antennas, array antennas and familiarize the concepts of smart antennas and modern antennas.

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Understand different types of aperture antennas with the help of basic antenna fundamentals.
CO-2	Understand the operating principles of microwave antennas.
CO-3	Apply the knowledge in the design of array antennas.
CO-4	Acquire knowledge of printed antenna and its design procedure
CO-5	Acquire basic knowledge of modern antenna technology

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UNIT-I
Fundamental parameters and definitions related to antennas, Theories of radiation, Image theory, Schelkunoff's equivalence theorem, Huygen's principle, Babinet's principle.

UNIT-II
Radiation from rectangular and circular apertures, design considerations, Fourier transform method in aperture antenna theory. Broadband antenna concept, Logperiodic antennas, Frequency independent antennas.

UNIT–III
Linear arrays: Uniform and Non uniform amplitude distribution, Planar arrays, Synthesis of antenna arrays: Schelkunoff polynomial method, Fourier transform method and Woodward-Lawson method, Concept and benefits of smart antennas.

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UNIT-IV
Printed antennas: Rectangular and circular patch antenna design, Feeding techniques for micro strip antennas, Methods of analysis, Printed antenna arrays, Bandwidth enhancement techniques, Compact and Tunable Micro strip antenna.

UNIT-V
Advanced antennas and arrays for aerospace and defense applications. Modern antenna technologies: Meta material based antennas, Leaky wave antennas, Dielectric resonator antenna.

Suggested Reading:

1	Constantine Balanis, "Modern Antenna Handbook",Johnwiley,2008.
2	Stutzman,W.L.andThiele,H.A.,"AntennaTheoryandDesign",2ndEd.,JohnWiley & Sons.
3	BahlIJ,andBhartia,"MicrostripAntennas",ArtechHouse,1982.
4	D.G.Fang,"AntennaTheoryandMicrostripAntennas",CRCpress2010
5	James.JR.HallPS.wood.C.,"MicrostripAntenna-TheoryandDesign",Peter Peregrinu.1981

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PHD4009EC	RADAR SYSTEMS ENGINEERING					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To familiarize the basic concepts of a RADAR system in target detection.
2	To know the features of RADAR target models and clutter.
3	To understand various types of RADAR systems and their applications.

Course Outcomes :	
On completion of this course, the student will be able to:	
CO-1	Understand the RADAR fundamentals
CO-2	Understand the principle of operation of various RADAR systems
CO-3	Apply the knowledge in the design of a RADAR system
CO-4	Characterize the target fluctuation
CO-5	Understand the concepts of phased array RADAR

UNIT-I
The RADAR range equation: RADAR fundamentals, Derivation of range equation, Search RADAR equation, Jamming and RADAR range with jamming, RADAR clutter and RADAR range with clutter.

UNIT-II
The theory of target detection: Noise and false alarms, Detection of one sample of signal with noise, Integration of pulse trains, Detection of fluctuating targets, CFAR, Optimum and matched Filter Theory, Loss factors in detection

UNIT–III
Targets and interference: Definition of RADAR cross section, RADAR cross section of simple and complex objects, Spatial distribution of cross section, Bi static cross section.
CW and FM RADAR: Doppler Effect. CW and FMCWRADAR, Airborne Doppler Navigation, Multi frequency CW RADAR.

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UNIT-IV
MTI RADAR: Delay line cancellers, Sub clutter Visibility, MTI using range gates and filters, Pulse Doppler RADAR, Non-coherent MTI RADAR, Tracking RADAR:Different types of tracking techniques. Tracking in range, Tracking in Doppler. Search Acquisition RADAR, Comparison of Trackers.

UNIT-V
Introduction to Synthetic Aperture RADAR (SAR) - Principles of SAR, Range resolution, Azimuthal resolution, backscattering coefficient. Range compression, azimuth compression, Doppler centroid, Doppler rate, range migration, range curvature, range ambiguities, azimuth ambiguities, Modes of SAR operation –Strip mode, Scanar mode ,Spot mode.

Suggested Reading:

1	DavidBarton.K,"ModernRADARsystemanalysis",Artechhouse,1988.
2	Fred Nathanson E, "RADAR design principles signal processing and the environment", McGrawHill.1969.
3	JohnC.Curlander,RobertN.McDonough,"SyntheticApertureRADARSystemsandSignal Processing, John Wiley &Sons Inc.
4	GiorgioFranceschetti,RiccardoLanari,"SyntheticApertureRADARProcessing'",CRC Press.
5	Skolnik,"IntroductiontoRADARsystems",McGrawhill,2ndEdition2003.

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PHD4010EC	SATELLITE RADIO NAVIGATION					
Pre-requisites			L	T	P	C
			3	-	-	6
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Explore the basics of Satellite Communications.
2	Sensitize about the GNSS signal structure, and various coordinate systems.
3	Analyze about the RINEX data format.
4	Review GPS III system, new signals and other GNSS constellations.
5	Comprehend about the NavIC and SRN applications.

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Understand the properties of Satellite systems.
CO-2	Study about the GPS and various coordinate systems.
CO-3	Explore the RINEX data formats and DoP.
CO-4	Estimate the various errors and understand about GPS III systems.
CO-5	Appreciate about the NavIC systems.

UNIT-I

Introduction to Satellites, History of Satellites, Satellite systems, basic principles and properties of satellite communication, Launch Vehicles and their types, Earth Stations and their types, Types of Satellites and Future Satellite based applications.

UNIT-II

Introduction to Satellite Navigation Systems, GPS fundamentals: Principle of Trilateration, Transit, History of GPS, GPS Operating Principle, and Architecture: Space, Control and User Segments and its Frequencies, GPS signal structure, Types of GPS receivers - Single and Dual frequency GPS receivers, desired GPS signal properties.

GPS Coordinate Systems: Earth Centered Earth Fixed (ECEF) and Earth Centered Inertial (ECI) Coordinate systems and World Geodetic System (WGS84) datum, Required Navigation Performance (RNP)safety standards, SPS and PPS services.

UNIT-III

Data Formats: RINEX Observation and Navigation Data formats, GPS user position calculation, Selective Availability, Spoofing and Anti spoofing, Dilution of Precision (DOP).

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UNIT-IV
GRNSS Errors: Ionosphere error, Troposphere error, Ephemeris error, Clock errors, Satellite and receiver instrumental biases, Multipath, GPS Modernization – Necessity, Objectives, New Signals and their benefits, GPS III Satellites, New Operational Control system and Future applications. Other Satellite Radio Navigation Systems: Russian GLONASS, European GALILEO, Japanese QZNSS, Chinese BeiDou and Indian NAVIC Systems: Principle of Operation, Features and their Current Status.

UNIT-V
Case Studies: NavIC Signals behavior at various static and dynamic scenarios, modeling of Ionosphere Delay, Analysis on Ionospheric Scintillations, Real time SRN applications.

Suggested Reading:

1	B.HofmannWollenhof,H.Lichtenegger,andJ.Collins,"GPSTheoryandPractice", Springer Wien, New York, 2000.
2	PratapMisraandPerEnge,"GlobalPositioningSystemSignals,Measurements,and Performance," Ganga-Jamuna Press, Massachusetts, 2001.
3	AhmedEl-Rabbany,"IntroductiontoGPS,"ArtechHouse,Boston,2002.

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PHD4011EC	GNSS AUGMENTATION SYSTEMS					
Pre-requisites	-		**L**	**T**	**P**	**C**
			3	-	-	6
Evaluation	**SEE**	100 Marks	**CIE**		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Review about the GPS, DGPS and its applications.
2	Recognize about SBAS, its operations and applications.
3	Analyze about the Indian GAGAN system and its significance.
4	Realize about the various SBAS across the world, their operations, and applications.
5	Make the students explore about the LAAS, its operation and its applications.

Course Outcomes:	
On completion of this course, the student will be able to:	
CO-1	Understand about the review of GNSS and DGPS
CO-2	Grasp about the SBAS and its operations.
CO-3	Appreciate about Indian GAGAN system, its architecture, and applications.
CO-4	Study about the various SBAS across the world.
CO-5	Comprehend about LAAS, its architecture and applications.

UNIT-I

Overview of GPS, Various GNSS across the world, Comparison of Global and Regional Satellite Systems, advantages and GNSS threats, Limitations of GNSS, DGPS – Principle of operation of DGPS, architecture, advantages, limitations, and GRNSS Applications.

UNIT-II

Augmentation Systems: Introduction, Satellite Based Augmentation Systems (SBAS), SBAS Features and Principle of operation of US based Wide area augmentation system (WAAS), architecture, advantages, limitations, and applications.

UNIT–III

Indian SBAS: Introduction to Indian GAGAN, Implementation, Technology demonstration, Technology integration, Effective flight management, GAGAN satellites, developments, GAGAN Applications in India.

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UNIT-IV
The European Geostationary Navigation Overlay Service (EGNOS) system, Japan's Multi-functional Satellite Augmentation System (MSAS), Russian The System for Differential Corrections and Monitoring (SDCM)system, The Chinese BeiDou Satellite-Based Augmentation System (BDSBAS)-Operation, features, and applications.

UNIT-V
LAAS: Categories of Precision Approach requirements of Civil Aviation for various phases of flight, Integral components of LAAS, LAAS architecture, operating principle, Protection Levels and Alert limits, LAAS Benefits, advantages, limitations, Error Sources in LAAS and its status, LAAS Services, LAAS: International Status, LAAS National status, LAAS applications.

Suggested Reading:

1	ElliotD.Kaplan,"UnderstandingGPSPrinciplesandApplications",ArtechHouseBoston, 1996.
2	BradfordW.ParkinsonandJamesJ.Spilker,"GlobalPositioningSystem:Theoryand Applications,"VolumeII,AmericanInstituteofAeronauticsandAstronautics,Inc.,Washington ,1996.
3	B.HofmannWollenhof,H.Lichtenegger,andJ.Collins,"GPSTheoryandPractice", SpringerWien,Newyork,2000.

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PHD4012EC	ANALOG AND MIXED SIGNAL IC DESIGN					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Familiarize the students with basic building blocks of Analog& Mixed signal IC design and their
2	Train the students to analyze and design basic building blocks of Analog and Mixed Signal IC
3	Impart skills for analyzing different responses of various Amplifiers and Op-Amp, etc.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Choose appropriate model of MOSFET as per the given circuit/application/condition.
CO-2	Choose, Analyze and Design various amplifiers & current Mirrors for a given application
CO-3	Analyze the effect of frequency and noise on various building blocks of analog IC Design.
CO-4	Analyze and Design complex analog circuits like comparator, OP-Amp and Band Gap references, etc.
CO-5	Choose, Analyze and Design various switched capacitor and mixed signal circuits

UNIT–I

Building Blocks of Op amp: *MOS Transistor* – Nanometer Transistor and its model – body effect, Channel Length Modulation and short channel effects – velocity saturation, sub-threshold conduction, threshold voltage control, drain induced barrier lowering, gate induced drain leakage, Complete MOS Transistor Model and large and small signal models of BJTs and MOSFETs. *Current Mirrors and Single Stage Amplifiers* – Simple CMOS current mirror, common source amplifier, source follower, common gate amplifier, cascade amplifiers, Source de-generated current mirrors, cascade current mirror, cascade gain stage and MOS differential pair and gain stage. *Biasing and References* – Analog IC biasing, establishing constant trans-conductance and band-gap reference – Positive and negative temperature coefficient basics and circuits.

UNIT–II

Basic Opamp and Compensation: Basic two-stage MOS Operational amplifier, characteristic parameters, compensation, design and analysis of two-stage MOS Opamp with given specifications. Stability and frequency compensation of op-amps.

UNIT–III

Operational Trans-conductance Amplifier (OTA): Advanced current Mirrors – Wilson current mirror, Enhanced output-impedance current mirror and gain boosting and wide swing current mirror with enhanced output impedance and bipolar current mirrors – bipolar gain stages. *Single stage Opamp* – Folded-cascade Opamp, current mirror Opamp, fully differential Opamp and common mode feedback circuits.

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UNIT-IV

Applications of Opamp Comparators: Op-Amp Based Comparators, Charge Injection Errors – Latched Comparators – CMOS and BiCMOS Comparators – Bipolar Comparators. *Switched capacitor circuits:* Basic building blocks; basic operation and analysis, inverting and non-inverting integrators, signal flow diagrams, first order filter. *Sample and hold circuits* - Performance requirements, MOS sample and hold basics, clock feed through problems, S/H using transmission gates, high input impedance S/H circuits, improved S/H circuits from the point of slewing time, clock feed through cancellations.

UNIT – V

Mixed Signal IC Applications: Data Converters – Review of Nyquist-Rate A/D and D/A converters, Noise Sources: Flicker, Thermal, Oversampling converters – Over sampling without noise shaping and with noise shaping, system architectures and digital decimation filters. *Phase locked loops* – simple PLL, charge pump PLL and dynamics of PLL. *Practical Issues* – Transistor mismatch, offset and techniques to reduce the analog non-idealities (like auto-zero, chopping, CDS etc) and Basics of Analog Layout

SUGGESTED READING:

1	Tony Chan Carusone, David Johns and Ken Martin, "*Analog Integrated Circuit Design*", 2nd edition, John Wiley & sons. 2013
2	Behzad Razavi, "*Design of Analog CMOS Integrated Circuits*", McGraw Hill Companies, 2013.
3.	Philip E. Allen and Douglas R. Holberg, "*CMOS Analog Circuit Design*", 2nd edition, Oxford University Press, 2010

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PHD4013EC	SYSTEM ON CHIP DESIGN					
Pre-requisites	Digital Signal Processing		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To understand the concepts of System on Chip Design methodology for Logic and Analog
2	To understand the concepts of System on Chip Design Validation
3	To understand the concepts of SOC Testing.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Upon successful completion of this course student should be able to understand about SoC Design Methodology.
CO-2	Ability to understand the design of different embedded memories
CO-3	Validation and Testing Concepts can be understood.
CO-4	Investigate new techniques for future systems
CO-5	Up on successful completion of this course student should be able to: understand about SoC Design Methodology.

UNIT–I Introduction: Driving Forces for SoC - Components of SoC - Design flow of SoC - Hardware/Software nature of SoC - Design Trade-offs - SoC Applications

UNIT–II

System-level Design: Processor selection-Concepts in Processor Architecture: Instruction set architecture (ISA), elements in Instruction Handing-Robust processors: Vector processor, VLIW, Superscalar, CISC, RISC—Processor evolution: Soft and Firm processors, Custom-Designed processors- on-chip memory

UNIT–III

Interconnection: On-chip Buses: basic architecture, topologies, arbitration and protocols, Bus standards: AMBA, Core Connect, Wishbone, Avalon - Network-on chip: Architecture-topologies-switching strategies - routing algorithms - flow control, Quality-of-Service- Re configurability in communication architectures

UNIT-IV

IP based system design: Introduction to IP Based design, Types of IP, IP across design hierarchy, IP life cycle, Creating and using IP - Technical concerns on IP reuse – IP integration - IP evaluation on FPGA prototypes

UNIT – V

SOC implementation: Study of processor IP, Memory IP, wrapper Design - Real-time operating system (RTOS), Peripheral interface and components, High-density FPGAs - EDA tools used for SOC design.

SOC testing: Manufacturing test of SoC: Core layer, system layer, application layer- P1500 Wrapper Standardization-SoC Test Automation (STAT).

SUGGESTED READING:

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1	Michael J.Flynn, Wayne Luk, —Computer system Design: Systemon-Chipl, Wiley-India, 2012.
2	Sudeep Pasricha, Nikil Dutt, —On Chip Communication Architectures: System on Chip Interconnectl, Morgan Kaufmann Publishers, 2008.
3	W.H.Wolf, —Computers as Components: Principles of Embedded Computing System Designl, Elsevier, 2008

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PHD4014EC	VLSI SIGNAL PROCESSING					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives :	
The course is taught with the objectives of enabling the student to:	
1	To enable the students to learn about the concept of pipelining and parallel processing in VLSI and the students to identify applications for unfolding Algorithm
2	To make the students understand the analysis of the VLSI system with high speed and low power and equip the students with knowledge of Systolic Design for Space Representations containing Delays
3	To make the students understand the concept of Power Reduction and Estimation Techniques VLSI signal processing

Course Outcomes :	
On completion of this course, the student will be able to :	
CO-1	Explain parallel and pipelining processing techniques.
CO-2	Identify applications for unfolding algorithm
CO-3	Analyze Systolic Design for Space Representations containing Delays
CO-4	Explain Cook-Toom Algorithm, the Fast Convolution algorithm by the Inspection method.
CO-5	Analyze Power Reduction techniques and Power Estimation techniques

UNIT – I

Introduction to DSP: Typical DSP algorithms, DSP algorithms benefits, Representation of DSP algorithms. Pipelining and Parallel Processing: Introduction, Pipelining of FIR Digital filters, Parallel Processing, Pipelining and Parallel Processing for Low Power, Retiming: Introduction–Definitions and Properties – Solving System of Inequalities – Retiming Techniques

UNIT - II

Folding and Unfolding, Folding: Introduction -Folding Transform - Register minimization Techniques – Register minimization in folded architectures – folding of multi-rate systems, Unfolding: Introduction – An Algorithm for Unfolding – Properties of Unfolding – critical Path, Unfolding and Retiming – Applications of Unfolding

UNIT – III

Systolic Architecture Design: Introduction – Systolic Array Design Methodology – FIR Systolic Arrays – Selection of Scheduling Vector – Matrix Multiplication and 2D Systolic Array Design– Systolic Design for Space Representations contains

UNIT – IV

Fast Convolution: Introduction – Cook-Toom Algorithm – Winograd algorithm – Iterated Convolution – Cyclic Convolution – Design of Fast Convolution algorithm by Inspection

UNIT – V

Low Power Design: Scaling Vs Power Consumption–Power Analysis, Power Reduction techniques – Power Estimation Approaches, Programmable DSP: Evaluation of Programmable Digital Signal Processors, DSP Processors for Mobile and Wireless Communications, Processors for Multimedia Signal Processing

Suggested Reading:

1	Keshab K. Parthi, "VLSI Digital Signal Processing-System Design and Implementation", 1998, Wiley Inter Science.
2	Kung S. Y, H. J. While House, T. Kailath, "VLSI and Modern Signal processing", 1985,Prentice Hall.
3	Jose E. France, Yannis Tsividis, "Design of Analog – Digital VLSI Circuits for Telecommunications and Signal Processing", 1994, Prentice Hall.
4	Medisetti V. K, "VLSI Digital Signal Processing", IEEE Press (NY), USA, 1995.

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PHD4015EC	WIRELESS SENSOR NETWORKS					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Design wireless sensor network system for different applications under consideration
2	This course provides a broad coverage of research results related to the design at various layers of wireless sensor networks.
3	Covered topics include network architectures, Physical Layer and MAC layer design concepts, routing protocols and Programming concepts

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Design wireless sensor network system for different applications under consideration.
CO-2	Understand the architecture details of different sensors network scenarios and select right type of sensor for various applications.
CO-3	Understand radio standards and communication protocols to be used for wireless sensor network-based systems.
CO-4	Use operating systems and programming languages for wireless sensor nodes, performance of wireless sensor networks systems and platforms.
CO-5	Design wireless sensor network system for different applications under consideration.

UNIT–I
Introduction and overview of sensor network architecture and its applications, Challenges for WSNs, WSN comparison with Mobile Ad Hoc Networks, Single Sensor node architecture with hardware components and operating systems.

UNIT–II
Network Architecture: Sensor Network scenarios, Optimization goals, Design principles for WSNs, Service interfaces of WSNs and Gateway concepts

UNIT–III
Physical layer and MAC protocols: Physical layer and Transceiver design considerations in WSNs, MAC protocols for WSNs, Low duty cycle protocols and wakeup concepts, Contention based and Scheduled based protocols, IEEE 802.15.4 MAC protocol..

UNIT-IV
Routing Protocols for WSNs: Gossiping and agent based unicast forwarding, Energy efficient unicast, Broadcast and multicast, Geographic routing and Mobile nodes..

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UNIT – V
Sensor Network programming: Challenges in Sensor network Programming, Node centric programming, nes C language, tiny GALS, thread based model, Macro programming, Dynamic programming, Sensor network simulators and environment

SUGGESTED READING:

1	H. Karl and A. Willig, *"Protocols and Architectures for Wireless Sensor Networks"*, John Wiley & Sons, India, 2012
2	Kazem Sohrbay, Daniel Minoli, Taieb Znati, " Wireless Sensor Networks Technology,Protocols and Applications", Wiley Publications, 2007
3	Waltenegus Dargie, Christian Poellabauer, " Fundamentals of WSNs, Theory and Practice", Wiley series on Wireless Communications and Mobile Computing, 2010
4	C. S. Raghavendra, K. M. Sivalingam, and T. Znati, Editors, *"Wireless Sensor Networks"*, Springer Verlag, 1st Indian reprint, 2010.
5	YingshuLi, MyT. Thai, Weili Wu, "*Wireless sensor Network and Applications*", Springer series on signals and communication technology, 2008.

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PHD4016EC	CPLD AND FPGA ARCHITECTURE					
Pre-requisites	-		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	Understand the basic operation of Programmable gate arrays
2	Learn the architecture of various types of FPGAs/CPLD and design a digital circuit and implement it on an FPGA.
3	Implemented the programming techniques used in FPGA design and Verification, testing FPGAs

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Evaluation of PLDs
CO-2	Familiarity architecture of various types of FPGAs/CPLD
CO-3	Design a digital circuit and implement it using reconfigurable logic
CO-4	Design and develop IP cores and Prototypes in FPGA design
CO-5	Apply simulators and verify develop FPGA designs.

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UNIT–I
Programmable Logic Devices: Revision of basic Digital systems, PROM, PLA, PAL, Architecture of PAL's applications, programming technologies, programmable logic design methods and tools

UNIT–II
CPLD's: complex programmable logic devices: logic block, I/O block, interconnect matrix, logic blocks and features of altera flex logic 10000 series CPLD"s , max 7000 series CPLD"s, AT & T– ORCA"s (Optimized Reconfigurable Cell Array), cypres flash 370 device technology, lattice plsi"s architectures.

UNIT–III
FPGAs: Field Programmable Gate Arrays: Logic blocks, routing architecture, Logic cells and features of commercially available FPGA"s- XILINX XC4000, SPARTAN II, virtexII FPGA"s, XILINX, Altera"s FPGA, ACETEL Act1, Act2, Act3 FPGAS , AMD FPGA.

UNIT-IV
Synthesis process: Placement: objectives, placement algorithms: Mincut-Based placement, iterative improvement Placement, simulated annealing. Routing: objectives, segmented channel routing, Maze routing, Routability estimation, Net delays, Computing signal delay in

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UNIT – V
FPGA implementation steps: simulation process, verification: introduction, logic simulation, design validation, timing verification. Testing concepts: failures, mechanisms and faults, fault coverage, ATPG methods, programmability failures, Case studies: programmable counter, ALU, Barrel shifter

SUGGESTED READING:

1	P.K. Chan & S. Mourad, "Digital Design Using Field Programmable Gate Array", Pearson Education 2009
2	S. Brown, R. Francis, J. Rose, Z.Vransic, "Field Programmable Gate array", Kluwer Publn, 1992 5 Manuals from Xilinx, Altera, AMD, Actel.
3	S.Trimberger, Edr.,"Field Programmable Gate Array Technology", Kluwer Academic Publications, 1994.
4	J. Old Field, R. Dorf, "Field Programmable Gate Arrays", John Wiley & Sons, Newyork, 1995.

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PHD4017EC	PRINCIPLES OF VLSI SYSTEM DESIGN					
Pre-requisites	Digital System Design		L	T	P	C
			3	-	-	3
Evaluation	SEE	100 Marks	CIE		-	

Course Objectives:	
The course is taught with the objectives of enabling the student to:	
1	To Understand the VLSI design flow
2	To understand different CMOS logic families and their circuit layout.
3	To understand various VLSI design methodologies.

Course Outcomes:	
On completion of this course, the student will be able to :	
CO-1	Understand the different levels of abstraction and issues with the technology
CO-2	Analyze static and Dynamic circuits performances
CO-3	Design strategies and full custom design
CO-4	Design of sub systems
CO-5	Understand and exploring case studies of CMOS Systems

UNIT–I

Introduction to VLSI System design hierarchical design-design abstraction-different levels of abstraction and domains. Computer aided design VLSI design flow-technology implications and economics, issues connected with technology defect densities yield and die size, components of chips cost.

UNIT–II

Static and dynamic CMOS circuits, circuit characterizations and performance estimation: Resistance, Capacitance and Inductance- delay estimations power dissipation static and dynamic, design margining-reliability issues.

UNIT–III

CMOS design methods: Structured design strategies-Hierarchy, regularity modularity, chip design options: Programmable logic, logic structures, gate arrays. Sea-of gate and gate array design standard cell-based designs-standard cell libraries design reuse-full custom mark design.

UNIT-IV

CMOS sub system design: Adders and Subtractors fast adders like carry bypass carry select and carry-look-ahead adders Multipliers, array and fast multipliers- Parity Generators- Zero-One Detectors- Binary Counters- Multiplexers- shifters-memory elements.

UNIT – V

CMOS System case study: Core of RISC Micro Controller ALU address architectures, Instruction sets pipelining major blocks of the processor and 6-Bit Flash A/D converter-high speed comparators and thermometer code converter.

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1	Weste Kamran Eshraghian, Principles of CMOS VLSI design- a systems perspective by NEIL, HE, Pearson Education Series, Asia, 2002
2	Wolf, Modern VLSI Design, Pearson Education Series, 2002..
3	Jean M. Rabey, "Digital Integrated Circuits", Prentice Hall India, 2003.

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