Sixth Semester					
Theory					
Sl. No.	**Category**	**Subject Code**	**Subject Name**	**L-T-P**	**Credit**
1	BSC	22CM6BS01T	Optimization Engineering	3-1-0	4
2	PCC9	22ELC6PC02T	Digital VLSI Design	3-0-0	3
3	PCC10	22ELC6PC03T	Machine Learning	3-0-0	3
4	PEC3	**Professional Elective-3:**			
		22ELC6PE01T	Digital Image Processing	3-0-0	3
		22ELC6PE02T	Digital System Design using Verilog		
		22ELC6PE03T	Internet of Things		
		22ELC6PE04T	Cloud Computing		
5	PEC4	**Professional Elective-4:**		3-0-0	3
		22ELC6PE05T	Analog VLSI Design		
		22ELC6PE06T	Wireless Sensor Networks		
		22ELC6PE07T	Natural Language Processing		
		22ELC6PE08T	Big Data Analytics		
6	OEC3	**Open Elective-3 ((For ELC Branch Students):**			
		19EE6OE01T	Electrical Energy Utilization	3-0-0	3
		19EE6OE02T	Introduction to Robotics and Autonomous Vehicles		
		19CE6OE01T	Plastic Waste Management		
		19CE6OE02T	Environment and Safety Engineering		
		19ME6OE01T	Introduction to Hybrid Vehicles		
		19ME6OE02T	Engineering Materials		
		22EC6OE01T	Fundamental of Satellite Communication		
7		**Open Elective-1 (To Other Branch Students):**			
		22ELC6OE01T	Image Processing Technique		
		22ELC6OE02T	Digital Design using Verilog		
Total Credit (Theory)					**19**
Practical					
1	PCC9	22ELC6PC02L	**PCC Lab-8:** Digital VLSI Design Laboratory	0-0-2	1
2	PCC10	22ELC6PC03L	**PCC Lab-9:** Machine Learning Laboratory	0-0-2	1
3	PSI	22CM6PS01L	Research and Lab-Based Project	0-0-3	2
4	HSMC	22CM6HS01L	Business Communication and Interview Skills	0-0-3	2
Total Semester Credit					**25**

COURSE DESCRIPTION: Optimization Engineering

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Optimization Engineering	
Course Type	Theory	
Course Code	22CM6BS01T	
Category	BSC	
Credit Point	4	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Optimization Engineering focuses on formulating and solving mathematical models to find the best outcomes under given constraints, requiring knowledge of calculus, linear algebra, and programming basics.	
Subject Description	Optimization Engineering involves designing mathematical models to achieve optimal solutions for real-world problems within given constraints. It applies techniques like linear, nonlinear, and dynamic programming, as well as stochastic methods, across domains such as engineering, economics, and logistics. The subject emphasizes problem-solving, algorithm development, and computational tools for decision-making and resource management.	
Objectives and Outcomes	**Objectives:** The course should enable the students : 1. To understand the theory of optimization methods and algorithms developed for solving various types of optimization problems. 2. To develop and promote and promote research interest in applying optimization techniques in problems of Engineering and Technology. 3. To apply the mathematical results and numerical of optimization theory to different Engineering problems.	
	Outcomes: The course should enable the students to: 1. Understand importance of optimization of industrial process management. 2. Apply basic concepts of mathematics to formulate an optimization problem. 3. Analyses and appreciate variety of performance measures for various optimization problems.	

Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	[1] S. S. Rao, *Engineering Optimization*, New Age International Publications. [2] A. Ravindran, D. T. Philips, J. Solberg, *Operations Research-Principle and Practice*, Second edition, Wiley India Pvt Ltd. [3] H.A.Taha, A.M.Natarajan, P.Balasubramanie, A.Tamilarasi, *Operations Research*, Pearson Education, Eighth Edition.	
Reference Book(s)	[1] S.D.Sharma, *Operations Research*, Kedarnath Publications. [2] F.S.Hiller, G.J.Lieberman, *Operations Research*, Tata McGraw Hill. [3] P.C.Biswal,*Optimization Engineering*, Scitech Publications [4] Prem Kumar Gupta, D.S.Hira, *Operations Research*, S.Chand Publications.	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	1. Understand importance of optimization of industrial process management.	
CO2	2. Apply basic concepts of mathematics to formulate an optimization problem.	
CO3	3. Analyses and appreciate variety of performance measures for various optimization problems.	

DETAILED SYLLABUS:

Module No. 1		**08 Hours**
Idea of Engineering optimization, Classification of optimization Problems, Optimization Problem and Model Formulation. **Linear programming:** Formulation of LPP, Simplex method, Big-M method, Two-phase Method, Dual Simplex method, Sensitivity analysis in linear		

programming.

Module No. 2		**08 Hours**
Transportation problems: Finding an initial basic feasible solution by Northwest Corner rule, Vogel's approximation method, Degeneracy, Optimality test, MODI method, stepping stone method. **Assignment problems:** Hungarian method for solution of Assignment Problems **Integer Programming:** Integer Programming, Mixed Integer Programming, Branch and Bound method.		

Module No. 3		**10 Hours**
Non-linear programming: Introduction to non-linear programming. Constrained optimization, Multivariable optimization: Method of Lagrange Multipliers, Kuhn-Tucker condition. **Unconstraint optimization**: Powell's Method, Steepest Descent (Cauchy) Method, Conjugate Gradient (Fletcher-Reeves) Method, Newton's Method.		

Module No. 4		**08 Hours**
Game Theory: Concept, Game models, two persons zero sum games and their solution, Pure & Mixed Strategy, solution of 2Xn and mX2 games by graphical approach. **Decision Theory:** Concept, Decision under risk (EMV) & uncertainty**.**		

Module No. 5		**08 Hours**
Queuing models: General characteristics, Markovian queuing model, M/M/1model, Limited queue capacity, multiple server, Finite sources, Queue discipline.		

COURSE DESCRIPTION: Digital VLSI Design

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Digital VLSI Design	
Course Type	Theory	
Course Code	22ELC6PC02T	
Category	PCC9	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	A solid understanding of Digital Electronics (logic gates, sequential circuits), CMOS fundamentals (MOSFET operation, fabrication, and scaling), and Basic Circuit Design is essential. Familiarity with SPICE simulations, and testing methodologies will enhance learning.	
Subject Description	The subject **Digital VLSI Design** focuses on the principles and methodologies for designing high-performance digital integrated circuits. It covers topics like CMOS technology, fabrication processes, and MOSFET characteristics, emphasizing logic circuit design and optimization. Students learn to design combinational and sequential circuits, analyze power dissipation, and address timing issues. Advanced topics include layout techniques, clock strategies, and design-for-testability (DFT) methodologies to enhance circuit reliability and manufacturability.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Understand VLSI design fundamentals, including IC technology, design flow, and fabrication processes. 2. Analyze MOSFET structure, operation, and characteristics with SPICE modeling and scaling. 3. Design CMOS combinational and sequential circuits, addressing power and layout considerations. 4. Learn design-for-testability techniques, fault models, and advanced testing methodologies like BIST.	

<table>
<tr><td></td><td colspan="3">Outcomes:
Upon completion of this course, the student will be able to:
1. Explain VLSI design principles, fabrication processes, and modular design concepts.
2. Analyze MOSFET characteristics and design CMOS inverters with performance constraints.
3. Design and optimize CMOS logic circuits, addressing power and timing issues.
4. Apply DFT techniques to improve circuit reliability and fault detection.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td colspan="2">Mid-Term Examination</td><td>30 %</td></tr>
<tr><td colspan="2">Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td colspan="2">Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td colspan="2">Surprise Test</td><td>5 %</td></tr>
<tr><td colspan="2">Assignment-1</td><td>2.5 %</td></tr>
<tr><td colspan="2">Assignment-2</td><td>2.5 %</td></tr>
<tr><td colspan="2">Attendance</td><td>5 %</td></tr>
<tr><td colspan="2">End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="3">1. Sung-Mo Kang, Yusuf Leblebici and Chul Woo Kim, CMOS Digital Integrated Circuits: Analysis and Design, 4th Edition, Tata McGraw-Hill Publishing Company Limited, 2015.
2. Debaprasad Das, VLSI Design, 2nd Edition, Oxford University Press, 2015, New Delhi.</td></tr>
<tr><td>Reference Book(s)</td><td colspan="3">1. Neil h. e. weste, David harris and Ayan Banerjee, CMOS VLSI design a circuits and systems perspective, 4th Edition, Pearson Education, 2015.
2. Jan M. Rabaey, Anantha Chandrakasan and Borivoje Nikolic, Digital Integrated Circuits – A Design Perspective, 2nd Edition , PHI Learning, 2016, New Delhi..
3. Wayne Wolf, Modern VLSI Design System on Chip Design, 3rd Edition, PHI Learning Publisher, 2016, New Delhi.
4. John P. Uyemura, CMOS Logic Circuit Design, 1st Edition, Springer, 2007, US.</td></tr>
<tr><td rowspan="6">Digital Learning Sources</td><td>Course Name</td><td colspan="2">Digital VLSI Design</td></tr>
<tr><td>Course Link</td><td colspan="2">https://nptel.ac.in/courses/108/103/108103108/</td></tr>
<tr><td>Course Instructor</td><td colspan="2">Prof. Chandan Karfa | IIT Guwahati</td></tr>
<tr><td>Course Name</td><td colspan="2">CMOS Digital VLSI Design</td></tr>
<tr><td>Course Link</td><td colspan="2">https://nptel.ac.in/courses/108/107/108107129/</td></tr>
<tr><td>Course Instructor</td><td colspan="2">Prof. Sudeb Dasgupta | IIT Roorkee</td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Explain VLSI design principles, fabrication processes, and modular design concepts.	PO1, PO2, PO4, PO5, PO7, PO10, PO11, PO12, PEO1, PEO2.
CO2	Analyze MOSFET characteristics and design CMOS inverters with performance constraints.	PO1, PO2, PO3, PO4, PO7, PO8, PO10, PO12, PEO1, PEO2.
CO3	Design and optimize CMOS logic circuits, addressing power and timing issues.	PO1, PO2, PO4, PO5, PO8, PO10, PO11, PEO1, PEO2.
CO4	Apply DFT techniques to improve circuit reliability and fault detection.	PO1, PO2, PO3, PO4, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1	**Introduction and MOS Transistor**	**12 Hours**
Introduction: IC technology an overview, Classification of IC technology, VLSI Design challenges, VLSI Design Flow, Design Hierarchy, Concept of Regularity, Modularity and Locality, VLSI Design Styles. Fabrication Processes Flow–Basic Concepts, the CMOS n-Well and p-well Process, Layout Design Rules, Stick Diagrams, Mask Layout Design. **MOS Transistor:** The MOS System under External Bias, Structure and Operation of MOS Transistor (MOSFET), MOSFET Current-Voltage Characteristics, SPICE models for MOS transistor, MOSFET Scaling, MOSFET Capacitance.		

Module No. 2	**Static Characteristics and MOS Inverters– Switching Characteristics and Interconnect Effects**	**12 Hours**
Static Characteristics: Introduction, Resistive-Load Inverters, Enhancement-Load nMOS Inverter, Depletion-Load nMOS Inverter, CMOS Inverter. **MOS Inverters– Switching Characteristics and Interconnect Effects:** Introduction, Delay-Time Definitions, Calculation of Delay-Times, Inverter Design with Delay Constraints, Switching Power Dissipation of CMOS Inverters		

Module No. 3	Combinational MOS Logic Circuits	08 Hours
Combinational MOS Logic Circuits: CMOS Logic Circuits, Complex Logic Circuits, Layout of Complex CMOS Logic Gates, AOI and OAI Gates, Pseudo-nMOS Gate, CMOS Full-Adder Circuit, CMOS Transmission Gates (Pass Gates), Pass Transistor Circuits, Complementary Pass-Transistor Logic (CPL), Power dissipation.		

Module No. 4	Sequential MOS Logic Circuits	06 Hours
Sequential MOS Logic Circuits: Static and Dynamic Latches and Registers, Timing issues, pipelines, clock strategies, Clocked Latch and Flip-Flop Circuits and CMOS D-Latch.		

Module No. 5	Design for Testability	06 Hours
Design for Testability: Introduction, Fault Types and Models, Controllability and Observability, Scan-Based Techniques, Built-In Self-Test (BIST) Techniques (Pseudo Random Pattern Generator, Linear Feedback Shift Register as an ORA , Output Response Analyzer, Built-In Logic Block Observer), Current Monitoring IDDQ Test.		

COURSE DESCRIPTION: Machine Learning

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Machine Learning	
Course Type	Theory	
Course Code	22ELC6PC03T	
Category	PCC10	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Probability and Statistics, Python, Data Manipulation, Algorithm Implementation, Data Structures and Algorithms.	
Subject	Machine Learning (ML) is a branch of artificial intelligence that enables systems to learn from data and improve performance without explicit	

Description	programming. This course introduces core ML concepts, including supervised, unsupervised, and reinforcement learning, with a focus on their applications across industries. Students will explore data preprocessing, feature engineering, and model evaluation techniques to develop robust and interpretable models. Key algorithms for classification, regression, clustering, and association rule mining are covered, alongside the practical use of tools and libraries like Python's scikit-learn. The course also delves into neural networks, their architectures, learning processes, and an introduction to deep learning. Emphasis is placed on solving real-world problems through hands-on exercises and projects. Students will gain a solid foundation in both theoretical principles and practical implementation. By the end, learners will be prepared to apply ML techniques to diverse challenges in domains such as healthcare, finance, and technology.
Objectives and Outcomes	**Objectives:** The course should enable the students : **1. Understand the Fundamentals of Machine Learning**: To introduce the fundamental concepts of machine learning, including human vs. machine learning, data preprocessing, model training, and evaluation techniques. **2. Develop Feature Engineering Skills**: To explore feature engineering concepts, including feature transformation, subset selection, and the application of Bayesian methods for conceptual learning and decision-making. **3. Master Supervised and Unsupervised Learning Techniques**: To study and implement supervised learning algorithms for classification and regression, as well as unsupervised learning techniques for clustering and association rule mining. **4. Explore Neural Networks and Deep Learning Basics**: To understand the structure and functioning of artificial neural networks, learning processes, activation functions, and an overview of deep learning concepts.
	Outcomes: The course should enable the students to: 1. Demonstrate a solid understanding of machine learning concepts and tools, including data preprocessing, inductive bias, and the bias-variance tradeoff. (Knowledge Level: Apply) 2. Design and implement feature engineering and Bayesian learning techniques to enhance model performance and interpretability. (Knowledge Level: Analyze) 3. Apply supervised and unsupervised learning algorithms to solve real-world problems in classification, regression, clustering, and association rule mining. (Knowledge Level: Evaluate)

	4. Develop and train artificial neural networks using backpropagation and explore deep learning architectures for complex problem-solving. (Knowledge Level: Create)	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, "Machine Learning", Pearson Education 2: C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2010. 2. C. M. Bishop, Pattern Recognition and Machine Learning, Springer, 2010	
Reference Book(s)	1. J. Friedman, T. Hastie, and R. Tibshirani.The elements of statistical learning.Vol. 1, no. 10. New York:Springer series in statistics, 2001. 2. S. Shalev-Shwartz, and S. Ben-David. Understanding machine learning	
Digital Learning Sources	**Course Name**	Introduction to Machine Learning
	Course Link	https://nptel.ac.in/courses/106/106/106106139/
	Course Instructor	Dr. Balaraman Ravindran, IIT Madras

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Demonstrate a solid understanding of machine learning concepts and tools, including data preprocessing, inductive bias, and the bias-variance tradeoff. (Knowledge Level: Apply)	
CO2	Design and implement feature engineering and Bayesian learning techniques to enhance model performance and interpretability. (Knowledge Level: Analyze)	
CO3	Apply supervised and unsupervised learning algorithms to solve real-world problems in classification, regression, clustering, and association rule mining. (Knowledge Level: Evaluate)	
CO4	Develop and train artificial neural networks using backpropagation and explore deep learning architectures for complex problem-solving. (Knowledge Level: Create)	

DETAILED SYLLABUS:

Module No. 1		**06 Hours**
Introduction to Machine Learning, Model Preparation, Modelling and Evaluation, Human learning versus machine learning, types of machine learning, applications of machine learning, tools for machine learning, Machine Learning Activities, Data structures for machine learning, Data Pre- processing, selecting a model, training a model, model representation and interpretability, evaluating performance of a model, improving performance of a model, Learning theory, Hypothesis and target class, Hilbert space, Inductive bias and bias-variance tradeoff.		

Module No. 2		**06 Hours**
Feature Engineering, Bayesian Concept Learning, Introduction to feature engineering, feature transformation, feature subset selection, Importance of Bayesian methods, Bayes' theorem, concept learning through Bayes' theorem, Bayesian Belief Network		

Module No. 3		**12 Hours**
Supervised Learning –Classification, Regression, Example of supervised learning, classification model, classification learning steps, common classification algorithms – KNN, Decission trees random forest, SVM, example of regression, common regression algorithms,		

Module No. 4		**12 Hours**
Unsupervised Learning –Clustering, pattern finding using association rules, Unsupervised learning versus supervised learning, applications of unsupervised learning, clustering and its types, Apriori algorithm for association rule learning.		

Module No. 5		**04 Hours**
Neural Network: Understanding the biological neuron, exploring artificial neuron, types of activation functions, early implementation of artificial neural network, architectures of neural network, learning process in artificial neural network, backpropagation, Overview of Deep Learning.		

COURSE DESCRIPTION: Digital Image Processing

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Digital Image Processing	
Course Type	Theory	
Course Code	22ELC6PE01T	
Category	PEC3	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Signal Processing	
Subject Description	Digital image processing involves using algorithms to enhance, analyze and transform digital images. It includes techniques like filtering, segmentation and object recognition, with applications in fields like medicine, remote sensing and AI.	
Objectives and Outcomes	**Objectives:** The course should enable the students : 1. Gain an insight into the various analytical methods and transforms used in image processing. 2. Familiarize with image enhancement and restoration techniques. 3. Mathematical modeling of different image compression techniques and their applications. 4. Understand the Concept of color image processing and morphological operations on gray image.	

	Outcomes: The course should enable the students to: 1. Understand the need for different types of image transforms and their properties for processing of gray and color image data. 2. Implement the signal processing algorithms and techniques in image enhancement, image restoration, Morphology and Image Compression. 3. Implement basic image processing algorithms in MATLAB. 4. Understand practical scope of digital image processing for most of the work currently underway in this field.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. R.C. Gonzalez, R.E. Woods, Digital Image Processing, 3rd Edition, Pearson Education, 2007, New Delhi. 2. S. Sridhar, Digital Image Processing, 2nd Edition, Oxford University Press, 2016, New Delhi.	
Reference Book(s)	1. Rafael C. Gonzalez, Richard E. Woods Digital Image Processing using MATLAB, Seventh Edition , Pearson Education, Inc, 2004, New Delhi. 2. William K. Pratt, Digital Image Processing, 4th Edition, Wiley, 2002, New York. 3. Anil K. Jain, 'Fundamentals of Digital Image Processing', 1st Edition, Pearson 2019, New Delhi. 4. B. Chanda, Dutta D. Majumder, Digital Image Processing And Analysis, 2nd Edition ,PHI, 2011 , New Delhi.	
Digital Learning sources	**Course Name**	DIGITAL IMAGE PROCESSING
	Course Link	https://nptel.ac.in/courses/117/105/117105135/
	Course Instructor	Prof. P.K. Biswas , Department of Electronics & Electrical Communication Engineering, I.I.T, Kharagpur.

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's

CO1	Understand the need for different types of image transforms and their properties for processing of gray and color image data.	
CO2	Implement the signal processing algorithms and techniques in image enhancement, image restoration, Morphology and Image Compression.	
CO3	Implement basic image processing algorithms in MATLAB.	
CO4	Understand practical scope of digital image processing for most of the work currently underway in this field.	

DETAILED SYLLABUS:

Module No. 1		**8 Hours**
Digital Image Fundamentals: Digital Image Processing: Introduction, Background of image processing, Fundamental steps in image processing, Elements of digital image processing systems. Digital image representation, Sampling and quantization, Relationship Between pixels, Imaging geometry: Translation, Rotation, Perspective Transformation. **Properties and Applications of Image Transforms:** Fourier Transform, Discrete Fourier Transform, Fast Fourier Transform, Discrete Cosine Transform, Walsh Transform, Hadamard Transform, Hotelling Transform, Fundamentals on wavelet transform.		

Module No. 2		**8 Hours**
Image Enhancement: Enhancement in spatial domain: Basic gray level transformations, Histogram processing, Smoothing and Sharpening of Spatial Filters. Enhancement in frequency domain: Introduction to filtering in frequency domain, Smoothing and Sharpening of frequency domain filters.		

Module No. 3		**8 Hours**
Image Restoration and Reconstruction: Image restoration/degradation model, Noise models in image processing, Restoration in the presence of noise only, Periodic noise reduction by frequency domain filtering, Linear position invariant degradations, Estimating the degradation function, Inverse filtering, Wiener filtering,		

Constrained least squares restoration.

Module No. 4		**6 Hours**
Image compression: Introduction and motivation, Fundamental concepts: Data redundancy (coding redundancy, inter pixel redundancy and psycho visual redundancy), Fidelity criteria, Image compression models, Image compression standards, Elements of information theory. Image compression methods: Huffman coding, Arithmetic coding, LZW coding, Run-Length Coding, Bit plane coding.		

Module No. 5		**6 Hours**
Color Image Processing: Color fundamentals, Conversion of color image to gray scale image, Color model (RGB, HSI, HSV, HLS, CMK, CMYK). **Morphological Image Processing:** Morphological Image Processing: Preliminaries, Erosion, Dilation, Opening and Closing, hit or Miss transformation, Boundary extraction, Hole filling, Extraction of connected components, Thinning, Thickening.		

COURSE DESCRIPTION: Digital System Design Using Verilog

Degree	B. Tech.	
Level	Undergraduate	
Branch	ELC (Electronics and Computer Engineering)	
Semester	1st	
Subject Name	Digital System Design Using Verilog	
Course Type	Theory	
Course Code	22ELC6PE02T	
Category	ESC (Engineering Science Courses)/ Program Open Elective-2	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Digital technology emerges as the key gate way to develop products that plays an important role in all the fields of engineering. To meet this challenge digital systems play a crucial role for the development of societal needs. To understand the course students should have strong knowledge on digital electronics and circuits. Knowledge of digital logic principles, combinational and sequential logic circuits is required to model integrated digital systems. Basic C-Programming will help the students to understand Verilog and its use in design and development of complex systems.	
Subject Description	Digital system design is a foundational course for developing large VLSI designs. This course will help students to understand the internal details of fundamental blocks of digital circuits and also their implementation details. This course teaches behavior of designing digital circuits and their RTL modeling using Verilog HDL. It also focuses on verifying these Models and synthesizing the RTL to standard cell libraries and FPGAs. Students aim practical experience by designing, modeling, implementing and verifying several digital circuits. This course aims to provide students with the understanding of the different technologies related to HDLs, construct, compile and execute Verilog HDL programs using fundamental timing issues.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Understand the internal logic of various combinational and sequential units that is needed to develop large VLSI design. 2. Acquire the concepts of register transfer level design development process 3. Study the Verilog HDL for modeling complex digital circuits	

	4. Explore the design methodology and verification of digital circuits by developing test benches.	
	Outcomes: Upon completion of this course, the student will be able to: 1. Understand the digital system designs skills using VERILOG HDL 2. Demonstrate the skill on cost-effective system designs through proper selection of implementation fabrics. 3. Analyze complete systems using synthesis and build small scale applications using Interfacing concepts. 4. Design, implement and test complete digital systems using VERILOG HDL and demonstrate the innovation skills.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Advanced Digital Design With the Verilog HDL, Michael D. Ciletti, 2nd Edition, PHI, ISBN: 978–0–07–338054–4 2015.	
Reference Book(s)	1. Digital Design: An Embedded Systems Approach Using VERILOG, Peter J. Ashenden,Elsevier, ISBN: 978-0-12-369527-7, 2010. 2. Digital Systems Design Using Verilog, Charles Roth, Lizy K. John, ByeongKil Lee,Cengage Learning, ISBN-10: 1285051076, 2015. 3. Fundamentals of Digital Logic with Verilog Design, Stephen Brown and ZvonkoVranesic, 6th Edition, McGraw Hill publication, ISBN: 978–0–07–338054–4, 2014.	
Digital Learning Resources	Digital Design with Verilog https://onlinecourses.nptel.ac.in/noc24_cs61/preview Prof. Chandan Karfa, Prof. Aryabartta Sahu, IIT Guwahati	
	Hardware modeling using Verilog https://onlinecourses.nptel.ac.in/noc20_cs63/preview Prof. Indranil Sengupta IIT Kharagpur	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's

CO1	Understand the digital system designs skills using VERILOG HDL	PO1, PO2, PO3, PO4, PO6
CO2	Demonstrate the skill on cost-effective system designs through proper selection of implementation fabrics.	PO1, PO2, PO3, PO4, PO6, PO7
CO3	Analyze complete systems using synthesis and build small scale applications using Interfacing concepts.	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Design, implement and test complete digital systems using VERILOG HDL and demonstrate the innovation skills.	PO1, PO2, PO3, PO4, PO5, PO6, PO7

DETAILED SYLLABUS:

Module No. 1	**Introduction to Verilog**	**10 Hours**
Introduction to Verilog: Verilog IEEE standards, Application Areas and Abstraction levels. Verilog Data Types: Net, Register and Constant. Verilog Operators: Logical, Arithmetic, Bitwise, Reduction, Relational, Concatenation and Conditional, Number representation and Verilog ports, Verilog Primitives.		

Module No. 2	**Design Methodology**	**07 Hours**
Introduction to Design Methodology: Digital Systems and Embedded Systems, Real-world circuits. Design Methodology: Design Flow-Architecture, Functional design and verification, Synthesis, Physical design. Design Optimization-Area, Timing and Power, System representation.		

Module No. 3	**Verilog Behavioural Modeling**	**10 Hours**
Behavioural Modeling: Latches and Level-Sensitive Circuits in Verilog, Cyclic Behavioural Models of Flip-Flops and Latches, Cyclic Behaviour and Edge Detection. A Comparison of Styles for Behavioural modeling, Behavioural Models of Multiplexers, Encoders, Decoders and Arithmetic circuits.		

Module No. 4	**Verilog Dataflow Styles**	**10 Hours**
Dataflow Modeling: Boolean Equation-Based Models of Combinational Logic, Propagation Delay and Continuous Assignments. Dataflow Models of a Linear-Feedback Shift Register. Modeling Digital Machines with Repetitive Algorithms Machines with Multi cycle Operations. Tasks & Functions.		

Module No. 5	Structural Modeling Styles	6 Hours
Structural Modeling: Design of Combinational Logic, Verilog Structural Models, Module Ports, Top-Down Design and Nested Modules. Gate level modeling.		

COURSE DESCRIPTION: Internet of Things

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Internet of Things	
Course Type	Theory	
Course Code	22ELC6PE03T	
Category	PEC3	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	A strong foundation in computer networks, embedded systems, and basic programming is essential for understanding the Internet of Things (IoT). Familiarity with wireless communication protocols, sensor integration, and data processing techniques is also recommended.	
Subject Description	The Internet of Things (IoT) explores the integration of physical devices, sensors, and software to create interconnected systems for seamless communication and data exchange. It covers concepts of device architecture, communication protocols, and data management techniques. The subject	

<table>
<tr><td></td><td colspan="2">emphasizes practical applications in smart environments, industrial automation, and healthcare. Students gain hands-on experience in designing, implementing, and managing IoT-based systems.</td></tr>
<tr><td rowspan="2">Objectives and Outcomes</td><td colspan="2">Objectives:
The course should enable the students :
1. To learn the basic issues, policy and challenges in the Internet.
2. To get an idea of the application areas where Internet of Things can be applied.
3. To understand the cloud and internet environment and various modes of communications with Internet.
4. To understand the various modes of communications with Internet.</td></tr>
<tr><td colspan="2">Outcomes:
The course should enable the students to:
1. Students will demonstrate proficiency in IoT architecture, communication protocols, and device integration.
2. They will design and develop functional IoT prototypes addressing real-world problems.
3. They will critically analyze data management and security challenges in IoT applications.
4. Apply IoT concepts to innovate in domains like smart cities, healthcare, and industrial automation.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. VijayMadisetti, Arshdeep Bahga,” Internet of ThingsA Hands-On-Approach”,2014, ISBN:978 0996025515
2. Honbo Zhou, ”The Internet of Things in the Cloud:A Middleware Perspective” — CRCPress- 2012.
3. Arshdeep Bahga, Vijay Madisetti, “Internet of Things (A Hands-On-Approach)”, VPT, 2014.</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. Luigi Atzor et.al, “The Internet of Things: A survey, “, Journal on Networks, Elsevier Publications, October 2010.
2. Olivier Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things – Key applications and Protocols”, Wiley, 2012..
3. Adrian McEwen, “Designing the Internet of Things”, Wiley Publishers, 2013.</td></tr>
</table>

Digital Learning sources	**Course Name**	Introduction to internet of things
	Course Link	NPTEL :: Computer Science and Engineering - NOC:Introduction to internet ofthings
	Course Instructor	Prof. Sudip Misra, IIT Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Students will demonstrate proficiency in IoT architecture, communication protocols, and device integration.	
CO2	They will design and develop functional IoT prototypes addressing real-world problems.	
CO3	They will critically analyze data management and security challenges in IoT applications.	
CO4	Graduates will apply IoT concepts to innovate in domains like smart cities, healthcare, and industrial automation.	

DETAILED SYLLABUS:

Module No. 1		**10 Hours**
Introduction & Concepts: Introduction to Internet of Things, Physical Design of IOT, Logical Design of IOT, IOT Enabling Technologies, IOT Levels. Domain Specific IOTs: Home Automation, Cities, Environment, Energy, Retail, Logistics, Agriculture, Industry, Health & Life Style, Challenges and Issues.		

Module No. 2		**10 Hours**
M2M & System Management with NETCONF-YANG: M2M, Difference between IOT and M2M, SDN and NFV for IOT, Software defined Networking, Network Function Virtualization, Need for IOT Systems Management, Simple Network Management Protocol, Limitations of SNMP, Network Operator Requirements, NETCONF, YANG, IOT Systems management with NETCONF-YANG.		

Module No. 3		**10 Hours**
IoT Protocols: Protocol Standardization for IoT and WSN Protocols-SCADA and RFID Protocols-Issues with IoT Standardization Protocols IEEE802.15.4-BACNet Protocol- , Architecture - Network layer – APS Layer – Security.		

Module No. 4		**05 Hours**

Case Study and IoT Application Development: IoT applications in home- infrastructures security- Industries- IoT electronic equipments.

Module No. 5		**05 Hours**
Use of Big Data and Visualization in IoT Industry 4.0 concepts - Sensors and sensor Node – Interfacing using Raspberry Pi/Arduino- Web Enabled Constrained Devices.		

COURSE DESCRIPTION: Cloud Computing

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Cloud Computing	
Course Type	Theory	
Course Code	22ELC6PE04T	
Category	PEC3	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	A solid understanding of computer networks, operating systems, and virtualization concepts is essential for cloud computing. Familiarity with programming, distributed systems, and data management techniques is also recommended.	
Subject Description	Cloud Computing introduces the concepts, architecture, and services of scalable and on-demand computing resources delivered over the internet. It covers virtualization, resource allocation, and cloud service models like IaaS, PaaS, and SaaS. The subject emphasizes practical applications in storage, computing, and data analytics in cloud environments. Students gain hands-on experience with cloud platforms and learn to design efficient, secure, and scalable cloud-based solutions.	
Objectives	**Objectives:** The course should enable the students :	

<table>
<tr><td rowspan="2">and Outcomes</td><td colspan="2">1. To provide students with the fundamentals and essentials of Cloud Computing.
2. To provide students a sound foundation of the Cloud Computing so that they are able to start using and adopting Cloud Computing services and tools in their real life scenarios.
3. To enable students exploring some important cloud computing driven commercial systems and applications.
4. To expose the students to frontier areas of Cloud Computing and information systems, while providing sufficient foundations to enable further study and research.</td></tr>
<tr><td colspan="2">Outcomes:
The course should enable the students to:
1. Explain the core concepts of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing.
2. Apply the fundamental concepts in datacenters to understand the tradeoffs in power, efficiency and cost.
3. Identify resource management fundamentals, i.e. resource abstraction, sharing and sandboxing and outline their role in managing infrastructure in cloud computing.
4. Analyze various cloud programming models and apply them to solve problems on the cloud.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Kai Hwang, Geoffrey C. Fox and Jack J. Dongarra, “Distributed and Cloud Computing from Parallel Processing to the Internet of Things”, Morgan Kaufmann, Elsevier, 2012</td></tr>
</table>

	2. Barrie Sosinsky, "Cloud Computing Bible" John Wiley & Sons, 2010	
Reference Book(s)	1.Cloud Computing: Concepts, Technology & Architecture**,** Thomas Erl, Ricardo Puttini, Zaigham Mahmood, Prentice Hall, 1st Edition (2013) 2. Mastering Cloud Computing, Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, McGraw-Hill Education, 1st Edition (2013)	
Digital Learning sources	**Course Name**	Cloud computing
	Course Link	https://nptel.ac.in/courses/106/105/106105167/
	Course Instructor	Prof. Soumya Kanti Ghosh, IIT Kharagpur
	Course Name	Cloud Computing and Distributed Systems Course
	Course Link	https://nptel.ac.in/courses/106/104/106104182/
	Course Instructor	Dr. Rajiv Misra, IIT Patna

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Explain the core concepts of the cloud computing paradigm: how and why this paradigm shift came about, the characteristics, advantages and challenges brought about by the various models and services in cloud computing.	
CO2	Apply the fundamental concepts in datacenters to understand the tradeoffs in power, efficiency and cost.	
CO3	Identify resource management fundamentals, i.e. resource abstraction, sharing and sandboxing and outline their role in managing infrastructure in cloud computing.	
CO4	Analyze various cloud programming models and apply them to solve problems on the cloud.	

DETAILED SYLLABUS:

Module No. 1		**10 Hours**
Evolution of Computing Paradigms - Overview of Existing Hosting Platforms, Grid Computing, Utility Computing, Autonomic Computing, Dynamic Datacenter Alliance, Hosting / Outsourcing, Introduction to Cloud Computing, Workload Patterns for the Cloud, "Big Data", IT as a Service, Technology Behind Cloud Computing,		

Module No. 2		**10 Hours**
A Classification of Cloud Implementations- Amazon Web Services - IaaS, The Elastic Compute Cloud (EC2), The Simple Storage Service (S3), The Simple Queuing Services (SQS), VMware vCloud - IaaS, vCloud Express, Google AppEngine - PaaS, The Java Runtime Environment,		

Module No. 3		**06 Hours**
The Python Runtime Environment- The Datastore, Development Workflow, Windows Azure Platform - PaaS, Windows Azure, SQL Azure, Windows Azure AppFabric,		

Module No. 4		**08 Hours**
Salesforce.com - SaaS / PaaS, Force.com, Force Database - the persistency layer, Data Security, Microsoft Office Live - SaaS, LiveMesh.com, Google Apps - SaaS, A Comparison of Cloud Computing Platforms, Common Building Blocks.		

Module No. 5		**06 Hours**
Cloud Security – Infrastructure security – Data security – Identity and access management Privacy- Audit and Compliance.		

COURSE DESCRIPTION: Analog VLSI Design

Degree	B. Tech.
Level	Undergraduate
Branch	Electronics and Computer Engineering
Semester	6th
Subject Name	Analog VLSI Design
Course Type	Theory
Course Code	22ELC6PE05T
Category	PEC4
Credit Point	3

Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	MOSFET Fundamentals, Circuit Theory, Analog Building Blocks, Frequency Response and Feedback	
Subject Description	**Analog VLSI Design** is a specialized field in electronics engineering focusing on the design, analysis, and implementation of analog circuits using CMOS technology. The subject covers essential building blocks such as operational amplifiers, differential amplifiers, current mirrors, voltage references, and oscillators. It delves into the principles of frequency response, feedback systems, and stability analysis to ensure robust circuit operation. A strong emphasis is placed on low-power design, noise reduction, and performance optimization to meet real-world constraints. Analog VLSI Design also explores ADC/DAC circuits, enabling seamless integration with digital systems. Students learn to apply simulation tools like SPICE for circuit verification and layout tools for physical design. The subject bridges the gap between device physics and system-level design, incorporating fabrication process knowledge. It finds applications in mixed-signal ICs, RF systems, and sensor interfaces. Through hands-on projects, students gain expertise in tackling challenges like process variations and parasitics. This field is critical for developing efficient and compact electronics in modern technology.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Understand the concept of Robust Analog Design andSingle-Stage Amplifiers. 2. Learn the concept of Differential Amplifier and Passive and Active Current Mirrors. 3. Learn the concept of Bandgap References and Operational Amplifier. 4. Understand the concept of Stability as well as Frequency Compensation and also learn the design methodology of amplifiers.	

<table>
<tr><td></td><td colspan="3">Outcomes:
Upon completion of this course, the student will be able to:
1. Analyze single stage amplifiers with different loads.
2. Acquire knowledge about differential amplifier with different loads and also analyze the concept of Passive and Active Current Mirrors.
3. Analyze the concept of Bandgap References and Operational Amplifier
4. Design and evaluate the performance of CMOS operational amplifiers with biasing as well as stability.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td colspan="2">Mid-Term Examination</td><td>30 %</td></tr>
<tr><td colspan="2">Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td colspan="2">Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td colspan="2">Surprise Test</td><td>5 %</td></tr>
<tr><td colspan="2">Assignment-1</td><td>2.5 %</td></tr>
<tr><td colspan="2">Assignment-2</td><td>2.5 %</td></tr>
<tr><td colspan="2">Attendance</td><td>5 %</td></tr>
<tr><td colspan="2">End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="3">1. Behzad Razavi, Design of Analog CMOS Integrated Circuits, 2nd Edition, Tata McGraw-Hill Publishing Company Limited, 2017.
2. Phillip E. Allen, Douglas R. Holberg, CMOS Analog Circuit Design, 3rd Edition, Oxford University Press, 2013.</td></tr>
<tr><td>Reference Book(s)</td><td colspan="3">1. David A Johns, Ken Martin, Analog Integrated Circuit Design, 2nd Edition, Wiley India Pvt. Limited, 2013.
2. Paul R Gray and R G Meyer, Analysis and design of analog integrated circuits, 6th Edition, Wiley, 2019.</td></tr>
<tr><td rowspan="6">Digital Learning sources</td><td>Course Name</td><td colspan="2">Analog IC Design</td></tr>
<tr><td>Course Link</td><td colspan="2">https://nptel.ac.in/courses/117/106/117106030/</td></tr>
<tr><td>Course Instructor</td><td colspan="2">Prof. S. Aniruddhan| IIT Madras</td></tr>
<tr><td>Course Name</td><td colspan="2">CMOS Analog VLSI Design</td></tr>
<tr><td>Course Link</td><td colspan="2">https://nptel.ac.in/courses/117/101/117101105/</td></tr>
<tr><td>Course Instructor</td><td colspan="2">Prof. A.N. Chandorkar| IIT Bombay</td></tr>
</table>

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Analyze single stage amplifiers with different loads.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO2	Acquire knowledge about differential amplifier with different loads and also analyze the concept of Passive and Active Current Mirrors.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO3	Analyze the concept of Bandgap References and Operational Amplifier	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO4	Design and evaluate the performance of CMOS operational amplifiers with biasing as well as stability.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1		**10 Hours**
Introduction to Analog Design: General Concepts, Levels of Abstraction, Robust Analog Design. **Single-Stage Amplifiers:** Basic Concepts, Common-Source Stage, Common-Source Stage with Resistive Load, CS Stage with Diode-Connected Load, CS Stage with Current- Source Load, CS Stage with Triode Load, CS Stage with Source Degeneration, Source Follower, Common-Gate Stage, Cascode Stage, Folded Cascode.		

Module No. 2		**10 Hours**
Differential Amplifiers: Single-Ended and Differential Operation, Basic Differential Pair, Qualitative Analysis,		

Quantitative Analysis, Common-Mode Response, Differential Pair with MOS Loads.

Passive and Active Current Mirrors:

Basic Current Mirrors, Cascode Current Mirrors, Active Current Mirrors, Large-Signal Analysis, Small-Signal Analysis, Common-Mode Properties.

Module No. 3		**06 Hours**

Bandgap References:

General Considerations, Supply-Independent Biasing, Temperature-Independent References, Negative-TC Voltage, Positive-TC Voltage, Bandgap Reference, PTAT current generation.

Module No. 4		**06 Hours**

Operational Amplifiers:

General Considerations, Performance Parameters, One-Stage Op Amps, Two-Stage Op Amps, Gain Boosting, Slew Rate, Power Supply Rejection.

Module No. 5		**04 Hours**

Design methodology of Amplifier:

Design methodology with examples of Single Stage Amplifiers (CS) with resistive and MOS load, Differential Amplifier with resistive and active load, two stage operational Amplifier.

COURSE DESCRIPTION: Wireless Sensor Networks

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Wireless Sensor Networks	
Course Type	Theory	
Course Code	22ELC6PE06T	
Category	PEC4	
Credit Point	3	
	Lecture	36 Hours

<table>
<tr><td rowspan="3">Time Commitment</td><td>Tutorial</td><td>08 Hours</td></tr>
<tr><td>Practice</td><td>Nil</td></tr>
<tr><td>Total</td><td>44 Hours</td></tr>
<tr><td>Recommended Background Knowledge</td><td colspan="2">Wireless Communication, Communication systems</td></tr>
<tr><td>Subject Description</td><td colspan="2">To understand the fundamentals of wireless sensor networks and its application to critical real time scenarios. To study the various protocols at various layers and its differences with traditional protocols.</td></tr>
<tr><td rowspan="2">Objectives and Outcomes</td><td colspan="2">Objectives:
The course should enable the students to:
1. Understand the basic WSN technology and supporting protocols
2. To learn various fundamental and emerging protocols of all layers
3. To study the design consideration of topology control and solution to the various problems.
4. Learn key routing protocols for sensor networks and main design issues.</td></tr>
<tr><td colspan="2">Outcomes:
Upon completion of this course, the student will be able to:
1. Understand and explain common wireless sensor node architectures.
2. Be able to carry out simple analysis and planning of WSNs.
3. To analyze routing and congestion algorithms
4. To design, develop , and carry out performance analysis of sensors on specific applications</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Waltenegus Dargie, Christian Poellabauer, “Fundamentals of Wireless Sensor Networks: Theory and Practice”, Wiley 2010
2. Mohammad S. Obaidat, Sudip Misra, “Principles of Wireless Sensor Networks”, Cambridge, 2014</td></tr>
<tr><td>Reference Book(s)</td><td colspan="2">1. Ian F. Akyildiz, Mehmet Can Vuran , “Wireless Sensor Networks”, Wiley 2010
2. C S Raghavendra, K M Sivalingam, Taieb Znati, “Wireless Sensor Networks”, Springer, 2010
3. C. Sivarm murthy & B.S. Manoj, “Adhoc Wireless Networks”, PHI-2004
4. FEI HU., XIAOJUN CAO, “Wireless Sensor Networks”, CRC Press, 2013</td></tr>
</table>

	5. Feng ZHAO, L GUIBAS, " Wireless Sensor Networks", ELSEVIER , 2004	
Digital Learning sources	**Course Name**	Wireless Ad Hoc and Sensor Network
	Course Link	https://archive.nptel.ac.in/courses/106/105/106105160/
	Course Instructor	Prof. Sudip Misra
	Course Name	Wireless Ad Hoc and Sensor Network
	Course Link	https://archive.nptel.ac.in/courses/106/105/106105160/
	Course Instructor	Prof. Sudip Misra

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Understand and explain common wireless sensor node architectures.	
CO2	Be able to carry out simple analysis and planning of WSNs.	
CO3	To analyze routing and congestion algorithms	
CO4	To design, develop , and carry out performance analysis of sensors on specific applications	

DETAILED SYLLABUS:

Module No. 1		**8 Hours**
Components of a wireless sensor node, Motivation for a Network of Wireless Sensor Nodes, Classification of sensor networks, Characteristics of wireless sensor networks, Challenges of wireless sensor networks, Comparison between wireless sensor networks and conventional wireless networks, Limitations in wireless sensor networks, Design challenges, Hardware architecture and applications		

Module No. 2		**6 Hours**
Physical Layer, Basic Components, Source Encoding, Channel Encoding, Modulation Medium Access Control: Wireless MAC Protocols, Characteristics of MAC Protocols in Sensor Networks, Contention-Free MAC Protocols, Contention-Based MAC Protocols, Hybrid MAC Protocols.		

Module No. 3		**8 Hours**
Routing Metrics, Flooding and Gossiping, Data-Centric Routing, Proactive Routing, On-Demand Routing, Hierarchical Routing, Location-Based Routing, QoS-Based Routing Protocols Node and Network Management: Power Management, Local Power Management aspects, Dynamic Power Management, Conceptual Architecture.		

Module No. 4		**8 Hours**
Clocks and the Synchronization Problem, Time Synchronization in Wireless Sensor Networks, Basics of Time Synchronization, Time Synchronization Protocols Localization: Ranging Techniques, Range-Based Localization, Range-Free Localization, Event Driven Localization.		

Module No. 5		**6 Hours**
Fundamentals of Network Security, Challenges of Security in Wireless Sensor Networks , Security Attacks in Sensor Networks, Protocols and Mechanisms for Security, IEEE 802.15.4 and Zig Bee Security.		

COURSE DESCRIPTION: Natural Language Processing

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Natural Language Processing	
Course Type	Theory	
Course Code	22ELC6PE07T	
Category	PEC4	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background	A foundational understanding of programming, data structures, and algorithms is essential for Natural Language Processing (NLP). Familiarity	

<table>
<tr><td>Knowledge</td><td colspan="2">with linguistics, probability, and machine learning concepts enhances comprehension of NLP techniques and applications.</td></tr>
<tr><td>Subject Description</td><td colspan="2">Natural Language Processing (NLP) explores the computational techniques for understanding, analyzing, and generating human language. It covers core topics such as tokenization, syntactic parsing, semantic analysis, and machine translation. The subject emphasizes applications in sentiment analysis, chatbots, and language modeling. Students gain hands-on experience with NLP libraries and frameworks to solve real-world language processing problems.</td></tr>
<tr><td rowspan="2">Objectives and Outcomes</td><td colspan="2">Objectives:
The course should enable the students :
1) Understand the fundamental concepts and techniques of Natural Language Processing (NLP).
2) Analyze linguistic structures and apply computational methods for language modeling and parsing.
3) Design and implement NLP solutions for tasks like sentiment analysis, machine translation, and text generation.
4) Explore advanced topics in NLP, such as deep learning approaches and multilingual processing.</td></tr>
<tr><td colspan="2">Outcomes:
The course should enable the students to:
1) Demonstrate proficiency in NLP techniques and tools for text processing and analysis.
2) Design and develop computational solutions for real-world language processing applications.
3) Critically analyze challenges in natural language understanding and generate innovative solutions.
4) Apply NLP concepts to domains like AI-driven assistants, content generation, and language translation systems.</td></tr>
<tr><td rowspan="9">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Dan Jurafsky and James H. Martin. Speech and Language Processing, Prentice-Hall. (3rd Edition)
2. James Allen. Natural Language Understanding, Pearson.
3. Chris Manning and Hinrich Schuetze. Foundations of Statistical Natural Language Processing, MIT Press.</td></tr>
</table>

	4. Ian Goodfellow, Yoshua Bengio, and Aaron Courville. Deep Learning, MIT Press.	
Reference Book(s)	1. Natural Language Processing, Skills gain - NLP, Tenserflow, Dialog Systems, Deep Learning. 2. Natural Language Processing using Python, Skills gain - NLP, Machine Learning specific NLP models. 3. Advanced NLP using Deep Learning, Skills gain - Deep Learning, Advanced NLP.	
Digital Learning sources	**Course Name**	Natural Language Processing
	Course Link	NPTEL :: Computer Science and Engineering - NOC:Natural Language Processing
	Course Instructor	Prof. Pawan Goyal, IIT Kharagpur
	Course Name	Natural Language Processing
	Course Link	NPTEL :: Computer Science and Engineering - Natural Language Processing
	Course Instructor	Prof. Pushpak Bhattacharyya, IIT Bombay

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Demonstrate proficiency in NLP techniques and tools for text processing and analysis.	
CO2	Design and develop computational solutions for real-world language processing applications.	
CO3	Critically analyze challenges in natural language understanding and generate innovative solutions.	
CO4	Apply NLP concepts to domains like AI-driven assistants, content generation, and language translation systems.	

DETAILED SYLLABUS:

Module No. 1		**10 Hours**
Introduction, Regular Expression, Text Normalization, Edit Distance, N-gram Language Model, Data Generalization and Smoothing, Kneser-Ney Smoothing. Lexical Semantics, Vector Semantics, Words and Vectors, Similarity Metrics Measures, Term Frequency Inverse Document Frequency, Word Embedding and its Semantic properties, Word2vec Models, Parts-of-Speech, HMM based POS Tagging, Sequence Processing, Context Free Grammar, Treebanks, Lexicalized Grammars.		

Module No. 2		**10 Hours**
Parsing: Ambiguity Resolution, Statistical/Probabilistic Parsing, PCFG, Evaluating Parser, Dependency Parsing, Dependency Relations and Formalisms, Transition-Based Dependency Parsing, Graph-Based Dependency Parsing, Representation of Meaning, Model-Theoretic Semantics, First-Order Logic, Event and State Representations, Description Logics.		

Module No. 3		**06 Hours**
Information Extraction, Named Entity Recognition, Relation Extraction, Time Extraction, Event Extraction, Template Filling, Semantic Role Labeling, Diathesis Alterations, The Proposition Bank, FramNet, Selection Restrictions,		

Module No. 4		**06 Hours**
Sentiment Analysis: Defining Emotions, Creating Affect Lexicons, Semi-supervised Induction of Affect Lexcons, Sentiment Recognition, Affect Recognition, Connotation Frames.		

Module No. 5		**08 Hours**
Extraction based Text Summarization, Abstraction based Text Summarization, Coreference Resolution, Discourse Analysis, Machine translation, Information Retrieval based Question Answering, Knowledge based Question Answering, Dialog Systems, Chatbots.		

COURSE DESCRIPTION: Big Data Analytics

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Big Data Analytics	
Course Type	Theory	
Course Code	22ELC6PE08T	
Category	PEC4	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background	A solid foundation in data structures, algorithms, and programming is essential for Big Data Analytics. Familiarity with databases, statistical	

<table>
<tr><td>Knowledge</td><td colspan="2">methods, and distributed computing concepts is also recommended.</td></tr>
<tr><td>Subject Description</td><td colspan="2">Big Data Analytics explores techniques and tools for processing, analyzing, and deriving insights from large and complex datasets. It covers core topics such as data preprocessing, distributed computing frameworks, and machine learning algorithms for big data. The subject emphasizes practical applications in business intelligence, healthcare, and social media analysis. Students gain hands-on experience with tools like Hadoop, Spark, and data visualization platforms to solve real-world big data challenges.</td></tr>
<tr><td rowspan="2">Objectives and Outcomes</td><td colspan="2">Objectives:
The course should enable the students :
1. Understand the Big Data Platform and its Use cases
2. Real- time Analytics Platform(RTAP) and IBM Info sphere
3. Provide HDFS Concepts and Interfacing with HDFS
4. Understand Map Reduce Jobs
5. Provide hands on Hodoop Eco System and apply analytics on Structured, Unstructured Data.</td></tr>
<tr><td colspan="2">Outcomes:
The course should enable the students to:
1. Identify Big Data and its Business Implications.
2. List the components of Hadoop and Hadoop Eco-System
3. Access and Process Data on Distributed File System
4. understand Data stage , Statistical analysis , Intelligent scheduler , Info sphere Streams
5. Develop Big Data Solutions using Hadoop Eco System
6. Analyze Infosphere BigInsights Big Data Recommendations.
7. Apply Machine Learning Techniques using R.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td>Mid-Term Examination</td><td>30 %</td></tr>
<tr><td>Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td>Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td>Surprise Test</td><td>5 %</td></tr>
<tr><td>Assignment-1</td><td>2.5 %</td></tr>
<tr><td>Assignment-2</td><td>2.5 %</td></tr>
<tr><td>Attendance</td><td>5 %</td></tr>
<tr><td>End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="2">1. Data Science and Big data Analytics - EMC Education Services , 2015-WILEY
2. Michael Minelli, Michehe Chambers, “Big Data, Big Analytics: Emerging Business Intelligence and Analytic Trends for Today’s Business”, 1st Edition, Ambiga Dhiraj, Wiely CIO Series</td></tr>
</table>

Reference Book(s)	1. Big Data Analytics - Pyne , Rao and Rao, Springer 4: 2. 2. Arvind Sathi, "Big Data Analytics: Disruptive Technologies for Changing the Game", 1st Edition, IBM Corporation, 2012. 3. Seema Acharya, Subhasini Chellappan, "Big Data Analytics" Wiley 2015.	
Digital Learning sources	**Course Name**	Data Analytics with Python
	Course Link	NPTEL :: Computer Science and Engineering - NOC:Data Analytics with Python
	Course Instructor	Prof. A. Ramesh, IIT Roorkee

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Identify Big Data and its Business Implications.	
CO2	List the components of Hadoop and Hadoop Eco-System	
CO3	Access and Process Data on Distributed File System	
CO4	understand Data stage , Statistical analysis , Intelligent scheduler , Info sphere Streams	
CO5	Develop Big Data Solutions using Hadoop Eco System	
CO6	Analyze Infosphere Big Insights Big Data Recommendations.	
CO7	Apply Machine Learning Techniques using R.	

DETAILED SYLLABUS:

Module No. 1		**08 Hours**
Introduction: Big Data Overview, BI Versus Data Science, Current Analytical Architecture, Drivers of Big Data. Data Analytics Lifecycle - Overview, Phases - Discovery, Data Preparation and Model planning, Model building, Communicate Results and Operationalize. Industry examples of Big Data.		

Module No. 2		**12 Hours**
Big Data Technology: Hadoop's parallel world, Data Discovery, Cloud and Big data, Predictive analytics, crowd sourcing analytics, Inter and Trans firewall analytics. Information management: Big data foundation, Big data computing platforms, Big data computation, more on Big data storage, Big data computational limitaitons.		

Module No. 3		**08 Hours**
Estimating moments, Counting oneness in a window , Decaying window - Real- time Analytics Platform(RTAP) applications, IBM Info sphere , Big data at rest , Info sphere streams ,Data stage , Statistical analysis , Intelligent scheduler , Info sphere Streams, Predictive Analytics , Supervised , Unsupervised learning , Neural networks, Mining Frequent item sets , Market based model		

Module No. 4		**06 Hours**
Apriori Algorithm , Handling large data sets in Main memory , Limited Pass algorithm , Counting frequent item sets in a stream , Clustering Techniques , Hierarchical –KMeans, Clustering high dimensional data Visualizations, Visual data analysis techniques, interaction techniques.		

Module No. 5		**06 Hours**
Systems and applications IBM for Big Data , Map Reduce Framework, Hadoop , Hive Sharding ,No SQL Databases , Hadoop Distributed file systems , Hbase, Impala , Analyzing big data with twitter , Big data for E-Commerce , Big data for blogs.		

COURSE DESCRIPTION: Image Processing Technique

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Image Processing Technique	
Course Type	Theory	
Course Code	22ELC6OE01T	
Category	OEC3	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil

<table>
<tr><td></td><td colspan="2">Total</td><td>44 Hours</td></tr>
<tr><td>Recommended Background Knowledge</td><td colspan="3">A strong foundation in linear algebra, calculus, and basic programming is essential for understanding Image Processing Techniques. Familiarity with digital signal processing and fundamental concepts of computer vision is also recommended.</td></tr>
<tr><td>Subject Description</td><td colspan="3">Image Processing Techniques explores methods for analyzing, enhancing, and transforming visual data using computational tools. It covers topics such as image acquisition, filtering, segmentation, and feature extraction. The subject emphasizes practical applications in areas like medical imaging, pattern recognition, and computer vision. Students gain hands-on experience with image processing algorithms and tools to solve real-world challenges.</td></tr>
<tr><td rowspan="2">Objectives and Outcomes</td><td colspan="3">Objectives:
The course should enable the students :
1. Gain an insight into the various analytical methods used in image processing.
2. Familiarize with image enhancement and restoration techniques.
3. Mathematical modeling of different image compression techniques and their applications.
4. Understand the Concept of color image processing and morphological operations on gray image.</td></tr>
<tr><td colspan="3">Outcomes:
The course should enable the students to:
1. Understand the fundamental concepts of a digital image processing system.
2. Implement the signal processing algorithms and techniques in image enhancement, and image restoration.
3. Learn the mathematical modeling of image compression and morphological image processing.
4. Gain knowledge about Color Image processing.</td></tr>
<tr><td rowspan="8">Assessment/ Evaluation</td><td colspan="2">Mid-Term Examination</td><td>30 %</td></tr>
<tr><td colspan="2">Quiz Test-1</td><td>2.5 %</td></tr>
<tr><td colspan="2">Quiz-Test-2</td><td>2.5 %</td></tr>
<tr><td colspan="2">Surprise Test</td><td>5 %</td></tr>
<tr><td colspan="2">Assignment-1</td><td>2.5 %</td></tr>
<tr><td colspan="2">Assignment-2</td><td>2.5 %</td></tr>
<tr><td colspan="2">Attendance</td><td>5 %</td></tr>
<tr><td colspan="2">End-Term Examination</td><td>50 %</td></tr>
<tr><td>Prescribed Text Book(s)</td><td colspan="3">1. R.C. Gonzalez, R.E. Woods, Digital Image Processing, 3rd Edition, Pearson Education, 2007, New Delhi.
2. S. Sridhar, Digital Image Processing, 2nd Edition, Oxford University Press, 2016, New Delhi.</td></tr>
</table>

Reference Book(s)	ael C. Gonzalez, Richard E. Woods Digital Image Processing using MATLAB, enth Edition , Pearson Education, Inc, 2004, New Delhi. 2. B. Chanda, Dutta D. Majumder, Digital Image Processing And Analysis, 2nd Edition ,PHI, 2011 , New Delhi.	
Digital Learning sources	Course Name	DIGITAL IMAGE PROCESSING
	Course Link	https://nptel.ac.in/courses/117/105/117105135/
	Course Instructor	Prof. P.K. Biswas , Department of Electronics & Electrical Communication Engineering, I.I.T, Kharagpur

CO's Mapping with PO's and PEO's

Course Outcomes	**Course Outcome Statement**	**PO's / PEO's**
CO1	Understand the fundamental concepts of a digital image processing system.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO2	Implement the signal processing algorithms and techniques in image enhancement, and image restoration.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO3	Learn the mathematical modeling of image compression and morphological image processing.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.
CO4	Gain knowledge about Color Image processing.	PO1, PO2, PO3, PO4, PO5, PO7, PO8, PO10, PO11, PO12, PEO1, PEO2.

DETAILED SYLLABUS:

Module No. 1		**08 Hours**
Introduction: Introduction: Background of image processing, Fundamental steps in image processing, Elements of digital image processing systems. Digital image representation, Sampling and quantization, Relationship between pixels: Neighbours, adjacency, connectivity, regions, boundaries and distance measure, Image geometry: translation, rotation, perspective transformation.		

Module No. 2		**8 Hours**
Image Enhancement: Enhancement in spatial domain: Point Processing: Log, Power law, Image Negatives, Piecewise linear transformation, Spatial correlation and convolution Histogram processing. Smoothing and Sharpening of Spatial Filters. Enhancement in frequency domain: Introduction to filtering in frequency domain, Smoothing and Sharpening of frequency domain filters.		

Module No. 3		**8 Hours**
Image Restoration and Reconstruction: Image Restoration: Degradation model, Restoration in presence of noise only – spatial filtering, Linear position invariant degradations, Estimating degradation functions, Inverse filtering, Wiener filtering. **Color Image Processing:** Color fundamentals, Conversion of color image to gray scale image, Color model (RGB, HSI, HSV, HLS, CMK, CMYK).		

Module No. 4		**6 Hours**
Image compression: Introduction and motivation, Fundamental concepts: Data redundancy (coding redundancy, inter pixel redundancy and psycho visual redundancy), Fidelity criteria, Image compression models, Image compression standards, Elements of information theory. Image compression methods: Huffman coding, Arithmetic coding, LZW coding, Run-Length Coding, Bit plane coding.		

Module No. 5		**6 Hours**
Morphological Image Processing: Preliminaries, Erosion, Dilation, Opening and Closing, hit or Miss transformation, Boundary extraction, Hole filling, Extraction of connected components, Thinning, Thickening.		

COURSE DESCRIPTION: Digital Design Using Verilog

Degree	B. Tech.
Level	Undergraduate
Branch	ELC (Electronics and Computer Engineering)
Semester	1st
Subject Name	Digital Design Using Verilog
Course Type	Theory

Course Code	22ELC6OE02T	
Category	ESC (Engineering Science Courses)/ Program Open Elective-2	
Credit Point	3	
Time Commitment	Lecture	36 Hours
	Tutorial	08 Hours
	Practice	Nil
	Total	44 Hours
Recommended Background Knowledge	Digital technology emerges as the key gate way to develop products that plays an important role in all the fields of engineering. To meet this challenge digital systems play a crucial role for the development of societal needs. To understand the course students should have strong knowledge on digital electronics and circuits. Knowledge of digital logic principles, combinational and sequential logic circuits is required to model integrated digital systems. Basic C-Programming will help the students to understand Verilog and its use in design and development of complex systems.	
Subject Description	Digital system design is a foundational course for developing large VLSI designs. This course will help students to understand the internal details of fundamental blocks of digital circuits and also their implementation details. This course teaches behavior of designing digital circuits and their RTL modeling using Verilog HDL. It also focuses on verifying these Models and synthesizing the RTL to standard cell libraries and FPGAs. Students aim practical experience by designing, modeling, implementing and verifying several digital circuits. This course aims to provide students with the understanding of the different technologies related to HDLs, construct, compile and execute Verilog HDL programs using fundamental timing issues.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Understand the internal logic of various combinational and sequential units that is needed to develop large VLSI design. 2. Acquire the concepts of register transfer level design development process 3. Study the Verilog HDL for modeling complex digital circuits 4. Explore the design methodology and verification of digital circuits by developing test benches.	
	Outcomes: Upon completion of this course, the student will be able to: 1. Understand the digital system designs skills using VERILOG HDL 2. Demonstrate the skill on cost-effective system designs through proper selection of implementation fabrics. 3. Analyze complete systems using synthesis and build small scale	

	applications using Interfacing concepts. 4. Design, implement and test complete digital systems using VERILOG HDL and demonstrate the innovation skills.	
Assessment/ Evaluation	Mid-Term Examination	30 %
	Quiz Test-1	2.5 %
	Quiz-Test-2	2.5 %
	Surprise Test	5 %
	Assignment-1	2.5 %
	Assignment-2	2.5 %
	Attendance	5 %
	End-Term Examination	50 %
Prescribed Text Book(s)	1. Advanced Digital Design With the Verilog HDL, Michael D. Ciletti, 2nd Edition, PHI, ISBN: 978–0–07–338054–4 2015.	
Reference Book(s)	4. Digital Design: An Embedded Systems Approach Using VERILOG, Peter J. Ashenden,Elsevier, ISBN: 978-0-12-369527-7, 2010. 5. Digital Systems Design Using Verilog, Charles Roth, Lizy K. John, ByeongKil Lee,Cengage Learning, ISBN-10: 1285051076, 2015. 6. Fundamentals of Digital Logic with Verilog Design, Stephen Brown and ZvonkoVranesic, 6th Edition, McGraw Hill publication, ISBN: 978–0–07–338054–4, 2014.	
Digital Learning Resources	Digital Design with Verilog https://onlinecourses.nptel.ac.in/noc24_cs61/preview Prof. Chandan Karfa, Prof. Aryabartta Sahu, IIT Guwahati	
	Hardware modeling using Verilog https://onlinecourses.nptel.ac.in/noc20_cs63/preview Prof. Indranil Sengupta IIT Kharagpur	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Understand the digital system designs skills using VERILOG HDL	PO1, PO2, PO3, PO4, PO6
CO2	Demonstrate the skill on cost-effective system designs through proper selection of implementation fabrics.	PO1, PO2, PO3, PO4, PO6, PO7
CO3	Analyze complete systems using synthesis and build small scale applications using Interfacing concepts.	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Design, implement and test complete digital systems using VERILOG HDL and demonstrate the innovation skills.	PO1, PO2, PO3, PO4, PO5, PO6, PO7

DETAILED SYLLABUS:

Module No. 1	**Introduction to Verilog**	**10 Hours**
Introduction to Verilog: Verilog IEEE standards, Application Areas and Abstraction levels. Verilog Data Types: Net, Register and Constant. Verilog Operators: Logical, Arithmetic, Bitwise, Reduction, Relational, Concatenation and Conditional, Number representation and Verilog ports, Verilog Primitives.		

Module No. 2	**Design Methodology**	**07 Hours**
Introduction to Design Methodology: Digital Systems and Embedded Systems, . Design Methodology: Design Flow-Architecture, Functional design and verification, Synthesis, Physical design.		

Module No. 3	**Verilog Behavioral Modeling**	**10 Hours**
Behavioral Modeling: Latches and Level-Sensitive Circuits in Verilog, Behavioral Models of Flip-Flops and Latches. A Comparison of Styles for behavioral modeling, Behavioral Models of Multiplexers, Encoders, Decoders and Arithmetic circuits.		

Module No. 4	**Verilog Dataflow Styles**	**10 Hours**
Dataflow Modeling: Boolean Equation-Based Models of Combinational Logic, Propagation Delay and Continuous Assignments. Dataflow Models of a Linear-Feedback Shift Register.		

Module No. 5	**Structural Modeling Styles**	**6 Hours**
Structural Modeling: Design of Combinational Logic, Verilog Structural Models, Module Ports, Top-Down Design and Nested Modules. Gate level modeling. Design of four-bit parallel adder using CLA and full adder.		

COURSE DESCRIPTION: Digital VLSI Design Lab

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Digital VLSI Design Lab	
Course Type	Laboratory	
Course Code	22ELC6PC02L	
Category	PCC9	
Credit Point	1	
Time Commitment	Lecture	05 Hours
	Tutorial	Nil
	Practice	20 Hours
	Total	25 Hours
Recommended Background Knowledge	Basic Electronics and Circuits, Digital Logic Design, Semiconductor Fundamentals, Programming Knowledge, Hardware Description Languages, Mathematical Foundations, Electronics Laboratory Experience, Basic Knowledge of EDA Tools (Optional)	
Subject Description	The Digital VLSI Design Lab provides practical exposure to the design, simulation, and implementation of digital circuits using CMOS technology. It equips students with the skills to model, synthesize, and analyze digital systems using hardware description languages (HDLs) such as Verilog or VHDL. Students gain hands-on experience with Electronic Design Automation (EDA) tools to design and simulate CMOS logic gates, combinational and sequential circuits, and memory elements. The lab emphasizes the principles of low-power, high-performance digital circuit design while exploring layout techniques and physical design processes.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Equip students with the knowledge and skills to model and simulate digital circuits using hardware description languages (HDLs) such as Verilog or VHDL. 2. Provide hands-on experience in designing and analyzing CMOS-based digital circuits, focusing on concepts like combinational and sequential logic, power efficiency, and performance optimization. 3. Train students in designing CMOS logic gates and their corresponding physical layouts using EDA tools.	

	4. Prepare students for careers in semiconductor design, embedded systems, and related research areas by familiarizing them with industry-standard tools and processes.	
	Outcomes: Upon completion of this course, the student will be able to: 1. Design and simulate digital circuits using Verilog or VHDL for a variety of applications. 2. Analyze and implement digital circuits based on CMOS technology, focusing on power, performance, and area optimization. 3. Use industry-standard EDA tools to simulate and verify the functionality and timing of digital designs. 4. Create combinational and sequential logic modules and optimize them for efficiency.	
Assessment/ Evaluation	Lab Experiments	20%
	Record Writing	10%
	Behavior/ Attitude	05%
	Quiz	10%
	Attendance	05%
	Final Lab Test	30%
	Final Viva/ Final Lab Quiz Test	20%
	Lab Experiments	20%
Prescribed Text Book(s)	1. "CMOS VLSI Design: A Circuits and Systems Perspective"Neil H. E. Weste, David Harris, Pearson. 2. "Verilog HDL: A Guide to Digital Design and Synthesis", Samir Palnitkar, Pearson Education 3. "Principles of CMOS VLSI Design", Neil H. E. Weste, Kamran Eshraghian Addison-Wesley 4. **"Fundamentals of Digital Logic with Verilog Design"**Stephen Brown, Zvonko VranesicMcGraw-Hill	
Digital Learning Resources	**Course Name**	**Architectural Design of Digital Integrated Circuits**
	Course Link	https://onlinecourses.nptel.ac.in/noc20_ee37/preview
	Course Instructor	**Architectural Design of Digital Integrated Circuits** Instructor: Prof. Indranil Hatai, IIEST Shibpur
	Course Name	**CMOS Digital VLSI Design**
	Course Link	https://onlinecourses.nptel.ac.in/noc22_ee08/preview
	Course Instructor	**CMOS Digital VLSI Design** Instructor: Prof. Sudeb Dasgupta, IIT Roorkee

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Develop digital circuits using Verilog HDL with gate-level, dataflow, and behavioral modeling techniques.	PO1, PO2, PO3, PO4, PO5
CO2	Realize fundamental digital components like logic gates, multiplexers, encoders, decoders, flip-flops, and finite state machines using Verilog HDL	PO1, PO2, PO3, PO5
CO3	Model and optimize combinational and sequential circuits such as full adders, binary-to-gray code converters, and state machines.	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Use Tanner EDA tools to design, simulate, and analyze CMOS circuits, including inverters, logic gates, transmission gates, and oscillators.	PO1, PO2, PO3, PO4, PO5, PO6

LABUS (EXPERIMENTS):

Sl. No.	Name of Experiments	Durations
1	Design and verification of a Full Adder Using Structural, Dataflow, and Behavioral Modeling in Verilog.	2h
2	**a)** Design and verification of a 3-Bit Comparator Using Verilog. **b)** Design and verification of a 4-bit Binary to Gray Code Converter Using Verilog.	2h
3	Design and Functional Verification of Combinational Circuits: 2:4 Decoder, 8:3 Encoder, and 8:1 MUX/DeMUX Using Verilog.	2h
4	Design, Simulation, and Synthesis Analysis of SR, JK, T, and D Flip-Flops Using Verilog, find out Gate-Level Netlist, Area Analysis, Power Consumption, and Timing Analysis.	2h
5	Design, Verification, and Synthesis Analysis of Finite State Machines (Mealy/Moore) for Sequence Generation Using Verilog.	2h
6	Design, Layout, and Analysis of CMOS Inverter Using Tanner EDA: Switching Characteristics, Functional Behavior, and Layout Verification.	2h
7	Design, Layout, and Analysis of Transmission Gate Using Tanner EDA: Switching Characteristics, Functional Behavior, and Layout Verification.	2h
8	Design, Layout, and Analysis of NAND Gate Using Tanner EDA: Switching Characteristics, Functional Behavior, and Layout Verification.	2h
9	Design, Layout, and Analysis of 2:1 MUX Using Tanner EDA:	2h

	Switching Characteristics, Functional Behavior, and Layout Verification.	
10	Design, Layout, and Analysis of Ring Oscillator(3 Inverter) Using Tanner EDA: Switching Characteristics, Functional Behavior, and Layout Verification.	2h

COURSE DESCRIPTION: Machine Learning Laboratory

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Machine Learning Laboratory	
Course Type	Laboratory	
Course Code	22ELC6PC03L	
Category	PCC10	
Credit Point	1	
Time Commitment	Lecture	05 Hours
	Tutorial	Nil
	Practice	20 Hours
	Total	25 Hours
Recommended Background Knowledge	A solid understanding of programming, particularly in Python, and knowledge of data structures and algorithms are essential for the Machine Learning Laboratory. Familiarity with statistics, linear algebra, and basic machine learning concepts is also recommended.	
Subject Description	The Machine Learning Laboratory provides hands-on experience in implementing machine learning algorithms and models. It covers tasks such as data preprocessing, model training, evaluation, and optimization. The laboratory emphasizes practical applications in classification, regression, clustering, and deep learning. Students gain proficiency in using libraries like TensorFlow, Scikit-learn, and PyTorch to solve real-world problems.	

Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Provide hands-on experience in implementing fundamental machine learning algorithms and models. 2. Develop proficiency in data preprocessing, feature engineering, and model evaluation techniques. 3. Explore practical applications of machine learning in areas like classification, regression, and clustering. 5. Familiarize students with advanced tools and libraries like TensorFlow, Scikit-learn, and PyTorch.	
	1. Students will demonstrate the ability to implement and optimize machine learning models for real-world problems. 2. They will effectively preprocess data and engineer features to enhance model performance. 3. They will analyze and evaluate models using appropriate metrics and optimization techniques. 4. Graduates will gain practical expertise in leveraging modern machine learning frameworks and tools.	
Assessment/ Evaluation	Lab Experiments	20%
	Record Writing	10%
	Behavior/ Attitude	05%
	Quiz	10%
	Attendance	05%
	Final Lab Test	30%
	Final Viva/ Final Lab Quiz Test	20%
	Lab Experiments	20%
Prescribed Text Book(s)	1. Peter Harrington, “Machine Learning in Action”, DreamTech 2. Michael Bowles, “Machine Learning in Python”, Wiley 3. Gavin Hackeling, Mastering Machine Learning with scikit-learn, Packt 4. Giuseppe Bonaccorso, Machine Learning Algorithms - Second Edition, Packt	

CO's Mapping with PO's and PEO's

Course Outcomes	Course Outcome Statement	PO's / PEO's
CO1	Students will demonstrate the ability to implement and optimize machine learning models for real-world problems.	
CO2	They will effectively preprocess data and engineer features to enhance model performance.	
CO3	They will analyze and evaluate models using appropriate	

	metrics and optimization techniques.	
CO4	Graduates will gain practical expertise in leveraging modern machine learning frameworks and tools	

Sl. No.	**Name of Experiments**	**Duration in Hrs**
1	Build a multivariate logistic regression model to classify glass type of glass given different glass mixture features using the Glass Identification Dataset from UCI Machine Learning Repository.	2
2	Implement supervised machine learning algorithm (Classification – K Nearest Neighbourhood) in python to classify breast tumour data into malignant breast tumour or benign breast tumour (use breast tumour dataset) and obtain its accuracy level.	2
3	Implement supervised machine learning algorithm (Classification – K Nearest Neighbourhood) in python to classify iris data into setosa, virginica, versicolor using iris dataset and obtain its accuracy level.	2
4	Implement supervised machine learning algorithm (Classification – Support Vector Machine) in python to classify breast tumour data into malignant breast tumour or benign breast tumour (use breast tumour dataset) and obtain its accuracy level.	2
5	Write a python program to build an email spam classifier using support vector machines for the Spam base dataset from UCI machine learning repository.	2
6	Implement unsupervised machine learning algorithm (Clustering – K Means) in python on Titanic dataset to cluster data (use Titanic dataset) by removing the class label.	2
7	Implement unsupervised machine learning algorithm (Clustering – K Means) in python on Breast Tumour dataset to cluster data (use Breast Tumour dataset) by removing the class label.	2
8	Implement unsupervised machine learning algorithm (Clustering – Hierarchical) in python on Titanic dataset to cluster data (use Titanic dataset).	2
9	Implement Apriori algorithm in python to find rules which explain association between different products for given transactions at a retail store. (The data is availableat https://drive.google.com/file/d/1NUXoptUlHY8z4KcFKpFA6sQN5KnWzk3p/view?usp=sharing)	2

10	Implement text classification using neural network in python / R on Twenty News group data set from UCI machine learning repository.	2
11	Implement supervised machine learning algorithm (Classification - Naïve Bayes algorithm) in python/R on Pima Indians Diabetes dataset and obtain its accuracy level.	
12	classification and prediction algorithms on UCI dataset using Python's scikit-learn library	

COURSE DESCRIPTION: Research and Lab-Based Project

Degree	B. Tech.	
Level	Undergraduate	
Branch	Electronics and Computer Engineering	
Semester	6th	
Subject Name	Research and Lab-Based Project	
Course Type	Laboratory	
Course Code	22CM6PS01L	
Category	PSI	
Credit Point	2	
Time Commitment	Lecture	10 Hours
	Tutorial	Nil
	Practice	20 Hours
	Total	30 Hours
Recommended Background Knowledge	Research and Lab-Based Projects involve conducting in-depth studies and experiments on advanced topics, requiring knowledge of research methodologies, experimental design, and relevant subject matter expertise.	
Subject Description	The Research and Lab-Based Project subject involves applying theoretical knowledge to solve real-world engineering problems through independent research and practical experimentation. Students design and execute projects, often in collaboration with faculty or industry, to address challenges in various engineering fields. The subject emphasizes innovation, critical thinking, and hands-on experience in developing prototypes, models, or systems.	
Objectives and Outcomes	**Objectives:** The course should enable the students to: 1. Enable students to apply theoretical concepts to solve practical engineering problems through independent research and experimentation.	

	2. Develop critical thinking, problem-solving, and analytical skills by designing and conducting research projects. 3. Foster collaboration and communication skills by working with faculty, peers, or industry experts on real-world projects. 4. Enhance students' ability to design, prototype, and test engineering systems or solutions using modern tools and methodologies.	
	Outcomes: Upon completion of this course, the student will be able to: 1. Gain hands-on experience in conducting research and experiments, addressing complex engineering problems. 2. Develop the ability to analyze data, evaluate outcomes, and propose solutions based on research findings. 3. Demonstrate the ability to work independently or in teams, showcasing effective time management and project coordination skills 4. Improve their communication skills, presenting their research findings clearly through reports, presentations, or publications.	
Assessment/ Evaluation	Project Work	40%
	Report Writing	20%
	Attendance	10%
	PPT presentation	30%

CO's Mapping with PO's and PEO's

Course Outcomes	**Course Outcome Statement**	**PO's / PEO's**
CO1	Gain hands-on experience in conducting research and experiments, addressing complex engineering problems.	PO1, PO2, PO3, PO4, PO5
CO2	Develop the ability to analyze data, evaluate outcomes, and propose solutions based on research findings.	PO1, PO2, PO3, PO5
CO3	Demonstrate the ability to work independently or in teams, showcasing effective time management and project coordination skills	PO1, PO2, PO3, PO4, PO5, PO6
CO4	Improve their communication skills, presenting their research findings clearly through reports, presentations, or publications.	PO1, PO2, PO3, PO4, PO5, PO6

DETAILED SYLLABUS :

Carry out a project on one of the latest emerging technologies approved by the Department Committee.

Sl. No.	**Idea related to projects**	**Durations**

1	Implement the project within an embedded system integrated with IoT technology and further extend the work to develop an FPGA-based embedded system.	
2	Undertake projects in Analog and Digital VLSI design, utilizing advanced EDA tools for development and implementation.	
3	Embark on projects in data science and big data analytics, as well as developing innovative mobile app applications.	
4	Engage in the design of communication network protocols and projects centred on Blockchain, FinTech, and immersive technologies such as Virtual and Augmented Reality.	
5	Undertake projects in Artificial Intelligence, Machine Learning, Deep Learning, Computer Vision, and Natural Language Processing, leveraging the power of Python programming.	
6	Engage in projects focused on Web Development, Cloud Computing, and Cybersecurity, exploring cutting-edge technologies and solutions	
7	Carry out the project on Nano-Electronics.	