

**M. TECH. TWO YEAR DEGREE**

**PROGRAM CURRICULUM**

(Applicable for the batches admitted from A.Y 2025-26)

**VLSI DESIGN**



**A D I T Y A**  
**U N I V E R S I T Y**

Aditya Nagar, ADB Road, Surampalem - 533 437

## VISION & MISSION OF THE UNIVERSITY

### VISION:

Aditya University aspires to be a globally recognized academic institution dedicated to quality education, cutting-edge research, and technological service to our country, and envisions itself as a beacon of holistic advancement and long-term impact, remaining dynamic in the ever-changing worlds of society, ecology, and economics.

### MISSION:

- Aditya University pushes boundaries to design high-quality curricula and to provide students with a vibrant and relevant education that prepares them for a changing world. Our industry insights and creative teaching methods attempt to equip our students to be lifelong learners.
- Aditya University's learning environment encourages intellectual curiosity, critical thinking, and cooperation, with the goal of providing students with an immersive education that fosters creativity and innovation. Our cutting-edge facilities, interactive classrooms, and supportive faculty aim to motivate students to realize their full potential and contribute to society.
- Aditya University promotes cross-disciplinary inquiry and discovery and leads cutting-edge research and innovation. Through strategic partnerships, research grants, and a dedicated faculty, we aim to advance science, technology, and social sciences and empower students and faculty to conduct transformative research that solves real-world problems and elevates our institution globally.
- Aditya University is committed to producing world-changing business leaders and entrepreneurs through its emphasis on entrepreneurship, mentorship, and incubation programmes.

### Department of Electronics and Communication Engineering

#### Vision:

To become a center of excellence in Electronics and Communication Engineering, fostering technological capability, professional commitment, and social responsibility through cutting-edge education, innovative research and sustainable solutions towards global technological advancement for the betterment of society.

#### Mission:

**M1:** To provide quality education supported by well-equipped laboratory facilities and strong industry collaboration for professional success and technological leadership.

**M2:** To promote cutting-edge technologies and foster innovative research Engineering to serve the needs of the society, industry, and scientific community.

**M3:** To inculcate professional ethics and personality development skills, empowering students with the values and interpersonal abilities required to succeed in diverse, global environments.

### PROGRAM OUTCOMES (POs)

After successful completion of the program, the graduates will be able to

PO 1	Independently carry out research /investigation and development work to solve practical problems
PO 2	Write and present a substantial technical report/document
PO 3	Demonstrate a degree of mastery over the area as per the specialization of the program. The mastery should be at a level higher than the requirements in the appropriate bachelor program.
PO 4	Learn, keep up with contemporary technologies and ways of working.
PO 5	Communicate effectively as an individual or a team leader in diverse and multidisciplinary groups.
PO 6	Use the principles of project management such as scheduling, work breakdown structure and be conversant with the principles of finance for profitable project management.

### PROGRAM SPECIFIC OUTCOMES (PSO's)

After successful completion of the program, the graduates will be able to

PSO1	Acquire competency in areas of VLSI including IC Fabrication, Design, Testing, Verification and prototype development focusing on applications.
PSO2	Design, implement, analyze and interpretation of VLSI projects using CAD & EDA tools: Cadence-Spice, Xilinx ISE, MATLAB, Mentor graphics, micro wind, DSCH
PSO3	Integrate multiple sub-systems to develop System On Chip, optimize its performance and excel in industry sectors related to VLSI domain.

### PROGRAM EDUCATIONAL OBJECTIVES (PEOs)

Graduates of the Program will

PEO 1	Post-Graduates will develop a strong foundation in VLSI design principles and techniques, enabling them to solve complex engineering problems, lead projects in the electronics sector, and contribute effectively to multi-disciplinary teams in both industry and academia.
PEO 2	Post-Graduates will engage in continuous learning and research in VLSI and related areas, utilizing emerging technologies and innovative approaches to design efficient systems and contribute to advancements in semiconductor technology.
PEO3	Post-Graduates will demonstrate ethical responsibility, professional integrity, and leadership in their careers by making significant contributions to societal and technological growth while adhering to sustainable practices in the electronics and communication industry.

## Department of Electronics and Communication Engineering

### Master of Technology in VLSI Design (VLSID)

#### Program Curriculum-2025

#### Credit Division:

S.No	Broad Category of Course	Credit Division
1	Program Core Courses (PCC)	30
2	Program Elective Courses (PEC)	15
3	University Elective Courses (UEC)	03
4	Technical Paper Publication (TPP)	02
5	Summer Internship (SI)	02
6	Project-Part I&II (PROJ)	28
7	Audit Course (AUC)	0
<b>Total</b>		<b>80</b>

**Program Core Courses (PCC):**

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502EC01	Analog IC Design	2	0	2	4	50	50	100	-
2502EC02	Digital IC design	2	0	2	4	50	50	100	-
2502EC03	Mixed Signal and RF IC Design	2	0	2	4	50	50	100	-
2502EC04	Verification using System Verilog and UVM	2	0	2	4	50	50	100	-
2502EC04	Physical Design Automation	2	0	2	4	50	50	100	-
2502EC05	VLSI Testing and Validation	2	0	2	4	50	50	100	VUVM
2502EC06	Microelectronics Device Modelling	2	1	0	3	50	50	100	AICD&DIC D
2502EC07	Nano-Electronics	3	0	0	3	50	50	100	AICD

**Program Elective Courses (PEC):**

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502EC09	FPGA based System Design	2	0	1	3	50	50	100	DICD
2502EC10	M/NEMS Technology	3	0	0	3	50	50	100	NE
2502EC11	Nanomaterials and Nanotechnology	2	1	0	3	50	50	100	NE
2502EC12	Network Security and Cryptography	3	0	0	3	50	50	100	VLSITV
2502EC13	Low Power VLSI circuit Design	2	1	0	3	50	50	100	MSD
2502EC14	VLSI Signal Processing	2	1	0	3	50	50	100	AICD&D ICD
2502EC15	SOC Design	2	1	0	3	50	50	100	DICD
2502EC16	Hardware Software co-design	2	1	0	3	50	50	100	FPGASD
2502EC17	VLSI fabrication Technology	3	0	0	3	50	50	100	-
2502EC18	Sensors and Sensor Circuit Design	2	1	0	3	50	50	100	MNT
2502EC19	ASIC Design	3	0	0	3	50	50	100	DICD
2502EC20	DSP algorithms for VLSI	2	1	0	3	50	50	100	VLSI SP
2502EC21	VLSI Architectures	2	1	0	3	50	50	100	FPGASD
2502EC22	VLSI Solid State Circuits	3	0	0	3	50	50	100	MDM
2502EC23	Machine Learning for VLSI Design	3	0	0	3	50	50	100	-

**University Elective Courses (UEC):**

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502CE28	Metro Rail Transportation Design and Construction (L&T EduTech)**	3	0	0	3	50	50	100	-
2502CE29	Building Information Modelling in Architecture, Engineering and Construction (L&T EduTech) **	3	0	0	3	50	50	100	-
2502CE30	Basic Concrete Technology	3	0	0	3	50	50	100	-
2502CE31	Repair and Rehabilitation of Structures	3	0	0	3	50	50	100	-
2502EE28	Neural Networks and Fuzzy Logic	3	0	0	3	50	50	100	-
2502EE29	Hybrid Electric Vehicles	3	0	0	3	50	50	100	-
2502EE30	Electrical Power Distribution and Automation (L&T EduTech) **	3	0	0	3	50	50	100	-
2502EE31	Renewable Energy & Power Evacuation (L&T EduTech) **	3	0	0	3	50	50	100	-
2502ME26	Design of fire and life safety systems(L&T EduTech) **	3	0	0	3	50	50	100	-
2502ME27	Green Engineering Systems	3	0	0	3	50	50	100	-
2502ME28	I.C. Engines	3	0	0	3	50	50	100	-
2502EC24	CAD Tools for VLSI Design	3	0	0	3	50	50	100	-
2502EC25	FPGA Design for Embedded Systems	3	0	0	3	50	50	100	-
2502AI30	Artificial Intelligence	3	0	0	3	50	50	100	-
2502AI31	Machine Learning techniques	3	0	0	3	50	50	100	-

\*\*The syllabus for the industry partner courses will be released in the department as and when required

**Technical Paper Publication (TPP):**

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502EC27	Technical Paper Publication	0	0	2	2	100	-	100	-

**Technical Seminar (TS):**

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502EC26	Technical Seminar	0	0	2	2	100	-	100	-

**Project-Part I&II (PROJ):**

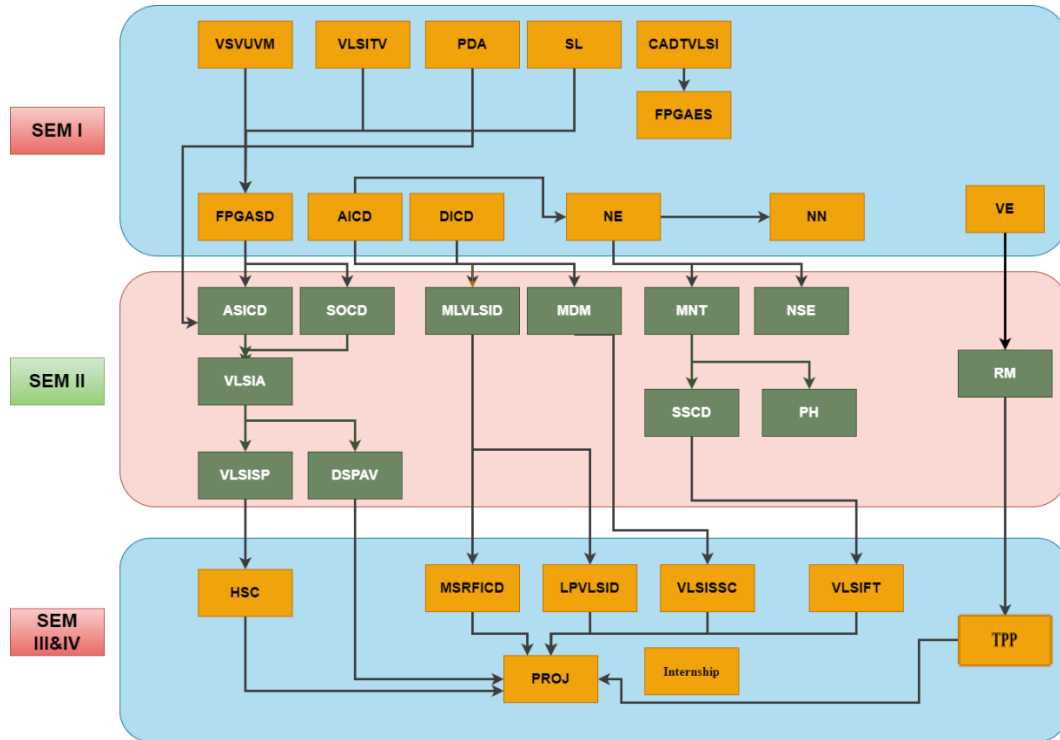
Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502EC28	Project-Part I (PROJ)	0	0	10	10	100	-	100	-
2502EC29	Project-Part II (PROJ)	0	0	18	18	50	50	100	-

**Audit Courses (AUC):**

Course Code	Course Title	L	T	P	C	CIE	SEE	Total	Pre-requisite
2502CE32	Value Education	2	0	0	0	100	-	100	-
2502CE33	Research Methodology	2	0	0	0	100	-	100	-

## 2025 M. Tech (VLSI DESIGN) CURRICULUM

### PRE-REQUISITE FLOW CHART



## Suggestive Semester-wise Curriculum

### I Semester

Course Code	Course Title	Course	Credits				Total Hours
		Category	L	T	P	Total	
2502EC01	Analog IC Design	PCC	2	0	2	4	6
2502EC02	Digital IC design	PCC	2	0	2	4	6
2502EC04	Verification using System Verilog and UVM	PCC	2	0	2	4	6
2502EC08	Nano-Electronics	PCC	3	0	0	3	3
	Program Elective Courses-I	PEC	-	-	-	3	3
	Program Elective Courses-II	PEC	-	-	-	3	3
2502CE32	Value Education	AUC	2	0	0	0	2
<b>Total</b>			<b>8</b>	<b>0</b>	<b>6</b>	<b>21</b>	<b>29</b>

### II Semester

Course Code	Course Title	Course	Credits				Total Hours
		Category	L	T	P	Total	
2502EC03	Mixed Signal & RF IC Design	PCC	2	0	2	4	6
2502EC05	Physical Design Automation	PCC	2	0	2	4	6
2502EC06	VLSI Testing and Validation	PCC	2	0	2	4	6
2502EC07	Microelectronics Device Modelling	PCC	2	1	0	3	3
	Program Elective Courses-III	PEC	-	-	-	3	3
	Program Elective Courses-IV	PEC	-	-	-	3	3
2502CE33	Research Methodology	AUC	2	0	0	0	2
<b>Total</b>			<b>10</b>	<b>1</b>	<b>6</b>	<b>21</b>	<b>29</b>

### III Semester

Course Code	Course Title	Course	Credits				Total Hours
		Category	L	T	P	Total	
	Program Elective Course -V	PEC	3	0	0	3	3
	University Elective Courses	UEC	3	0	0	3	3
2502EC26	Technical Seminar	TS	0	0	2	2	-
2502EC28	Project Part-I	PROJ	0	0	10	10	18
<b>Total</b>			<b>6</b>	<b>0</b>	<b>12</b>	<b>18</b>	<b>24</b>

### IV Semester

Course Code	Course Title	Course	Credits				Total Hours
		Category	L	T	P	Total	
2502EC27	Technical Paper Publication	TPP	0	0	2	2	6
2502EC29	Project Part-II	PROJ	0	0	18	18	34
<b>Total</b>			<b>0</b>	<b>0</b>	<b>20</b>	<b>20</b>	<b>40</b>

Program Elective Course-I		
S.NO	Course code	Course name
1	2502EC09	FPGA based System Design
2	2502EC15	SOC Design
3	2502EC19	ASIC Design

Program Elective Course-II		
S.NO	Course code	Course name
1	2502EC10	M/NEMS Technology
2	2502EC13	Low Power VLSI circuit Design
3	2502EC20	DSP algorithms for VLSI

<b>Program Elective Course-III</b>		
<b>S.NO</b>	<b>Course code</b>	<b>Course name</b>
1	2502EC11	Nanomaterials and Nanotechnology
2	2502EC14	VLSI Signal Processing
3	2502EC16	Hardware Software co-design

<b>Program Elective Course-IV</b>		
<b>S.NO</b>	<b>Course code</b>	<b>Course name</b>
1	2502EC12	Network Security & Cryptography
2	2502EC17	VLSI fabrication Technology
3	2502EC21	VLSI Architectures

<b>Program Elective Course-V</b>		
<b>S.NO</b>	<b>Course code</b>	<b>Course name</b>
1	2502EC18	Sensors and Sensor Circuit Design
2	2502EC22	VLSI Solid State Circuits
3	2502EC23	Machine Learning for VLSI Design

## ANALOG IC DESIGN

<b>Course Code: 2502EC01</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>2</b>	<b>0</b>	<b>2</b>	<b>4</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Design basic building blocks of CMOS analog ICs.
- CO2:** Analyze the characteristics of different CMOS circuits.
- CO3:** Compare performance metrics of CMOS amplifiers.
- CO4:** Develop the two stage CMOS operational amplifiers.
- CO5:** Analyze the basic comparator and different performance parameters of comparator.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	2	1	1	2	-
<b>CO2:</b>	2	2	1	1	2	-
<b>CO3:</b>	2	2	2	1	2	-
<b>CO4:</b>	2	3	1	1	2	-
<b>CO5:</b>	2	2	2	2	2	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	1	2	-
<b>CO2:</b>	1	2	-
<b>CO3:</b>	1	2	-
<b>CO4:</b>	1	2	-
<b>CO5:</b>	1	2	-

### UNIT – I

**MOS Devices and Modeling:** The MOS Transistor, Passive Components- Capacitor & Resistor, Integrated circuit Layout, CMOS Device Modeling - Simple MOS Large-Signal Model, Other Model Parameters, Small-Signal Model for the MOS Transistor, Computer Simulation Models, Sub-threshold MOS Model.

**Practice:**

1. Simulation of MOS Device Characterization and parametric analysis.
2. CMOS Inverter - DC, AC, Transient Analysis.

### UNIT – II

**Analog CMOS Sub-Circuits:** MOS Switch, MOS Diode, MOS Active Resistor, Current Sinks and Sources, Current Mirrors-Current mirror with Beta Helper, Degeneration, Cas code current Mirror and Wilson Current Mirror, Current and Voltage References, Band gap Reference.

**Practice:**

1. Analysis and Design of Common Source Amplifier with Diode Connected Load.
2. Analysis and Design of Common Gate Amplifier with Resistive load and Current Source load.

### UNIT – III

**CMOS Amplifiers:** Inverters, Differential Amplifiers, Cascode Amplifiers, Current Amplifiers, Output Amplifiers, High Gain Amplifiers Architectures.

**Practice:**

1. Analysis and Design of Simple Current Mirror and Suggest a circuit to minimize the error in the output current.
2. Analysis and Design of Differential Amplifier with Active load and Current Source Load.

### UNIT – IV

**CMOS Operational Amplifiers:** Design of CMOS Op Amps, Compensation of Op Amps, Design of Two-Stage Op Amps, Power- Supply Rejection Ratio of Two-Stage Op Amps, Cascode Op Amps, Measurement Techniques of OP Amp.

**Practice:**

1. Analysis and Design of Cascode Amplifier and Suggest a Circuit to overcome Voltage Headroom Limitation.
2. Analysis and Design of Two-Stage Op-Amp with Frequency Compensation.

### UNIT – V

**Comparators:** Characterization of Comparator, Two-Stage, Open-Loop Comparators, Other Open Loop Comparators, Improving the Performance of Open-Loop Comparators, Discrete Time Comparators

**Practice:**

1. Analysis and Design of open loop comparator.

**Text Books:**

- 1 CMOS Analog Circuit Design - Philip E. Allen and Douglas R. Holberg, Oxford University Press, International Second Edition/Indian Edition, ISBN Number- 0195116445
- 2 Analysis and Design of Analog Integrated Circuits- Paul R. Gray, Paul J. Hurst, S. Lewis and R. G. Meyer, Wiley India, Fifth Edition, ISBN Number- 0470245999

**Reference Books:**

- 1 Analog Integrated Circuit Design- David A. Johns, Ken Martin, Wiley Student Edition, ISBN Number- 9788126543939
- 2 Design of Analog CMOS Integrated Circuits- Behzad Razavi, TMH Edition, ISBN Number- 938706784X

**Web Links:**

- 1 <http://www.aicdesign.org/OnLineLectures.html>
- 2 <http://nptel.ac.in/courses/117106030/>
- 3 [www.mentor.com](http://www.mentor.com)
- 4 [www.cadence.com](http://www.cadence.com)

## DIGITAL IC DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC02</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>4</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Infer the functionality of MOS circuits.
- CO2:** Analyze various combinational circuits designs in CMOS
- CO3:** Analyze sequential logic gates designs in CMOS
- CO4:** Infer the functionality of arithmetic building blocks.
- CO5:** Analyze different semiconductor memories

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	1	1	1	2	1
<b>CO2:</b>	2	3	1	1	2	1
<b>CO3:</b>	2	2	3	1	2	1
<b>CO4:</b>	2	3	1	1	2	1
<b>CO5:</b>	2	2	3	2	2	1

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	1	2	3
<b>CO2:</b>	1	2	3
<b>CO3:</b>	1	2	3
<b>CO4:</b>	1	3	2
<b>CO5:</b>	1	3	2

### UNIT – I

MOS Design:

Pseudo NMOS Logic: Inverter, Inverter threshold voltage, Output high voltage, Output Low voltage, Gain at gate threshold voltage, Transient response, Rise time, Fall time, Pseudo NMOS logic gates, Transistor equivalency, CMOS Inverter logic.

**Practice:**

1. Inverter Characteristics.
2. NAND and NOR Gate

### UNIT – II

Combinational MOS Logic Circuits: MOS logic circuits with NMOS loads, Primitive CMOS logic gates – NOR & NAND gate, Complex Logic circuits design – Realizing Boolean expressions using NMOS gates and CMOS gates, AOI and OIA gates, CMOS full adder, CMOS transmission gates, Designing with Transmission gates.

**Practice:**

1. XOR and XNOR Gate
2. Full Adder

### **UNIT – III**

Sequential MOS Logic Circuits: Behavior of bistable elements, SR Latch, Clocked latch and flip flop circuits, CMOS D latch and edge triggered flip-flop.

**Practice:**

1. RS-Latch
2. Ring Oscillator

### **UNIT – IV**

Dynamic Logic Circuits: Basic principle, Synchronous dynamic pass transistor circuits, Dynamic CMOS transmission gate logic, High performance Dynamic CMOS circuits, Dynamic logic vs Domino logic.

**Practice:**

1. Clock Divider
2. Synchronous Counter

### **UNIT – V**

Semiconductor Memories: Types, RAM array organization, DRAM – Types, Operation, Leakage currents in DRAM cell and refresh operation, SRAM operation Leakage currents in SRAM cells, Flash Memory- NOR flash and NAND flash.

**Practice:**

1. Asynchronous Counter
2. 1-Bit RAM

### **Text Books:**

1. CMOS Digital Integrated Circuits Analysis and Design, Sung-Mo Kang, Yusuf Leblebici, TMH, 3rd Ed, ISBN Number- 0072460539.
2. Digital Integrated Circuits, Jan M Rabaey, Pearson Education, 2nd Edition, ISBN Number- 9385152343

### **Reference Books:**

1. Introduction to VLSI Systems: A Logic, Circuit and System Perspective, Ming - BO Lin, CRC Press, ISBN Number- 143986859X
2. Digital Integrated Circuits –A Design Perspective, JanM.Rabaey, Anantha Chandrakasan, Borivoje Nikolic, PHI, 2nd Ed, ISBN Number- 0130909963

### **Web Links:**

1. <https://subodhtripathi.files.wordpress.com/2012/01/0072460539cmos1.pdf>
2. <https://highered.mheducation.com/sites/0072460539/index.html>
3. <https://www.scribd.com/doc/102546275/CMOS-Digital-Integrated-Circuits- Sung-Mo-Kang-Leblebici>
4. <https://infoscience.epfl.ch/Infoscience>

## MIXED SIGNAL and RF IC DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC03</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>4</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Comprehend the fundamental components used in analog and digital circuit design.
- CO2:** Explore the applications of data converters in various fields.
- CO3:** Analyze the stability and performance of PLL.
- CO4:** Infer bottlenecks specific to RF IC design.
- CO5:** Interpret RF Transceiver Architecture.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	1	1	1	2	-
<b>CO2:</b>	2	3	1	1	2	-
<b>CO3:</b>	2	2	2	1	2	-
<b>CO4:</b>	2	3	1	1	2	-
<b>CO5:</b>	2	2	2	1	2	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	1	2	-
<b>CO2:</b>	1	2	-
<b>CO3:</b>	1	2	-
<b>CO4:</b>	1	2	-
<b>CO5:</b>	1	3	-

### UNIT – I

Basic Building Blocks, Op-Amp, Capacitors, Switches, Non-overlapping Clocks, Basic Operation and Analysis, Resistor Equivalence of a Switched Capacitor, Parasitic-Sensitive Integrator, Parasitic-Insensitive Integrators, Signal-Flow-Graph Analysis, Noise in Switched-Capacitor Circuit.

**Practice:**

1. Fully compensated op-amp with resistor and miller compensation
2. Parasitic sensitive integrator switched capacitor circuits

### UNIT – II

Ideal D/A Converter, Ideal A/D Converter, Quantization Noise, Deterministic Approach, Stochastic Approach, Signed Codes, Performance Limitations, Resolution, Offset and Gain Error, Accuracy and Linearity Integrating Converters, Successive Approximation Converters, DAC-Based Successive Approximation, Charge Redistribution A/D, Resistor-Capacitor Hybrid, Speed Estimate for Charge Redistribution Converters, Error Correction in Successive-Approximation Converter.

**Practice:**

1. Parasitic insensitive integrator switched capacitor circuits
2. Design two stage cross coupled clamped comparator.

**UNIT – III**

Basic Phase-Locked Loop Architecture, Voltage Controlled Oscillator, Divider Phase Detector, Loop Filter, The PLL in Lock, Linearized Small-Signal Analysis, Second Order PLL Model, Limitations of the Second-Order Small-Signal Model, PLL Design Example, Jitter and Phase Noise, Period Jitter, P-Cycle Jitter, Adjacent Period Jitter, other Spectral Representations of Jitter, Probability Density Function of Jitter, Ring Oscillators, LC Oscillators, phase Noise of Oscillators, jitter and Phase Noise in PLLS.

**Practice:**

1. Design Strobed Flip-flop comparator.
2. Design of PLL

**UNIT – IV**

**INTRODUCTION TO RF AND WIRELESS TECHNOLOGY:** Complexity comparison, Design bottle necks, Applications, Analog and digital systems, Choice of Technology.

**BASIC CONCEPTS IN RF DESIGN:** Nonlinearity and time variance, ISI, Random process and noise, sensitivity and dynamic range, passive impedance transformation.

**Practice:**

1. Design of VCO
2. Band gap reference circuit

**UNIT – V**

**Multiple Access:** Techniques and wireless standards, mobile RF communication, FDMA, TDMA, CDMA, Wireless standards.

**Transceiver Architectures:** General considerations, receiver architecture, Transmitter Architecture, transceiver performance tests, case studies.

**Amplifiers, Mixers And Oscillators:** LNAs, down conversion mixers, Cascaded Stages, oscillators, Frequency synthesizers.

**Practice:**

1. Implement a PLL based frequency synthesizer.

**Text Books:**

1. David A Johns, Ken Martin: Analog IC design, Wiley, ISBN Number- 9788126543939
2. R Gregorian and G C Temes: Analog MOS integrated circuits for signal processing, Wiley, ISBN Number- 9788126517978

**Reference Books:**

1. Roubik Gregorian: Introduction to CMOS Op-amps and comparators, Wiley, ISBN Number- 0471317780
2. Behzad Razavi, RF Microelectronics Prentice Hall of India, ISBN Number- 0137134738

**Web Links:**

1. [https://home.iitk.ac.in/~ashwinrs/2022\\_EE698I.html](https://home.iitk.ac.in/~ashwinrs/2022_EE698I.html)
2. [https://onlinecourses.nptel.ac.in/noc24\\_ee75](https://onlinecourses.nptel.ac.in/noc24_ee75)
3. [https://onlinecourses.nptel.ac.in/noc24\\_ee13](https://onlinecourses.nptel.ac.in/noc24_ee13)

## VERIFICATION USING SYSTEM VERILOG AND UVM

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC04</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>4</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Interpret the concepts of verification methodologies and data types.
- CO2:** Summarize the concepts of procedural statements, routines and assertions
- CO3:** Illustrate the concepts of OOP terminology
- CO4:** Explain the randomization in System Verilog.
- CO5:** Analyze the concepts of functional coverage.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	-	3	2	-	-
<b>CO2:</b>	1	-	3	2	-	-
<b>CO3:</b>	1	-	2	3	-	-
<b>CO4:</b>	1	-	3	2	-	-
<b>CO5:</b>	2	-	3	2	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	2	-
<b>CO2:</b>	1	2	-
<b>CO3:</b>	1	2	-
<b>CO4:</b>	1	2	-
<b>CO5:</b>	1	2	-

### UNIT – I

Verification Using System Verilog: What is the Functional Verification, What is the Assertion based Verification, Why use System Verilog for Verification, OOP concept for System Verilog, Layered approach for Verification, Designing with OOP, OOP classes, OOP connections, Block level testing using OOP, Chip Level Testing, Functional Coverage, Assertion Based verification, Interfacing with C

**Practice:**

1. Basic Testbench in System Verilog
2. Building a Simple Environment

### UNIT – II

Universal Verification Methodology, Understanding Verification Component Overview, Transaction Level Modeling (TLM), Developing Reusable Verification Component, Using Verification component, Using Register Layer Class

**Practice:**

1. Randomized Testing with UVM

### UNIT – III

Low Power Verification Techniques (CPF/UPF): Need of Power Aware Simulation, Understanding Unified Power Format file, Writing CPF/UPF, Assertions checking for the low power Simulation

#### Practice:

1. Scoreboarding in UVM
2. Implementing Functional Coverage in UVM

### UNIT – IV

Verification of SOC with ARM/MIPS Processor, ARM architecture as covered in Embedded classes, Development of ARM/MIPS BFM, Writing C test case on ARM, Using ARMCC and ARMSS compiler and linking it with simulator

#### Practice:

1. Assertion-Based Verification using SystemVerilog Assertions (SVA)
2. Protocol Verification using UVM

### UNIT – V

Verification Environment build and Automation. Use of Make file, Perl & TCL script in running the test, Running Regression of the test suit for the Device Under test, Automatic regression results generation, Merging of the code & functional coverage, Ranking of the test suit.

#### Practice:

1. Integrating a UVM-based Testbench with a SystemC Model
2. Low-Power Verification using UVM

#### Text Books:

1. Hardware Verification with System Verilog- Mike Mintz & Robert, Ekendahl  
System Verilog for Verification – Chris Spear, ISBN Number- 0-387717382
2. IEEE Standard for SystemVerilog--Unified Hardware Design, Specification, and Verification Language, ISBN Number- 1504445104

#### Reference Books:

1. UVM user Manual

#### Web links:

1. [https://www.udemy.com/course/uvm-for-verification-part-2-projects/?utm\\_source=adwords&utm\\_medium=udemyads&utm\\_campaign=Search\\_DSA\\_Beta\\_Prof\\_la.EN\\_cc.INDIA&campaigntype=Search&portfolio=India&language=EN&product=Course&test=&audience=DSA&topic=&priority=Beta&utm\\_content=deal4584&utm\\_term=.ag\\_160270535665\\_.ad\\_696202838340\\_.kw\\_.de\\_c\\_.dm\\_.pl\\_.ti\\_dsa-1677053911888\\_.li\\_9147583\\_.pd\\_.&matchtype=&gad\\_source=1&gclid=CjwKC\\_AjwnqK1BhBvEiwAi7o0Xyj21cvFN97-KGpQbnyHVxUHRk6YsxUkWaYMefK8G4fucWJFzXicMxoCLOWQAvD\\_BwE](https://www.udemy.com/course/uvm-for-verification-part-2-projects/?utm_source=adwords&utm_medium=udemyads&utm_campaign=Search_DSA_Beta_Prof_la.EN_cc.INDIA&campaigntype=Search&portfolio=India&language=EN&product=Course&test=&audience=DSA&topic=&priority=Beta&utm_content=deal4584&utm_term=.ag_160270535665_.ad_696202838340_.kw_.de_c_.dm_.pl_.ti_dsa-1677053911888_.li_9147583_.pd_.&matchtype=&gad_source=1&gclid=CjwKC_AjwnqK1BhBvEiwAi7o0Xyj21cvFN97-KGpQbnyHVxUHRk6YsxUkWaYMefK8G4fucWJFzXicMxoCLOWQAvD_BwE)
2. [https://iisc.talentsprint.com/micro-electronics-and-semiconductor-technologies/mobile/?utm\\_source=g\\_search&utm\\_medium=paid\\_google&utm\\_campaign=iisc-mest-g\\_search-performance-lower\\_funnel&utm\\_content=iisc-mest-g\\_search-performance-lower\\_funnel-audience&utm\\_term=verilog%20course&placement=&matchtype=b&device=c&net](https://iisc.talentsprint.com/micro-electronics-and-semiconductor-technologies/mobile/?utm_source=g_search&utm_medium=paid_google&utm_campaign=iisc-mest-g_search-performance-lower_funnel&utm_content=iisc-mest-g_search-performance-lower_funnel-audience&utm_term=verilog%20course&placement=&matchtype=b&device=c&net)

- [work=g&gad\\_source=1&gclid=CjwKCAjwnqK1BhBvEiwAi7o0XznNmhPCp4msgOwCxRqsq0XNSyS-hyIEOwuMWi0NDoaNEj6jQ4s75RoC8\\_0QAvD\\_BwE](https://www.maven-silicon.com/best-vlsi-courses/online-vlsi-course-march/?utm_source=Google_Search_Online&campaignid=16685447008&gad_source=1&gclid=CjwKCAjwnqK1BhBvEiwAi7o0X-k33iGbPiuXc0s77-XaIFvyCWOGNYZUTEckwy3QzP9wHI2t1nR6CxoC8e8QAvD_BwE)
3. [https://www.maven-silicon.com/best-vlsi-courses/online-vlsi-course-march/?utm\\_source=Google\\_Search\\_Online&campaignid=16685447008&gad\\_source=1&gclid=CjwKCAjwnqK1BhBvEiwAi7o0X-k33iGbPiuXc0s77-XaIFvyCWOGNYZUTEckwy3QzP9wHI2t1nR6CxoC8e8QAvD\\_BwE](https://www.maven-silicon.com/best-vlsi-courses/online-vlsi-course-march/?utm_source=Google_Search_Online&campaignid=16685447008&gad_source=1&gclid=CjwKCAjwnqK1BhBvEiwAi7o0X-k33iGbPiuXc0s77-XaIFvyCWOGNYZUTEckwy3QzP9wHI2t1nR6CxoC8e8QAvD_BwE)

## PHYSICAL DESIGN AUTOMATION

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC05</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>4</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Summarize the relationship between design automation algorithms and various constraints in VLSI fabrication and design technology.
- CO2:** Make use of the design algorithms to meet the critical design parameters.
- CO3:** Identify layout optimization techniques and map them to the algorithms
- CO4:** Develop proto-type EDA tool and test its efficacy
- CO5:** Distinguish the different partitioning algorithms and its evolution.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	-	3	1	-	-
<b>CO2:</b>	3	-	2	-	-	-
<b>CO3:</b>	2	-	2	3	-	-
<b>CO4:</b>	3	-	1	-	-	-
<b>CO5:</b>	2	-	2	3	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	2	-
<b>CO2:</b>	2	2	1
<b>CO3:</b>	2	2	-
<b>CO4:</b>	2	2	1
<b>CO5:</b>	2	2	-

### UNIT – I

VLSI design Cycle, Physical Design Cycle, Design Rules, Layout of Basic Devices, and Additional Fabrication, Design styles: full custom, standard cell, gate arrays, field programmable gate arrays, sea of gates and comparison, system packaging styles, multi-chip modules. Design rules, layout of basic devices, fabrication process and its impact on physical design, interconnect delay, noise and cross talk, yield and fabrication cost.

**Practice:**

- 1) Graph algorithms
  - a) Graph search algorithms
    - i. Depth first search
    - ii. Breadth first search
  - b) Spanning tree algorithm
    - i. Kruskal's algorithm
  - c) Shortest path algorithm
    - i. Dijkstra algorithm
    - ii. Floyd- Warshall algorithm
  - d) Steiner tree algorithm

- 2) Computational geometry algorithm
  - a) Line sweep method
  - b) Extended line sweep method

## UNIT – II

Factors, Complexity Issues and NP-hard Problems, Basic Algorithms (Graph and Computational Geometry): graph search algorithms, spanning tree algorithms, shortest path algorithms, matching algorithms, min-cut and max-cut algorithms, Steiner tree algorithms

### Practice:

- I) Partitioning algorithms
  - a) Group migration algorithms
  - b) Kernighan –Lin algorithm
  - c) Extensions of Kernighan-Lin algorithm
- II) Fiduccias –Mattheyses algorithm
  - i) Goldberg and Burstein algorithm
- III) Simulated annealing and evolution algorithms
  - a) Simulated annealing algorithm
  - b) Simulated evolution algorithm
- IV) Metric allocation method

## UNIT – III

Basic Data Structures, atomic operations for layout editors, linked list of blocks, bin based methods, neighbor pointers, corner stitching, multi-layer operations.

## UNIT – IV

Graph algorithms for physical design: classes of graphs, graphs related to a set of lines, graphs related to set of rectangles, graph problems in physical design, maximum clique and minimum coloring, maximum k-independent set algorithm, algorithms for circle graphs.

### Practice:

- I) Floor planning algorithms
  - i) Constraint based methods
  - ii) Integer programming based methods
  - iii) Rectangular dualization based methods
  - iv) Hierarchical tree based methods
  - v) Simulated evolution algorithms
  - vi) Time driven Floor planning algorithms

## UNIT – V

Partitioning algorithms: design style specific partitioning problems, group migrated algorithms, simulated annealing and evolution, and Floor planning and pin assignment, Routing and placement algorithms.

### Practice:

- I) Routing algorithms
  - a) Two terminal algorithms
  - b) Maze routing algorithms
  - c) Lee's algorithm
  - d) Soukup's algorithm
  - e) Hadlock algorithm
- II) Line-Probe algorithm
- III) Shortest path based algorithm

- II) Multi terminal algorithm
- a) Stenier tree based algorithm
- i) SMST algorithm
- ii) Z-RST algorithm

**Text Books:**

1. Naveed Shervani, Algorithms for VLSI Physical Design Automation, 3rd Edition, Kluwer Academic, ISBN Number- 0792383931
- Charles J Alpert, Dinesh P Mehta, Sachin S Sapatnekar, Handbook of Algorithms for
2. Physical Design Automation, CRC Press, ISBN Number- 0849372429

**Reference Books:**

1. Algorithms for VLSI Physical Design Automation Hardcover, Naveed A. Sherwani, ISBN Number- 0792383931

**Web Links:**

1. <https://nptel.ac.in/courses/106105161/>
2. [https://eecs.wsu.edu/~daehyun/teaching/2014\\_EE582/](https://eecs.wsu.edu/~daehyun/teaching/2014_EE582/)
3. [http://users.ece.utexas.edu/~dpan/PDA\\_syllabus.pdf](http://users.ece.utexas.edu/~dpan/PDA_syllabus.pdf)

## VLSI TESTING AND VALIDATION

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC06</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>4</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Analyze the basic faults that occur in digital systems
- CO2:** Testing of stuck at faults for digital circuits, Design for testability.
- CO3:** Analyse testing issues in the field of digital system design critically for conducting research
- CO4:** Solve engineering problems by modelling different faults for fault free simulation in digital circuits
- CO5:** Apply appropriate research methodologies and techniques to develop new testing strategies for digital and mixed signal circuits and systems

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	1	3	1	-	-
<b>CO2:</b>	1	1	3	1	-	-
<b>CO3:</b>	2	2	2	1	-	-
<b>CO4:</b>	2	2	2	1	-	-
<b>CO5:</b>	3	2	2	1	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	-	-
<b>CO2:</b>	2	-	-
<b>CO3:</b>	2	2	2
<b>CO4:</b>	2	2	2
<b>CO5:</b>	2	2	2

### UNIT – I

#### **Introduction to Testing:**

Testing Philosophy, Role of Testing, Digital and Analog VLSI Testing, VLSI Technology Trends affecting Testing, Types of Testing, Fault Modeling: Defects, Errors and Faults, Functional Versus Structural Testing, Levels of Fault Models, Single Stuck-at Fault.

#### **Practice:**

1. Introduction to test bench architecture.
2. Combinational Circuit Testing (adder and multiplier)

### UNIT – II

#### **Logic and Fault Simulation:**

Simulation for Design Verification and Test Evaluation, Modeling Circuits for Simulation, Algorithms for True value Simulation, Algorithms for Fault Simulation.

**Practice:**

1. Analysis of code coverages and write development of functional coverage.

**UNIT – III****Testability Measures:**

SCOAP Controllability and Observability, High Level Testability Measures, Digital DFT and Scan Design: Ad-Hoc DFT Methods, Scan Design, Partial-Scan Design, Variations of Scan.

**UNIT – IV****Built-In Self-Test:**

The Economic Case for BIST, Random Logic BIST: Definitions, BIST Process, Pattern Generation, Response Compaction, Built-In Logic Block Observers, Test-Per-Clock, Test-Per-Scan BIST Systems, Circular Self-Test Path System, Memory BIST, Delay Fault BIST.

**Practice:**

1. Design for Test and Automatic Test pattern Generation for a 4-bit counter.
2. Design for Test and Automatic Test pattern Generation for a 4-bit counter.

**UNIT – V****Boundary Scan Standard:**

Motivation, System Configuration with Boundary Scan: TAP Controller and Port, Boundary Scan Test Instructions, Pin Constraints of the Standard, Boundary Scan Description Language: BSDL Description Components, Pin Descriptions.

**Practice:**

1. Perform the logic equivalence (formal verification).

**Text Books:**

- Essentials of Electronic Testing for Digital, Memory and Mixed Signal VLSI Circuits -
1. M.L. Bushnell, V. D. Agrawal, Kluwer Academic Publishers, ISBN Number- 4330981722
  2. Digital Systems and Testable Design - M. Abramovici, M.A. Breuer and A.D. Friedman, Jaico Publishing House, ISBN Number- 8172248911

**Reference Books:**

1. Digital Circuits Testing and Testability - P.K. Lala, Academic Press, ISBN Number- 0124343309

**Web Links:**

1. <https://www.slideshare.net/labishettybhanu/trends-and-challenges-in-vlsi>
2. <http://www.engr.uconn.edu/~tehrani/teaching/test>
3. <http://nptel.ac.in/courses/106103116/34>
4. <http://eesemi.com/bist.html>
5. <http://slideplayer.com/slide/6546550/>

## MICROELECTRONICS DEVICE MODELLING

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC07</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Understand the physics of 2-terminal MOS operation and its characteristics.
- CO2:** Understand the physics of 4-terminal MOSFET operation and its characteristics.
- CO3:** Analyze the SOI MOSFET electrical characteristics.
- CO4:** Interpret various MOSFET models.
- CO5:** Analyse various high k dielectrics

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	1	-	2	2	-
<b>CO2:</b>	-	1	-	-	2	-
<b>CO3:</b>	-	3	-	-	3	-
<b>CO4:</b>	-	3	-	-	3	-
<b>CO5:</b>	-	3	-	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	-
<b>CO3:</b>	-	2	-
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	3	-

### UNIT – I

2-terminal MOS device: threshold voltage modelling (ideal case as well as considering the effects of  $Q_f$ ,  $\Phi_{ms}$  and  $Dit$ ).

### UNIT – II

C-V characteristics (ideal case as well as taking into account the effects of  $Q_f$ ,  $\Phi_{ms}$  and  $Dit$ ); MOS capacitor as a diagnostic tool (measurement of non-uniform doping profile, estimation of  $Q_f$ ,  $\Phi_{ms}$  and  $Dit$ ).

### UNIT – III

4-terminal MOSFET: threshold voltage (considering the substrate bias); above threshold I-V modelling (SPICE level 1,2,3 and 4).

**UNIT – IV**

Sub threshold current model; scaling; effect of threshold tailoring implant (analytical modelling of threshold voltage using box approximation); buried channel MOSFET. Short channel, DIBL and narrow width effects; small signal analysis of MOSFETs (Meyer “s model).

**UNIT – V**

SOI MOSFET: basic structure; threshold voltage modelling Advanced topics: hot carriers in channel; EEPROMs; CCDs; high-K gate dielectrics.

**Text Books:**

1. D.G. Ong, “Modern MOS Technology: Processes, Devices and Design”, Mc Graw Hill,1984, ISBN Number- 0070477094
2. Y. Taur and T.H. Ning, “Fundamentals of modern VLSI Devices” Cambridge Univ. Press,1998, ISBN Number- 1107635713

**Reference Books:**

1. Physics of Semiconductor Devices, S.M. Sze, Wiley, ISBN Number- 8126517026

**Web Links:**

1. <https://nptel.ac.in/courses/117106033/>
2. <https://www.sciencedirect.com/topics/materials-science/device-modeling>

## NANO-ELECTRONICS

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC08</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Demonstrate challenges due to scaling on CMOS devices.
- CO2:** Analyse and explain working of novel MOS based silicon devices and various multi gate devices.
- CO3:** Analyse working of spin electronic devices
- CO4:** Summarize nano electronics systems and building blocks such as: low dimensional semiconductors, hetero structures, carbon nano tubes, quantum dots, nanowires etc.
- CO5:** Develop nano electronics systems and building blocks such as: carbon nanotubes, quantum dots, nanowires etc.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	1	-	2	-	-
<b>CO2:</b>	-	3	2	2	-	-
<b>CO3:</b>	2	2	-	3	-	-
<b>CO4:</b>	-	3	2	-	-	-
<b>CO5:</b>	-	2	1	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	-
<b>CO3:</b>	-	2	-
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	2	-

### UNIT – I

Properties of Individual Nano particles: Introduction, Metal Nano Clusters, Semiconducting Nanoparticles, Rare Gas and Molecular Clusters, Methods of Synthesis.

### UNIT – II

The nanoscale MOSFET, Fin FETs, Vertical MOSFETs, limits to scaling, system integration limits (interconnect issues etc.), Resonant Tunneling Transistors.

Carbon Nano Structures: Introduction, Carbon Molecules, Carbon Clusters, Carbon Nano Tubes, Application of Carbon Nanotubes.

### UNIT – III

Carbon Nanotubes for Data Processing–Introduction, Electronic Properties, Synthesis of Carbon Nanotubes, Carbon Nanotube Interconnects, Carbon Nanotubes Field Effect Transistors (CNTFETs), Nanotubes for Memory Applications, Prospects of an All- CNT

Nanoelectronics.

Neuro electronic Interfacing: Semiconductor Chips with Ion Channels, Nerve Cells, and Brain: Introduction, Ion-Electronic Interface, Neuron-Silicon Circuits, Brain- Silicon Chips.

#### **UNIT – IV**

Optical3-DTime-of-Flight Imaging System: Introduction, Taxonomy of Optical3-DTechniques, CMOS Imaging, CMOS 3-D Time-of-Flight Image Sensor, Application Examples

Pyroelectric Detector Arrays for IR Imaging: Introduction, Operation Principle of Pyroelectric IR Detectors, Pyroelectric Materials, Realized Devices, Characterization, and Processing Issues

#### **UNIT – V**

Electronic Noses: Introduction, Operating Principles of Gas Sensor Elements, Electronic Noses, Signal Evaluation, Dedicated Examples.2- DTactileSensorsandTactileSensorArrays: Introduction, Definitions and Classifications, Resistive Touch screens, Ultrasonic Touchscreens, Robot Tactile Sensors, Fingerprint Sensors.

#### **Text Books:**

1. Introduction to Nanotechnology, C.P. Poole Jr., F.J. Owens, Wiley, ISBN Number- 0471079359
2. Nano electronics and Information Technology (Advanced Electronic Materials and Novel Devices), Waser Ranier, Wiley-VCH, ISBN Number- 3527409270

#### **Reference Books:**

1. Nano systems, K.E. Drexler, Wiley, ISBN Number- 9780471575184
2. The Physics of Low-Dimensional Semiconductors, John H.Davies, “Cambridge University Press, ISBN Number- 052148491X

#### **Web Links:**

- 1 <https://www.nano.gov/html/facts/faqs.html>
- 2 [https://ec.europa.eu/health/ph\\_risk/committees/04\\_scenihp/docs/scenihp\\_o\\_003.pdf](https://ec.europa.eu/health/ph_risk/committees/04_scenihp/docs/scenihp_o_003.pdf)
- 3 <http://www.nanobuildings.com/>

## FPGA BASED SYSTEM DESIGN

<b>Course Code: 2502EC09</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>2</b>	<b>0</b>	<b>1</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Identify different types of programmable logic devices.
- CO2:** Compare the performance of different FPGAs and their programming Technologies
- CO3:** Analyze different SRAM programmable FPGA architectures
- CO4:** Analyze different Anti-Fuse Programmed FPGA architectures
- CO5:** Develop digital circuits with ACT architectures

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	2	2	-	-	-
<b>CO2:</b>	3	2	3	-	-	-
<b>CO3:</b>	3	3	3	-	-	-
<b>CO4:</b>	3	3	3	-	-	-
<b>CO5:</b>	3	3	3	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	1
<b>CO3:</b>	-	2	1
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	2	-

### UNIT – I

#### **Introduction to Programmable Logic Devices:**

Introduction, Simple Programmable Logic Devices - Read Only Memories, Programmable Logic Arrays, Programmable Array Logic, Programmable Logic Devices/Generic Array Logic; Complex Programmable Logic Devices – Architecture of Xilinx Cool Runner XCR3064XL, CPLD, CPLD Implementation of a Parallel Adder with Accumulation.

#### **Practice:**

1. Implementation of simple combinational design in Xilinx
2. Design of A Counter Using the On Board Clock

### UNIT – II

#### **Field Programmable Gate Arrays:**

Organization of FPGAs, FPGA Programming Technologies, Programmable Logic Block Architectures, Programmable Interconnects, Programmable I/O blocks in FPGAs, Dedicated Specialized Components of FPGAs, Applications of FPGAs.

#### **Practice:**

1. Design and implement a traffic light control circuit
2. FPGA System design Using IP Integrator

### **UNIT – III**

#### **Programming FPGAs:**

SRAM Programmable FPGAs, Introduction, Programming Technology, Device Architecture, The Xilinx XC2000, XC3000 and XC4000 Architectures.

#### **Practice:**

1. Hardware Debugging using VIO

### **UNIT – IV**

#### **ACT FPGA Architectures:**

Anti-Fuse Programmed FPGAs, Introduction, Programming Technology, Device Architecture, The Actel ACT1, ACT2 and ACT3 Architectures

#### **Practice:**

1. Design of an ALU and hardware debugging using VIO

### **UNIT – V**

#### **Applications:**

Design Applications, General Design Issues, Counter Examples, A Fast Video Controller, A Position Tracker for a Robot Manipulator, A Fast DMA Controller, Designing Counters with ACT devices, Designing Adders and Accumulators with the ACT Architecture.

#### **Practice:**

1. Integrated logic analyzer (ILA) core for hardware debugging

#### **Text Books:**

1. Field Programmable Gate Array Technology, Stephen M. Trimberger, Springer International Edition, ISBN Number- 0792394194.
2. Digital Systems Design, Charles H. Roth Jr, LizyKurian John, Cengage Learning, ISBN Number- 813150574X.

#### **Reference Books:**

1. Digital Systems Design with FPGAs and CPLDs, Ian Grout, Elsevier, Newnes, ISBN Number- 075068397X
2. Digital Design Using Field Programmable Gate Arrays, Pak K. Chan/Samiha Mourad, Pearson Low Price Edition, ISBN Number- 8131724409

#### **Web Links:**

1. [www.cs.umd.edu/class/sum2003/cmsc311/Notes/Comb/pla.html](http://www.cs.umd.edu/class/sum2003/cmsc311/Notes/Comb/pla.html)
2. [www.eng.ucy.ac.cy/theocharides/Courses/ECE664/L5.pdf](http://www.eng.ucy.ac.cy/theocharides/Courses/ECE664/L5.pdf)
3. [www.soc.napier.ac.uk/~bill/pdf/ICD\\_C09.PDF](http://www.soc.napier.ac.uk/~bill/pdf/ICD_C09.PDF)
4. [https://en.wikipedia.org/wiki/Complex\\_programmable\\_logic\\_device](https://en.wikipedia.org/wiki/Complex_programmable_logic_device).

## M/NEMS TECHNOLOGY

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC10</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Explain the fundamental concepts, materials, and applications of Micro-Electro-Mechanical Systems (MEMS) and Nano-Electro-Mechanical Systems (NEMS). Describe the various fabrication technologies for MEMS, including
- CO2:** photolithography, thin film deposition, etching techniques, micromachining, and packaging.
- CO3:** Design and analyze different types of MEMS sensors, understanding the engineering mechanics behind their operation.
- CO4:** Design and evaluate micro actuators using various actuation mechanisms such as thermal forces, shape memory alloys, piezoelectric crystals, and electrostatic forces.
- CO5:** Apply the principles of quantum mechanics and molecular dynamics to understand and design nanosystems and molecular electronics.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	2	3	1	2	1
<b>CO2:</b>	3	3	2	1	1	2
<b>CO3:</b>	3	2	3	1	2	2
<b>CO4:</b>	3	2	3	1	2	2
<b>CO5:</b>	3	2	3	2	1	2

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	1	1
<b>CO2:</b>	3	1	1
<b>CO3:</b>	2	1	1
<b>CO4:</b>	2	1	1
<b>CO5:</b>	1	1	1

### UNIT – I

#### OVERVIEW AND INTRODUCTION

New trends in Engineering and Science: Micro and Nano scale systems Introduction to Design of MEMS and NEMS, Overview of Nano and Micro electromechanical Systems, Applications of Micro and Nano electro mechanical systems, Micro electromechanical systems, devices and structures Definitions, Materials for MEMS: Silicon, silicon compounds, polymers, metals.

### UNIT – II

#### MEMS FABRICATION TECHNOLOGIES

Microsystem fabrication processes: Photolithography, Ion Implantation, Diffusion, Oxidation. Thin film depositions: LPCVD, Sputtering, Evaporation, Electroplating; Etching

techniques: Dry and wet etching, electrochemical etching; Micromachining: Bulk Micromachining, Surface Micromachining, High Aspect-Ratio (LIGA and LIGA-like) Technology; Packaging: Microsystems packaging, Essential packaging technologies, Selection of packaging materials.

### **UNIT – III**

#### **MICRO SENSORS**

MEMS Sensors: Design of Acoustic wave sensors, resonant sensor, Vibratory gyroscope, Capacitive and Piezo Resistive Pressure sensors- engineering mechanics behind these Microsensors. Case study: Piezo-resistive pressure sensor.

### **UNIT – IV**

#### **MICRO ACTUATORS**

Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces (Parallel plate, Torsion bar, Comb drive actuators), Micromechanical Motors and pumps. Case study: Comb drive actuators.

### **UNIT – V**

#### **NANOSYSTEMS AND QUANTUM MECHANICS**

Atomic Structures and Quantum Mechanics, Molecular and Nanostructure Dynamics: Shrodinger Equation and Wavefunction Theory, Density Functional Theory, Nanostructures and Molecular Dynamics, Electromagnetic Fields and their quantization, Molecular Wires and Molecular Circuits.

#### **Text Books:**

1. Marc Madou, “Fundamentals of Micro fabrication”, CRC press, ISBN Number- 08493945112
2. Stephen D. Senturia, “Micro system Design”, Kluwer Academic Publishers, ISBN Number- 0792372468

#### **Reference Books:**

1. Tai Ran Hsu, “MEMS and Microsystems Design and Manufacture”, Tata McGraw Hill, ISBN Number- 007048709X
2. Chang Liu, “Foundations of MEMS”, Pearson education India limited, ISBN Number- 0132497360

#### **Web Links:**

1. [https://en.wikipedia.org/wiki/Nanoelectromechanical\\_systems](https://en.wikipedia.org/wiki/Nanoelectromechanical_systems)
2. <https://www.sciencedirect.com/topics/nursing-and-health-professions/nanoelectromechanical-system>

## NANOMATERIALS AND NANOTECHNOLOGY

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC11</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Understand the basic science behind the design and fabrication of nano scale systems.
- CO2:** Understand and formulate new engineering solutions for current problems and competing technologies for future applications.
- CO3:** Develop the inter disciplinary projects applicable to wide areas by clearing and fixing the boundaries in system development
- CO4:** Gather detailed knowledge of the operation of fabrication and characterization
- CO5:** An ability to apply knowledge of science and Engineering

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	1	-	2	-	-
<b>CO2:</b>	-	3	2	2	-	-
<b>CO3:</b>	-	2	-	3	-	-
<b>CO4:</b>	-	3	2	-	-	-
<b>CO5:</b>	-	2	1	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	-
<b>CO3:</b>	-	2	2
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	2	2

### UNIT – I

Introduction of nano materials and nanotechnologies, Features of nanostructures, Applications of nano materials and technologies. Nano dimensional Materials 0D, 1D, 2D structures – Size Effects – Fraction of Surface Atoms – Specific Surface Energy and Surface Stress – Effect on the Lattice Parameter – Phonon Density of States – the General Methods available for the Synthesis of Nanostructures – precipitate – reactive– hydrothermal/solvo thermal methods – suitability of such methods for scaling – potential Uses.

### UNIT – II

Fundamentals of nano materials, Classification, Zero-dimensional nano materials, One-dimensional nano materials, Two-dimensional nano materials, Three dimensional nano materials. Low-Dimensional Nano materials and its Applications, Synthesis, Properties, and Applications of Low-Dimensional Carbon- Related Nano materials.

**UNIT – III**

Micro- and Nanolithography Techniques, Emerging Applications Introduction to Micro electromechanical Systems (MEMS), Advantages and Challenges of MEMS, Fabrication Technologies, Surface Micromachining, Bulk Micromachining, Molding. Introduction to Nano Photonics.

**UNIT – IV**

Introduction, Synthesis of CNTs - Arc-discharge, Laser-ablation, Catalytic growth, Growth mechanisms of CNT's - Multi-walled nano tubes, Single-walled nano tubes Optical properties of CNT's, Electrical transport in perfect nano tubes, Applications as case studies. Synthesis and Applications of CNT's.

**UNIT – V**

Ferroelectric materials, coating, molecular electronics and nano electronics, biological and environmental, membrane based application, polymer based application.

**Text Books:**

1. Kenneth J. Klabunde and Ryan M. Richards, "Nanoscale Materials in Chemistry", 2nd edition, John Wiley and Sons, ISBN Number- 0470222700  
I Gusev and A A Rempel, "Nanocrystalline Materials", Cambridge International
2. Science Publishing, 1st Indian edition by Viva Books Pvt. Ltd, ISBN Number- 1898326266

**Reference Books:**

1. B. S. Murty, P. Shankar, Baldev Raj, B. B. Rath, James Murday, "Nanoscience and Nanotechnology", Tata McGraw Hill Education, ISBN Number- 978-3-642-28030-6
2. Bharat Bhushan, "Springer Handbook of Nanotechnology", Springer, 3rd edition, ISBN Number- 3642025242

**Web Links:**

1. <https://nptel.ac.in/courses/118104008>
2. <https://en.wikipedia.org/wiki/Nanotechnology>

## NETWORK SECURITY AND CRYPTOGRAPHY

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC12</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Explain basic concepts of encryption techniques.
- CO2:** Identify and utilize different forms of cryptography techniques
- CO3:** Illustrate authentication requirements with algorithms.
- CO4:** Apply authentication and security in the network applications.
- CO5:** Compare different types of threats to the system and handle the same.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	2	3	3	-	3	-
<b>CO2:</b>	3	1	-	-	2	-
<b>CO3:</b>	3	3	2	-	-	-
<b>CO4:</b>	2	1	1	-	2	-
<b>CO5:</b>	3	3	2	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	1
<b>CO3:</b>	-	2	1
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	3	-

### UNIT – I

#### Security & Number Theory

Need, security services, Attacks, OSI Security Architecture, one time passwords, Model for Network security, Classical Encryption Techniques like substitution ciphers, Transposition ciphers, Cryptanalysis of Classical Encryption Techniques. Introduction, Fermat's and Euler's Theorem, The Chinese Remainder Theorem, Euclidean Algorithm, Extended Euclidean Algorithm, and Modular Arithmetic.

### UNIT – II

#### Private-Key(Symmetric)Cryptography

Block Ciphers, Stream Ciphers, RC4 Stream cipher, Data Encryption Standard (DES), Advanced Encryption Standard (AES), Triple DES, RC5, IDEA, Linear and Differential Cryptanalysis.

### UNIT – III

RSA, Key Distribution and Management, Diffie-Hellman Key Exchange, Elliptic Curve Cryptography, Message Authentication Code, hash functions, message digest algorithms: MD4 MD5, Secure Hash algorithm, RIPEMD-160, HMAC.

#### UNIT – IV

##### **Authentication:**

IP and Web Security Digital Signatures, Digital Signature Standards, Authentication Protocols, Kerberos, IP security Architecture, Encapsulating Security Payload, Key Management, Web Security Considerations, Secure Socket Layer and Transport Layer Security, Secure Electronic Transaction.

#### UNIT – V

##### **System Security:**

Intruders, Intrusion Detection, Password Management, Worms, viruses, Trojans, Virus Countermeasures, Firewalls, Firewall Design Principles, Trusted Systems.

##### **Text Books:**

1. Cryptography and Network Security, Behrouz A. Forouzan and Debdeep Mukhopadhyay, Tata McGrawHill, 2010, ISBN Number- 007070208X
2. William Stallings, “Cryptography and Network Security, Principles and Practices”, Pearson Education, 3rd Edition, ISBN Number- 0131873164

##### **Reference Books:**

1. CharlieKaufman,RadiaPerlmanandMikeSpeciner,“NetworkSecurity,Private Communication in a Public World”, Prentice Hall, 2nd Edition, ISBN Number- 0130460192
2. CryptographyandNetworkSecurity:PrinciplesandPractice,WilliamStallings, William Stallings, Pearson Education, 5th Edition, ISBN Number- 0136097049

##### **Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc21\\_cs16](https://onlinecourses.nptel.ac.in/noc21_cs16)
2. <https://www.cs.vsb.cz/ochodkova/courses/kpb/cryptography-and-network-security - principles-and-practice-7th-global-edition.pdf>

## LOW POWER VLSI CIRCUIT DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC13</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Make use of the Low-Power Design Approaches in complex systems design.
- CO2:** Contrast different Low-Voltage and Low-Power design approaches for a target design.
- CO3:** Inspect the low power methods to get the circuits for Capacitance power reduction.
- CO4:** Choose the suitable design among the list of Low-Voltage Low-Power Adders or Multipliers
- CO5:** Extend the knowledge of power management strategies in power efficient Designs.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	2	2	2	1	1
<b>CO2:</b>	3	2	3	2	1	1
<b>CO3:</b>	3	3	3	2	1	1
<b>CO4:</b>	3	3	3	2	1	1
<b>CO5:</b>	3	3	3	2	1	1

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	1	2	3
<b>CO2:</b>	1	2	3
<b>CO3:</b>	1	3	2
<b>CO4:</b>	1	2	3
<b>CO5:</b>	1	2	3

### UNIT – I

#### **Fundamentals of Low Power VLSI Design:**

Need for Low Power Circuit Design, Sources of Power Dissipation – Switching Power Dissipation, Short Circuit Power Dissipation, Leakage Power Dissipation, Glitching Power Dissipation, Short Channel Effects – Drain Induced Barrier Lowering and Punch Through, Surface Scattering, Velocity Saturation, Impact Ionization, Hot Electron Effect.

### UNIT – II

#### **Low-Power Design Approaches:**

Low-Power Design through Voltage Scaling: VTCMOS circuits, MTCMOS circuits, Voltage Scaling Using High-Level Transformations: Multilevel Voltage Scaling, Challenges in MVS Voltage Scaling Interfaces, Static Timing Analysis Dynamic Voltage and Frequency Scaling. Architectural Level Approach – Pipelining and Parallel Processing Approaches.

### UNIT – III

#### **Switched Capacitance Minimization:**

Probabilistic Power Analysis: Random logic signals, probability and frequency, probabilistic power analysis techniques, signal entropy, Bus Encoding: Gray Coding, One-Hot Coding, Bus-Inversion, T0 Coding, Clock Gating, Gated-Clock FSMs FSM State Encoding, FSM Partitioning, Pre computation, Glitching Power Minimization.

### UNIT – IV

#### **Low-Voltage Low-Power Adders and Multipliers:**

Introduction, Standard Adder Cells, CMOS Adder's Architectures – Ripple Carry Adders, Carry Look-Ahead Adders, Carry Select Adders, Carry Save Adders, Low- Voltage Low-Power Design Techniques –Trends of Technology and Power Supply Voltage, Low Voltage Low-Power Logic Styles.

### UNIT – V

#### **Low power clock distribution:**

Low power clock distribution: Power dissipation in clock distribution, single driver versus distributed buffers, Zero Skew versus tolerable skew, chip and package co design for clock network.

#### **Text Books:**

- 1 Low-Voltage, Low-Power VLSI Subsystems – Kiat-Seng Yeo, Kaushik Roy, TMH  
. Professional Engineering, ISBN Number- 007143786X.
- 2 Low-Power VLSI Circuits and Systems, AjitPal, SPRINGER PUBLISHERS, ISBN  
. Number- 9788132219361.

#### **Reference Books:**

- 1 Practical Low Power Digital Vlsi Design, Gary Yeap Motorola, Springer Science  
. Business Media, LLC, ISBN Number- 0792380096.
- 2 Low Power CMOS Design– Anantha Chandrakasan, IEEE Press/ Wiley International,  
. ISBN Number- 0780334299

#### **Web Links:**

1. <https://archive.nptel.ac.in/courses/106/105/106105034/>  
[https://chippedge.com/what-is-low-power-vlsi-](https://chippedge.com/what-is-low-power-vlsi-design/#:~:text=The%20aim%20of%20low%20power,makes%20up%20the%20static%20power.)
2. [design/#:~:text=The%20aim%20of%20low%20power,makes%20up%20the%20static%20power.](https://chippedge.com/what-is-low-power-vlsi-design/#:~:text=The%20aim%20of%20low%20power,makes%20up%20the%20static%20power.)

## VLSI SIGNAL PROCESSING

<b>Course Code: 2502EC14</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Explain parallel and pipelining processing techniques.
- CO2:** Identify applications for unfolding algorithm.
- CO3:** Analyse Systolic Design for Space Representations containing Delays.
- CO4:** Explain Cook-Toom Algorithm, Fast Convolution algorithm by Inspection method.
- CO5:** Analyse Power Reduction techniques and Power Estimation techniques.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	3	1	2	1	2	1
<b>CO2:</b>	3	1	2	1	2	1
<b>CO3:</b>	3	2	3	1	1	2
<b>CO4:</b>	2	3	2	1	1	1
<b>CO5:</b>	3	2	3	2	1	2

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	2	1
<b>CO2:</b>	2	2	1
<b>CO3:</b>	3	3	2
<b>CO4:</b>	2	2	1
<b>CO5:</b>	3	2	3

### 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, Definition sand Properties, Solving System of Inequalities, Retiming Techniques.

### UNIT – II

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 contain Delays.

### **UNIT – IV**

#### **Fast Convolution:**

Introduction–Cook-Toom Algorithm–Wino gard algorithm–Iterated Convolution– Cyclic Convolution– Design of Fast Convolution algorithm by Inspection.

### **UNIT – V**

Digital lattice filter structures, bit level arithmetic, architecture, redundant arithmetic. Numerical strength reduction, synchronous, wave and asynchronous pipe lines, low power design. Low Power Design: Scaling Vs Power Consumption, Power Analysis, Power Reduction techniques, Power Estimation Approaches.

#### **Text Books:**

1. KeshabK. Parthi[A1], VLSI Digital signal processing systems, design and Implementation [A2], Wiley, Inter Science, ISBN Number- 0471241865
2. Mohammad Isamail and Terri Fiez, Analog VLSI signal and information processing, McGraw Hill ISBN Number- 0070323860

#### **Reference Books:**

1. S.Y. Kung, H.J. White House, T. Kailath, VLSI and Modern Signal Processing, Prentice Hall, ISBN Number- 013942699X

#### **Web Links:**

1. <https://archive.nptel.ac.in/courses/108/105/108105157/>
2. <https://ee.iitpkd.ac.in/node/61>

## SOC DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC15</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Explain about SoC
- CO2:** Illustrate the design of different embedded memories.
- CO3:** Summarize the validation and Testing Concepts.
- CO4:** Identify new techniques for future systems.
- CO5:** Explain the examples of applications and systems developed using a co-design approach.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	-	3	-	-	-
<b>CO2:</b>	2	-	3	2	-	-
<b>CO3:</b>	-	-	3	2	-	-
<b>CO4:</b>	3	-	2	2	-	-
<b>CO5:</b>	3	-	2	2	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	-	2
<b>CO2:</b>	-	-	2
<b>CO3:</b>	-	-	2
<b>CO4:</b>	-	-	2
<b>CO5:</b>	-	-	2

### UNIT – I

Introduction- System tradeoffs and evolution of ASIC Technology- System on chip concepts and methodology– SoC design issues -SoC challenges and components.

### UNIT – II

Design Methodological For Logic Cores- SoC Design Flow – On-chip buses –Design process for hard cores –Soft and firm cores – Core and SoC design examples.

### UNIT – III

Design Methodology for Memory and Analog Cores- Embedded memories –Simulation modes Specification of analog circuits – A to D converter –Phase locked loops –High I/O.

### UNIT – IV

Design Validation- Core level validation –Test benches –SoC design validation – Co simulation – hardware/Software co-verification. Case Study: Validation and test of systems on chip.

**UNIT – V**

SoC Testing- SoC Test Issues –Cores with boundary scan –Test methodology for design reuse– Testing of microprocessor cores – Built in self-method –testing of embedded memories.

**Text Books:**

- 1 Rochit Rajsunah, System-on-a-chip: Design and Test, ArtechHouse. Prakash Raslinkar, Peter Paterson & Leena Singh, ISBN Number- 978-1475774689
- 2 System-on-a-chip verification: Methodology and Techniques, Kluwer Academic Publishers, ISBN Number- 0792372794

**Reference Books:**

- 1 M.Keating, D.Flynn, R.Aitken, A, GibbonsShi, Low Power Methodology Manual for System-on- Chip Design Series: Integrated Circuits and Systems, Springer, ISBN Number- 0387718184
- 2 Validation and test of systems on chip, IEEE conference on ASIC/SOC, L.Balado, E.Lupon, ISBN Number- 0-7803-5632-2

**Web Links:**

1. <https://nanohub.org/courses/ECE695R/o1a/outline/unit1introductionandbackground/115overviewofsocdesignflow?time=00:07:37>
2. <https://www.synopsys.com/blogs/chip-design/system-on-chip-design.html>

## HARDWARE SOFTWARE CO-DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC16</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Analyze embedded system’s hardware and software design issues.
- CO2:** Develop the applications on 8051, ADSP2106 and TMS320C60 processors.
- CO3:** Demonstrate modern embedded architectures and compilation technologies.
- CO4:** Interpret the Design and co-design by using design verification tools.
- CO5:** Build the system from system level specification languages

**Mapping of Course Outcomes with Program Outcomes:**

<b>CO/PO</b>	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>
<b>CO1:</b>	1	1	2	1	1	-
<b>CO2:</b>	1	1	1	1	1	-
<b>CO3:</b>	2	2	2	1	1	-
<b>CO4:</b>	2	2	2	1	1	-
<b>CO5:</b>	3	2	2	1	1	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

<b>CO/PSO</b>	<b>PSO1</b>	<b>PSO2</b>	<b>PSO3</b>
<b>CO1:</b>	-	2	2
<b>CO2:</b>	-	2	2
<b>CO3:</b>	-	2	2
<b>CO4:</b>	-	2	2
<b>CO5:</b>	-	2	2

### UNIT – I

#### **Co- Design Issues:**

Co- Design Models, Architectures, Languages, A Generic Co-design Methodology.  
Co- Synthesis Algorithms: Hardware software synthesis algorithms: hardware, software partitioning distributed system co synthesis.

### UNIT – II

#### **Prototyping and Emulation:**

Prototyping and emulation techniques, prototyping and emulation environments, future developments in emulation and prototyping architecture specialization techniques, system communication infrastructure

**Target Architectures:** Architecture Specialization techniques, System Communication infrastructure, Target Architecture and Application System classes, Architecture for control dominated systems (8051-Architectures for High performance control), Architecture for Data dominated systems (ADSP21060, TMS320C60), Mixed Systems.

### **UNIT – III**

#### **Compilation Techniques and Tools for Embedded Processor Architectures:**

Modern embedded architectures, embedded software development needs, compilation technologies, practical consideration in a compiler development environment.

### **UNIT – IV**

#### **Design Specification and Verification:**

Design, co-design, the co-design computational model, concurrency coordinating concurrent computations, interfacing components, design verification, implementation verification, verification tools, interface verification

### **UNIT – V**

#### **Languages for System – Level Specification and Design-I:**

System – level specification, design representation for system level synthesis, system level specification languages.

#### **Languages for System-Level Specification and Design-II:**

Heterogeneous specifications and multi-language co-simulation, the cosyma system and lycos system.

#### **Text Books:**

1. Hardware / Software Co- Design Principles and Practice, Jorgen Staunstrup, Wayne Wolf, Springer, ISBN Number- 8181286847
2. Hardware / Software Co- Design, Giovanni DeMicheli, Mariagiovanna Sami, Kluwer Academic Publishers, ISBN Number- 0792338839

#### **Reference Books:**

- 1 A Practical Introduction to Hardware/Software Co-design, Patrick R. Schaumont, Springer Publications, ISBN Number- 1489990607

#### **Web Links:**

1. <https://embedded.eecs.berkeley.edu/Research/hsc/abstract.html>
2. <http://ieeexplore.ieee.org/document/6172642/>
3. <http://www.tik.ee.ethz.ch/education/lectures/hswcd/>
4. <http://ieeexplore.ieee.org/document/715400/>

## VLSI FABRICATION TECHNOLOGY

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC17</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Summarize Clean Room Environment and Wafer Preparation
- CO2:** Outline Oxidation, Diffusion, and Implantation
- CO3:** Identify Epitaxial Growth methodologies
- CO4:** Analyze various Lithography Process
- CO5:** Outline the Fabrication and Packaging technique

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	2	-	-	-	-
<b>CO2:</b>	-	2	2	-	-	-
<b>CO3:</b>	-	3	2	-	-	-
<b>CO4:</b>	-	3	2	-	-	-
<b>CO5:</b>	-	2	2	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	-
<b>CO3:</b>	-	2	-
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	2	-

### UNIT – I

Clean Room Environment and Wafer Preparation: Crystal Structure of a solid, Defects in material. Types of clean room, Contamination in clean room, Electronic Grade Silicon Czochralski crystal growing, Silicon Shaping, Wafer cleaning processes and wet chemical etching techniques.

### UNIT – II

Oxidation, Diffusion, and Implantation: Kinetics of Silicon dioxide growth both for thick, thin, and ultrathin films; Oxidation Techniques and Systems Models of Diffusion in Solids, Defects due to oxidation, Solid State diffusion modeling and technology, Implantation Equipment, Principles, techniques and applications, removal of implant damage.

### UNIT – III

Epitaxial Growth: Metallization's and MBE, Defects in Epitaxial Layer Dielectric Deposition, PECVD and Rapid Thermal Annealing, E-beam evaporation, Sputtering, Thermal Evaporation, Dry Etching

**UNIT – IV**

Lithography: Optical Lithography, E-beam lithography, X-ray, and Other Lithography techniques

**UNIT – V**

Fabrication and Packaging: Fabrication of MOSFET, Process to Package a chip (Dicing, Attaching, wire bonding, Chip package header), Fabrications of other devices.

**Text Books:**

1. S.M. Sze, “VLSI Technology”, McGraw Hill, 2nd Edition, ISBN Number-0070582912.
2. G. S. May, S. M. Sze, Fundamentals of Semiconductor Fabrication, Wiley, ISBN Number- 0471232793

**Reference Books:**

1. James D Plummer, Michael D. Deal, Peter Griffin, “Silicon VLSI Technology: fundamentals practice and Modeling”, Prentice Hall India, ISBN Number-0130850373
2. Wai Kai Chen, “VLSI Technology” CRC press, ISBN Number- 084931738X

**Web Links:**

1. <https://nptel.ac.in/courses/117106093>
2. <https://chippedge.com/fabrication-process-in-vlsi/>

## SENSORS AND SENSOR CIRCUIT DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC18</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Explain the basic concepts of op-amp and filters for sensor circuits
- CO2:** Clasify various sensor circuit performances along with application
- CO3:** Summarize the performance of sensors using various circuits
- CO4:** Illustrate the basic concepts of signal conditioning circuits
- CO5:** Develop circuits using sensors for measuring corresponcing parameters

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	-	3	-	-	-
<b>CO2:</b>	2	-	2	3	-	-
<b>CO3:</b>	-	-	3	2	-	-
<b>CO4:</b>	-	-	2	3	-	-
<b>CO5:</b>	3	-	2	2	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	-	2
<b>CO2:</b>	-	-	2
<b>CO3:</b>	-	-	2
<b>CO4:</b>	-	-	2
<b>CO5:</b>	-	-	2

### UNIT – I

#### **Review of Measurements and instrumentation:**

Review of Static characteristics of Instrument systems, dynamic characteristics of Instrument systems, Review of Op-Amp Circuit, passive-, and active-filters.

### UNIT – II

#### **Analog Signal Conditioning:**

Principles of analog signal conditioning, Signal-Level and Bias Changes, Linearization, Conversions, Filtering and Impedance Matching, Concept of Loading, **PASSIVE CIRCUITS:** Voltage Divider, Bridge Circuits, Bridge Resolution , Bridge Applications

### UNIT – III

#### **Digital Signal Conditioning:**

Review of Digital Electronics: Digital Information, Fractional Binary Numbers, Boolean Algebra, Digital Electronics Circuits: comparator, converter, Digital-to-Analog Converters (DACs), Analog-to-Digital Converters (ADCs) : Flash-, SAR, Dual Slope, Sensor-to-Frequency Conversion, Data-Acquisition Systems: Hardware and Software of Data Aquisition System (DAS) , Characteristics of digital data: Digitized Value, Sampled Data Systems, Linearization,

#### UNIT – IV

**Definition of Temperature:** Thermal Energy, absolute and relative Temperature, Metal resistance versus temperature devices: Resistance versus Temperature Approximations, Resistance-Temperature Detectors (RTD), Other thermal sensor: Bimetal Strips, Gas Thermometers, Vapor-Pressure Thermometers, Liquid-Expansion Thermometers, Solid-State Temperature Sensors, Design considerations

#### UNIT – V

**Optical Sensors:** Fundamentals of em radiation, Characteristics of Light, Photometry, photodetectors

#### Text Books:

1. Process Control Instrumentation Technology, 6th Edition, Author: Curtis D. Johnson, Publisher: Prentice Hall International Edition, ISBN Number- 0139382003
2. Measurement, Instrumentation, and Sensors Handbook, Author/Chief Editor: John G. Webster., Publisher: CRC – Press – Taylor and Francis Group, ISBN Number- 084932145X

#### Reference Books:

1. Introduction to Instrumentation and Measurement, 3rd Edition”, Authors: Robert B. Northrop, Publisher: CRC – Press – Taylor and Francis Group, ISBN Number- 1466596775

#### Web Links:

1. [https://onlinecourses.nptel.ac.in/noc21\\_ee32](https://onlinecourses.nptel.ac.in/noc21_ee32)
2. <https://www.colorado.edu/ecee/academics/online-programs/ms-ee-coursera/curriculum/embedded-systems/ecea-5340-sensor-and-sensor>

## ASIC DESIGN

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC19</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Illustrate VLSI tool-flow and appreciate FPGA architecture
- CO2:** Explain the issues involved in ASIC design flow
- CO3:** Summarize the algorithms used for ASIC construction.
- CO4:** Outline the basics of System on Chip & On-chip communication architectures
- CO5:** Identify high performance algorithms available for ASICs IC

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	-	3	-	-	-
<b>CO2:</b>	1	-	3	1	-	-
<b>CO3:</b>	2	-	2	3	-	-
<b>CO4:</b>	-	-	3	-	-	-
<b>CO5:</b>	1	-	3	1	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	2	-
<b>CO2:</b>	2	2	-
<b>CO3:</b>	2	2	-
<b>CO4:</b>	2	2	-
<b>CO5:</b>	2	2	-

### UNIT – I

Types of ASICs, VLSI Design flow, Programmable ASICs - Antifuse, SRAM, EPROM, EEPROM based ASICs. Programmable ASIC logic cells and I/O cells. Programmable interconnects. Latest Version - FPGAs and CPLDs and Soft-core processors.

### UNIT – II

**Trade off issues at System Level:** Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, System Partitioning, Power Dissipation, Partitioning Methods. Trade off issues at System Level: Optimization with regard to speed, area and power, asynchronous and low power system design. ASIC physical design issues, System Partitioning, Power Dissipation, Partitioning Methods.

### UNIT – III

ASIC floor planning, Placement and Routing.

**UNIT – IV**

System-On-Chip Design - SoC Design Flow, Platform-based and IP based SoC Designs, Basic Concepts of Bus-Based Communication Architectures, On-Chip Communication Architecture Standards, Low-Power SoC Design.

**UNIT – V**

High performance algorithms for ASICS/ SoCs as case studies – Canonic Signed Digit Arithmetic, KCM, Distributed Arithmetic, High performance digital filters for sigma-delta ADC, USB controllers, OMAP

**Text Books:**

1. M.J.S. Smith, "Application Specific Integrated Circuits", Pearson, ISBN Number- 9788177584080
2. H.Gerez, "Algorithms for VLSI Design Automation", John Wiley, ISBN Number- 0471984892

**Reference Books:**

1. J..M.Rabaey, A. Chandrakasan, and B.Nikolic, "Digital Integrated Circuit Design Perspective (2/e)", ISBN Number- 9385152343
2. D.A.Hodges, "Analysis and Design of Digital Integrated Circuits (3/e)", MGH, ISBN Number-0070291535

**Web Links:**

1. <https://www.ansys.com/en-in/simulation-topics/what-is-asic-design>
2. <https://www.arm.com/glossary/asic>

## DSP ALGORITHMS FOR VLSI

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC20</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Summarize the concepts of Digital Signal Processing
- CO2:** Illustrate the architectural features of Programmable digital signal processors.
- CO3:** Infer the TMS320C54XX processor architecture details, addressing modes and on-chip peripherals.
- CO4:** Develop algorithms using Instruction set of TMS320C54XX
- CO5:** Implement basic DSP algorithms for filters.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	1	-	2	-	-
<b>CO2:</b>	1	3	-	2	-	-
<b>CO3:</b>	1	2	-	3	-	-
<b>CO4:</b>	2	3	-	-	-	-
<b>CO5:</b>	1	2	-	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	1	1
<b>CO2:</b>	-	1	1
<b>CO3:</b>	-	1	1
<b>CO4:</b>	-	1	1
<b>CO5:</b>	-	1	1

### UNIT – I

**INTRODUCTION TO DIGITAL SIGNAL PROCESSING:** Introduction, A Digital Signal Processing System, The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear Time-Invariant Systems, Digital Filters, Decimation and Interpolation

### UNIT – II

**ARCHITECTURES FOR PROGRAMMABLE DIGITAL SIGNAL PROCESSORS:** Introduction, Basic Architectural Features, DSP Computational Building Blocks, Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Features for External Interfacing.

### UNIT – III

**PROGRAMMABLE DIGITAL SIGNAL PROCESSORS:** Introduction, Commercial digital Signal-processing Devices, Data Addressing Modes of TMS320C54xx., Memory Space of TMS320C54xx Processors, Program Control.

**UNIT – IV**

Detail Study of TMS320C54X & 54xx Instructions and Programming, On-Chip peripherals, Interrupts of TMS320C54XX Processors, Pipeline Operation of TMS320C54xx Processor.

**UNIT – V**

IMPLEMENTATION OF BASIC DSP ALGORITHMS: Introduction, The Q-notation, FIR Filters, IIR Filters, Interpolation and Decimation Filters (one example in each case).

**Text Books:**

1. Digital Signal Processing, Avatar Singh and S. Srinivasan, Thomson Learning, ISBN Number- 9788131500347
2. Digital Signal Processing: A practical approach, Ifeachor E. C., Jervis B. W Pearson Education, PHI, ISBN Number- 0201596199

**Reference Books:**

1. Digital Signal Processors, B Venkataramani and M Bhaskar TMH, ISBN Number- 9780070702561
2. Architectures for Digital Signal Processing, Peter Pirsch John Wiley, ISBN Number- 8126523034

**Web Links:**

1. [https://onlinecourses.nptel.ac.in/noc20\\_ee44/](https://onlinecourses.nptel.ac.in/noc20_ee44/)
2. <https://www.oreilly.com/library/view/vlsi-digital-signal/9780471241867/sec-1.2.html>

## VLSI ARCHITECTURES

	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Course Code: 2502EC21</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Discuss the basic architecture of VLSI
- CO2:** Analysing various algorithms of for VLSI architectures
- CO3:** Analyzing the optimized architectures
- CO4:** Interpret the clocking mechanism of VLSI architectures
- CO5:** Interpret the data processing of various VLSI architectures

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	1	-	2	-	-
<b>CO2:</b>	1	3	2	2	-	-
<b>CO3:</b>	1	2	-	3	-	-
<b>CO4:</b>	2	3	2	-	-	-
<b>CO5:</b>	1	2	1	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	2
<b>CO2:</b>	-	2	2
<b>CO3:</b>	-	2	2
<b>CO4:</b>	-	2	2
<b>CO5:</b>	-	2	2

### UNIT – I

**Introduction:** Review of VLSI Design flow. Goals of VLSI Design: Optimization of speed, power dissipation, cost and reliability.

### UNIT – II

**Algorithm to architecture transformation:** Architectural antipodes, transform approach to VLSI architectures, graph based formalism for describing processing algorithms, isomorphic architecture.

Equivalence transforms for combinational computations: Common assumptions, pipelining, replication, time sharing, associatively transform and other algebraic transforms.

### UNIT – III

**Architectural Synthesis and Optimization:** Circuit specifications for architectural synthesis, fundamental architectural synthesis problems, temporal domain-scheduling, spatial domain-binding, sequencing graphs, hierarchical models, synchronization problem, area and performance estimation, data path and control unit synthesis, constrained and unconstrained scheduling, scheduling of pipelined circuits.

#### UNIT – IV

**Clocking of synchronous circuits:** single-phase and two-phase clocking, wave pipelining, collective clock buffer design, distributed clock buffer trees, hybrid clock distribution networks and impact of clock distribution delay on I/O timing.

#### UNIT – V

**Asynchronous data processing architectures:** data consistency problem of vectored acquisition-plain bit parallel synchronization, unit distance coding, suppression of cross patterns, handshaking, partial handshaking, data consistency problem of scalar acquisition-synchronization at single place, synchronization at multiple places, synchronization from a slow clock, metastable synchronizer behavior.

#### Text Books:

1. Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication, Hubert Kaeslin, Cambridge University Press, ISBN Number- 0521882672
2. Synthesis and Optimization of Digital Circuits, Giovanni De Micheli, McGraw Hill, ISBN Number- 780070163331

#### Reference Books:

1. VLSI Array Processors, S.Y. Kung, Prentice Hall, ISBN Number- 013942749X
2. Clock generators for SoC processors: Circuits and Architectures, Kluwer Academic Publishers, ISBN Number- 1402080794

#### Web Links:

1. <https://archive.nptel.ac.in/courses/108/105/108105118/>
2. <http://cva.stanford.edu/publications/1999/arvlsi99.pdf>

## VLSI SOLID STATE CIRCUITS

**Course Code: 2502EC22**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Interpret important parameters governing the high speed performance of devices and circuits
- CO2:** Model the properties of hetero junctions from the energy band diagram point of view
- CO3:** Model the physics and operation and modeling of MESFETs
- CO4:** : Interpret the operation and performance parameters of HEMT, HBTs
- CO5:** Interpret the operation and performance of Optoelectronics Devices

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	-	1	-	2	-	-
<b>CO2:</b>	-	2	2	2	-	-
<b>CO3:</b>	-	2	-	3	-	-
<b>CO4:</b>	-	3	2	-	-	-
<b>CO5:</b>	-	2	1	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	-
<b>CO3:</b>	-	2	-
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	2	-

### UNIT – I

#### Basic Properties of Compound Semiconductors

Important parameters governing the high speed performance of devices and circuits: Transit time of charge carriers, junction capacitances, ON-resistances and their dependence on the device geometry and size, carrier mobility, doping concentration and temperature - Materials properties: Merits of III –V binary and ternary compound semiconductors (GaAs, InP, InGaAs, AlGaAs, SiC, GaN etc.), different SiC structures, silicon-germanium alloys and silicon carbide for high speed devices, as compared to silicon based devices - Band diagrams, homo and heterojunctions.

### UNIT – II

#### Metal Semiconductor related parameters and devices

Metal semiconductor contacts and Metal Insulator Semiconductor and MOS devices: Native oxides of Compound semiconductors for MOS devices and the interface state density related issues

### UNIT – III

**Metal semiconductor Field Effect Transistors (MESFETs):** Basic features, Pinch off voltage

and threshold voltage.

#### UNIT – IV

##### **HEMT, HBTs and Optoelectronics Devices**

High Electron Mobility Transistors (HEMT): The generic Modulation Doped FET (MODFET) structure for high electron mobility realization, Principle of operation and the unique features of HEMT. Hetero junction Bipolar transistors (HBTs)

#### UNIT – V

Principle of operation and the benefits of hetero junction BJT for high speed applications.

Optoelectronic Devices: Basic working principles and performance parameters of LED, Photodetectors and SolarCell.

#### **Text Books:**

1. B. J. Baliga, Gallium Nitride and Silicon Carbide Power Devices, World Scientific, ISBN Number- 9813109408
2. Sandip Tiwari, Compound Semiconductor Device Physics, Academic Press, ISBN Number- 012691740X

#### **Reference Books:**

1. Robert F. Pierret, Semiconductor Device Fundamentals, Addison-Wesley, ISBN Number- 0201543931
2. S. M. Sze, High-Speed Semiconductor Devices, Wiley, ISBN Number- 0471623075

#### **Web Links:**

1. <https://in.video.search.yahoo.com/search/video?fr=mcafee&p=VLSI+SOLID+STATE+CIRCUITS+NPTEL&type=E210IN826G91832#id=5&vid=00729441fd52c602f8aa240ce1358c68&action=click>
2. <https://ceat.okstate.edu/ece/research/ece-old-files/vlsi-solid-state.html>

## MACHINE LEARNING FOR VLSI DESIGN

**Course Code: 2502EC23**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Identify the goals, applications, types and design issues of machine learning techniques.
- CO2:** Analyse different machine learning algorithms.
- CO3:** Discuss the support vector machines and neural network models.
- CO4:** Demonstrate ensemble learning and clustering techniques.
- CO5:** Identifying various methods to incorporate in VLSI with machine learning

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	1	2	-	-	-
<b>CO2:</b>	1	1	2	-	-	-
<b>CO3:</b>	1	2	3	-	-	-
<b>CO4:</b>	1	2	3	-	-	-
<b>CO5:</b>	2	2	3	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	-	2	-
<b>CO2:</b>	-	2	-
<b>CO3:</b>	-	2	-
<b>CO4:</b>	-	2	-
<b>CO5:</b>	-	2	-

### UNIT – I

**Introduction:** Aims and applications of machine learning, learning systems, various aspects of developing a learning system, overfitting, underfitting, bias-variance tradeoff

### UNIT – II

**Instance based learning:** Instance based learning, Feature reduction, Collaborative filtering-based recommendation, Bayesian learning: Probability and Bayes learning, Linear regression, Decision trees,

### UNIT – III

**Logistic Regression:** Logistic Regression, Support Vector Machine, Kernel, Neural network: Perceptron, multilayer network, backpropagation, introduction to deep neural network

#### UNIT – IV

**Computational learning:** Computational learning theory, PAC learning model, Sample complexity, VC Dimension, Ensemble learning, Clustering: k-means, adaptive hierarchical clustering, Gaussian mixture model

#### UNIT – V

**Machine Learning in VLSI Design:** A Taxonomy for Machine Learning in VLSI Design, Machine Learning for Lithographic Process Models: Masks, and Physical Design, Yield Enhancements, Machine Learning based Aging Analysis, Machine Learning Hardware: Energy-Efficient Design of Advanced Machine Learning Hardware

#### Text Books:

1. Bishop, C. Pattern Recognition and Machine Learning. Berlin: Springer-Verlag, ISBN Number- 0241973376
2. Ethem Alpaydin, Introduction to Machine Learning, PHI, ISBN Number- 8120341600

#### Reference Books:

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning Data Mining, Inference, and Prediction, ISBN Number- 0387848576
2. Elfadel, Ibrahim M., Duane S. Boning, and Xin Li, eds. Machine Learning in VLSI Computer-Aided Design. Springer, ISBN Number- 3030046656

#### Web Links:

1. [https://onlinecourses.nptel.ac.in/noc21\\_cs24/](https://onlinecourses.nptel.ac.in/noc21_cs24/)
2. <https://chippedge.com/role-of-machine-learning-in-vlsi-design/>

## BASIC CONCRETE TECHNOLOGY

**Course Code: 2502CE30**

**L T P C**  
**3 0 0 3**

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO 1: Understand the chemical composition, hydration, and physical properties of Portland cement.
- CO 2: Evaluate the effects of mineral and chemical admixtures on concrete performance.
- CO 3: Classify and assess aggregates based on mechanical properties, grading, and thermal behavior.
- CO 4: Analyze workability and setting characteristics of fresh concrete, including relevant testing methods.
- CO 5: Design and proportion concrete mixes using BIS and ACI methods, ensuring quality control.

**Mapping of course Outcomes with Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	2	3	1	-	-	-
<b>CO2</b>	2	1	3	-	-	-
<b>CO3</b>	2	1	3	-	-	-
<b>CO4</b>	2	1	3	-	-	-
<b>CO5</b>	2	2	3	-	-	-

**Mapping of course outcomes with program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT – I**

**Cement:** Portland cement – chemical composition – Hydration, Setting of cement – Structure of hydrate cement – Test on physical properties – Different grades of cement.  
**Admixtures:** Types of admixtures – mineral and chemical admixtures.

## UNIT - II

**Aggregates:** Classification of aggregate – Particle shape & texture –, strength & other mechanical properties of aggregate – Specific gravity, Bulk density, porosity, adsorption & moisture content of aggregate – Bulking of sand – Deleterious substance in aggregate – Soundness of aggregate – Alkali aggregate reaction – Thermal properties – Sieve analysis – Fineness modulus – Grading curves – Grading of fine & coarse Aggregates – Gap graded aggregate – Maximum aggregate size.

## UNIT – III

**Fresh Concrete:** Workability – Factors affecting workability – Measurement of workability by different tests – Setting times of concrete – Effect of time and temperature on workability – Segregation & bleeding – Mixing and vibration of concrete – Steps in manufacture of concrete – Quality of mixing water.

## UNIT - IV

**Hardened Concrete :** Water / Cement ratio – Abram’s Law – Gelspaoe ratio – Nature of strength of concrete – Maturity concept – Strength in tension & compression – Factors affecting strength – Relation between compressive & tensile strength - Curing. Testing Of Hardened Concrete: Compression tests – Tension tests– Flexure tests – Splitting tests – Pull-out test, Non-destructive testing methods – codal provisions for NDT. Elasticity, Creep & Shrinkage – Modulus of elasticity – Dynamic modulus of elasticity – Poisson’s ratio – Creep of concrete – Factors influencing creep.

## UNIT – V

**Mix Design:** Factors in the choice of mix proportions – Durability of concrete – Quality Control of concrete – Statistical methods – Acceptance criteria – Proportioning of concrete mixes by IS codes mix design. Special Concretes: Introduction to light weight concrete – Cellular concrete

### Text Books:

1. Properties of Concrete by A. M. Neville Pearson 5th edition Education ltd. (ISBN: 9780273755807)
2. Concrete Technology by M. S. Shetty. – S. Chand & Co. (ISBN: 9788121900034)
3. Concrete Technology by Job Thomas -Cengage learning India Pvt Ltd.( ISBN: 9788131521099)

### Reference Books:

1. Concrete Technology by M.L. Gambhir. – Tata Mc. Graw Hill Publishers, New Delhi. (ISBN: 9780070141100)
2. Concrete: Microstructure, Properties and Materials – P. K. Mehta and J. M. Monteiro, McGraw Hill Publishers. (ISBN: 9780071797870)

### Web Links:

1. [www.Nptel.Ac.In/Courses/105102012/](http://www.Nptel.Ac.In/Courses/105102012/)
2. [www.archive.nptel.ac.in/noc/courses/noc15/SEM1/noc15-ce01](http://www.archive.nptel.ac.in/noc/courses/noc15/SEM1/noc15-ce01)
3. <https://archive.nptel.ac.in/courses/105/102/105102012/>

## REPAIR AND REHABILITATION OF STRUCTURES

**Course Code: 2502CE31**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

At the end of the Course, Student will be able to

- CO 1: Identify the causes of deterioration of concrete structures.
- CO 2: Illustrate the various materials for repair and rehabilitation techniques.
- CO 3: Construct the various strengthening and stabilization techniques.
- CO 4: Determine various repair techniques of damaged structures.
- CO 5: Evaluate the usage of different types of concretes and durability aspects.
- CO 6: Classify the usage of high performance concretes for repairing works.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	3	2	2	2	2	-
<b>CO2</b>	3	2	2	2	2	-
<b>CO3</b>	3	2	2	2	2	-
<b>CO4</b>	3	2	2	2	2	-
<b>CO5</b>	2	2	1	2	1	-

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

### UNIT-I

#### Materials for Repair and Rehabilitation:

Admixtures- types of admixtures- purposes of using admixtures- chemical composition- Natural admixtures- Fibers- wraps- Glass and Carbon fiber wraps- Steel Plates-Non destructive evaluation: Importance- Concrete behavior under corrosion, disintegrated mechanisms- moisture effects and thermal effects – Visual investigation- Acoustical emission methods-Corrosion activity measurement-chloridecontent– Depth of carbonation- Impact echo methods- Ultrasound pulse velocity methods- Pull out tests.

### UNIT-II

#### Strengthening and Stabilization:

Techniques- design considerations-Beam shear capacity strengthening- Shear Transfer strengthening-stress reduction techniques- Column strengthening-flexural strengthening-

Connection stabilization and strengthening, Crack stabilization.

### **UNIT-III**

#### **Bonded Installation Techniques:**

Externally bonded FRP- Wet layup sheet, bolted plate, near surface mounted FRP, fundamental debonding mechanisms-intermediate crack debonding- CDC debonding- plate end debonding- strengthening of floor of structures.

### **UNIT-IV**

#### **Fibre Reinforced Concrete:**

Properties of constituent materials- Mix proportions, mixing and casting methods-Mechanical properties of fibre reinforced concrete- applications of fibre reinforced concretes-Light weight concrete- properties of light weight concrete-No fines concrete-design of light weight concrete- Flyash concrete- Introduction- classification of flyash- properties and reaction mechanism of flyash- Properties of flyash concrete in fresh state and hardened state- Durability of flyash concretes.

### **UNIT-V**

#### **High Performance Concrete:**

Introduction- Development of high performance concretes-Materials of high performance concretes-Properties of high performance concretes - Self Consolidating concrete-properties- qualifications.

#### **Text Books:**

1. Concrete repair and maintenance illustrated-Peter Emmons, published by Brandon W. Emmons.(ISBN: 9780876291916)
2. Experimental Techniques and Instrumentation, Dr.M.Sreenivasa Reddy, Dr.S.Govindarajan and Dr.S.Pachaiappan, Charulatha Publications, 2022.

#### **Reference Books:**

1. Rehabilitation of Concrete Structures, Dr. B. Vidivelli, Standard Publishers Distributors. (ISBN: 978-8180140276)
2. Concrete technology, M S Shetty, S. Chand Publications.( ISBN: 9788121900034)
3. Concrete technology, Neville & Brooks, pearson education ltd.( ISBN: 9788131708384)

#### **Web Links:**

1. <http://nptel.ac.in/courses/112101095/38>
2. <http://www.nptel.ac.in/courses/105105041/module%206.pdf>
3. [https://www.youtube.com/watch?v=N4KrZ\\_DcZrE](https://www.youtube.com/watch?v=N4KrZ_DcZrE)

## NEURAL NETWORKS AND FUZZY LOGIC

**Course Code: 2502EE28**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO 1: Explain artificial neuron models.
- CO 2: Explain various learning methods of ANN.
- CO 3: Apply different algorithms of ANN.
- CO 4: Distinguish between Classical and Fuzzy Sets.
- CO 5: Apply application of fuzzy logic control to real time systems.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	3	-	1	1	-	-
<b>CO2</b>	3	-	1	1	-	-
<b>CO3</b>	3	-	1	1	-	-
<b>CO4</b>	3	-	1	1	-	-
<b>CO5</b>	3	-	1	1	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT-I: Introduction to Neural Networks**

Introduction, Humans and Computers, Organization of the Brain, Biological Neuron, Biological and Artificial Neuron Models, Hodgkin-Huxley Neuron Model, Integrate-and Fire Neuron Model, Spiking Neuron Model, Characteristics of ANN, McCulloch-Pitts Model, Applications of ANN.

**UNIT-II: Essentials of Artificial Neural Networks**

Artificial Neuron Model, Operations of Artificial Neuron, Types of Neuron Activation Function, ANN Architectures, Classification Taxonomy of ANN, Connectivity, Neural Dynamics (Activation and Synaptic), Learning Strategy (Supervised, Unsupervised, Reinforcement), Learning Rules, Types of Application.

**UNIT-III: Multilayer feed forward Neural Networks**

Credit Assignment Problem, Generalized Delta Rule, Derivation of Back propagation (BP) Training, Summary of Backpropagation Algorithm, Kolmogorov Theorem, Learning Difficulties and Improvements, Radial Basis Function (RBF) Neural Network – Kohonen Self Organising feature Map (KSOM).

**UNIT-IV: Classical & Fuzzy Sets**

Introduction to classical sets - properties, Operations and relations; Fuzzy sets, Membership, Uncertainty, Operations, properties, fuzzy relations, cardinalities, membership functions.

**UNIT-V: Fuzzy Logic Modules**

Fuzzification, Membership value assignment, development of rule base and decision making system, Defuzzification to crisp sets, Defuzzification methods.

**Text Books:**

1. Neural Networks, Fuzzy logic, Genetic algorithms: synthesis and applications by Rajasekharan and Rai – PHI Publication. (ISBN: 9788120353343)
2. Introduction to Neural Networks using MATLAB 6.0 - S.N.Sivanandam, S.Sumathi, S.N.Deepa, TMH. (ISBN: 9780070591127)

**Reference Books:**

1. Neural Networks, James A Freeman and Davis Skapura, Pearson Education. (ISBN: 9780201513769)
2. Fuzzy sets University and information, J.Klin and T.A.Folger, Prentice Hall. (ISBN: 9789353065782)
3. Introduction to artificial neural systems, J.M.Zurada, Jaico Publication house.( ISBN: 9780314933911)

**Web Links:**

1. <http://nptel.ac.in/courses/108104049/16>
2. [www.archive.nptel.ac.in/courses/127/105/127105006/](http://www.archive.nptel.ac.in/courses/127/105/127105006/)
3. [www.geeksforgeeks.org/fuzzy-logic-introduction/](http://www.geeksforgeeks.org/fuzzy-logic-introduction/)

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## HYBRID ELECTRIC VEHICLES

**Course Code: 2502EE29**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO 1: Analyze the architectures of HEVs with various components.
- CO 2: Illustrate the concept of Electric Vehicle and Hybrid Electric Vehicles.
- CO 3: Explain the Plan concept of Plug-in Electrical Vehicles.
- CO 4: Analyze the power electronics converters for HEVs.
- CO 5: Apply various energy storage technologies in Hybrid Vehicles.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	1	-	3	2	-	-
<b>CO2</b>	1	-	3	2	-	-
<b>CO3</b>	1	-	3	2	-	-
<b>CO4</b>	1	-	3	2	-	-
<b>CO5</b>	1	-	3	2	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT-I: Introduction**

Introduction to Electric Vehicles: History of electric vehicles, social and environmental importance of electric vehicles, impact of modern drive-trains on energy supplies- Challenges and Key Technologies of EVs – Challenges for EV Industry in India

**UNIT-II: Hybridization of Automobile**

Fundamentals of vehicle, components of conventional vehicle and propulsion load, Drive cycles and drive terrain, Concept of electric vehicle and hybrid electric vehicle, Plug-in hybrid vehicle, constituents of PHEV, comparison of HEV and PHEV; Fuel Cell vehicles and its constituents.

**UNIT-III: Plug-in Hybrid Electric Vehicle**

PHEVs and EREVs, PHEV Architectures, equivalent electric range of blended PHEVs, Fuel economy and power management of PHEVs, end-of-life battery for electric power grid support, vehicle to grid technology, battery charging.

**UNIT-IV: Power Electronics in HEVs**

Rectifiers and Buck converter used in HEVs, isolated and non-isolated bidirectional DC-DC converter, regenerative braking, voltage source inverter, current source inverter, PWM rectifier in HEVs, EV and PHEV battery chargers.

**UNIT-V: Battery and Storage Systems:**

Energy Storage Parameters; Lead–Acid Batteries; Ultra capacitors; Flywheels - Superconducting Magnetic Storage System; Pumped Hydroelectric Energy Storage; Compressed Air Energy Storage - Storage Heat; Energy Storage as an Economic Resource.

**Text Books:**

1. Advanced Electric Drive Vehicles, Ali Emadi, CRC Press.( ISBN: 9781138072855)
2. Electric and Hybrid Vehicles: Design Fundamentals, Iqbal Hussein, CRC Press. (ISBN: 9780367693930)

**Reference Books:**

1. Introduction to Hybrid Vehicle System Modeling and Control, Wei Liu, Wiley.( ISBN: 9788126556205)
2. Electric and Hybrid Vehicles Technologies, Modelling and Control: A Mechatronic Approach”, Amir Khajepour, Saber Fallahand Avesta Goodarzi, John Wiley & Sons Ltd. (ISBN: 9781118341513)

**Web Links:**

- 1 <https://archive.nptel.ac.in/courses/108/103/108103009/>
- 2 [https://ndl.iitkgp.ac.in/he\\_document/nptel/nptel/IN\\_N\\_1\\_E\\_E\\_12391\\_I\\_t\\_H\\_a\\_E\\_V\\_1402\\_4\\_D\\_o\\_H\\_E\\_v\\_14030\\_14031](https://ndl.iitkgp.ac.in/he_document/nptel/nptel/IN_N_1_E_E_12391_I_t_H_a_E_V_1402_4_D_o_H_E_v_14030_14031)

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## GREEN ENGINEERING SYSTEMS

**Course Code: 2502ME27**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes: At the end of the Course, Student will be able to:**

- CO1:** Distinguish the various solar energy collection methods and measuring instruments.
- CO2:** Explain the different methods of solar energy storage and their applications.
- CO3:** Illustrate the various types of wind mills and performance characteristics.
- CO4:** Explain the principle of Biomass production, Geothermal energy sources and Ocean thermal energy conversion
- CO5:** Illustrate the various types of electrical systems and mechanical systems.
- CO6:** Compare the various energy efficient process.

**Mapping of Course Outcomes with Program Outcomes:**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>
<b>CO1:</b>	2	1	1	1	-	-
<b>CO2:</b>	2	2	1	1	-	-
<b>CO3:</b>	2	2	2	1	-	-
<b>CO4:</b>	2	1	-	1	-	-
<b>CO5:</b>	2	1	-	1	-	-
<b>CO6:</b>	2	1	-	1	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

	<b>PSO1</b>	<b>PSO2</b>
<b>CO1:</b>	-	3
<b>CO2:</b>	-	3
<b>CO3:</b>	-	3
<b>CO4:</b>	-	3
<b>CO5:</b>	-	3

### UNIT – I

**Introduction:** Solar Radiation: Role and potential of new and renewable sources, the solar energy option, Environmental impact of solar power, structure of the sun, the solar constant, sun-earth relationships, coordinate systems of the sun, extraterrestrial and terrestrial solar radiation, solar radiation on titled surface, instruments for measuring solar radiation and sun shine, solar radiation data, numerical problems. Photo voltaic energy conversion – types of PV cells, I-V characteristics

**Solar Energy Collection:** Flat plate and concentrating collectors, classification of concentrating collectors, orientation and thermal analysis, advanced collectors.

## UNIT – II

**Solar Energy Storage and Applications:** Different methods, sensible, latent heat and stratified storage, solar ponds, solar applications- solar heating/cooling technique, solar distillation and drying, solar cookers, central power tower concept and solar chimney.

**Wind Energy:** Sources and potentials, horizontal and vertical axis windmills, performance characteristics, betz criteria, types of winds, wind data measurement.

## UNIT – III

**Bio-Mass:** Principles of bio-conversion, anaerobic/aerobic digestion, types of bio-gas digesters, gas yield, combustion characteristics of bio-gas, utilization for cooking, bio fuels, I.C. engine operation and economic aspects.

**Geothermal Energy:** Resources, types of wells, methods of harnessing the energy, potential in India.

**Ocean Energy:** OTEC, Principles of utilization, setting of OTEC plants, thermodynamic cycles. Tidal and wave energy: Potential and conversion techniques, mini-hydel power plants, and their economics.

## UNIT – IV

**Electrical Systems:** Energy efficient motors, energy efficient lighting and control, selection of luminaire, variable voltage variable frequency drives (adjustable speed drives), controls for HVAC (heating, ventilation and air conditioning), demand site management.

**Mechanical Systems:** Fuel cells- principle, thermodynamic aspects, selection of fuels & working of various types of fuel cells, Environmentally friendly and Energy efficient compressors and pumps.

## UNIT – V

**Energy Efficient Processes:** Environmental impact of the current manufacturing practices and systems, benefits of green manufacturing systems, selection of recyclable and environment friendly materials in manufacturing, design and implementation of efficient and sustainable green production systems with examples like environmentally friendly machining, vegetable based cutting fluids, alternate casting and joining techniques, zero waste manufacturing.

**Green Buildings:** Definition, features and benefits. Sustainable site selection and planning of building for maximum comfort. Environmentally friendly building materials like bamboo, timber, rammed earth, hollow blocks, lime & lime pozzolana cement, agro materials and industrial waste.

### Text Books:

- 1 Solar Energy – Principles of Thermal Collection and Storage/Sukhatme S.P. and J.K. Nayak/ TMH.
- 2 Non-Conventional Energy Resources/ Khan B.H/ Tata McGraw Hill, New Delhi,

### Reference Books:

- 1 Renewable Energy Technologies /Ramesh & Kumar /Narosa.
- 2 Renewable Energy Resources-2 Edition/ J. Twidell and T. Weir/ BSP Books Pvt. Ltd.

### Web Links:

- 1 [https://onlinecourses.nptel.ac.in/noc17\\_me33](https://onlinecourses.nptel.ac.in/noc17_me33)
- 2 <https://nptel.ac.in/courses/105107176/20>

## I.C.ENGINES

**Course Code: 2502ME28**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO1: Summarize the finite element methods
- CO2: Analyse one-dimensional problems in trusses and beams
- CO3: Solve structural problems using CST and axis - symmetric formulation
- CO4: Apply finite elements to higher order, Iso-parametric elements, and one-dimensional heat transfer analysis.
- CO5: Apply finite element methods to dynamic analysis.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1</b>	2	1	1	1	-	-
<b>CO2</b>	2	2	1	1	-	-
<b>CO3</b>	2	2	2	1	-	-
<b>CO4</b>	2	1	-	1	-	-
<b>CO5</b>	2	1	-	1	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT – I: Gas Exchange Processes**

Inlet and exhaust processes in the four stroke cycle volumetric efficiency quasi static effects combined quasi static and dynamic effects variation with speed and valve area and timing-flow through valves poppet valve geometry and timing flow rate and discharge efficient, residual gas fraction exhaust gas flow rate and temperature variation, scavenging in wnikelid engines, scavenging parameters and mdeluctual scavenging processes. Flow through parts supercharging and turbo changing methods of power buying abusive relationships compressors, turbines wave compression devices.

**UNIT – II: Charge Motion Within The Cylinder**

Intake Jet Flow, Mean velocity and turbulence characteristics definitions application to engine velocity data swirl swirl measurement, swirl generation during induction swit modification within the cylinder squish pre chamber engine flow crevice flows and blowby News nerated

by piston-cylinder wall interaction

### **UNIT – III: Combustion In S.I And C.I Engines**

Review of normal and abnormal combustion in SI and Ci engine cyclic variation in combustion of St engine analysis of cylindrical pressure data in SI and CI engine. EMP Flix SI engines common rail fuel injection system in Ci engines fuel spray behavior in CI engine

### **UNIT – IV: Electric Vehicles**

Introduction Limitations of IC Engines as prime mover. History of EV, components of EV. and AC electric machines: Introduction and basic structure, Electric vehicle drive train, advantages and limitations Permanent magnet and switched reluctance motors.

### **UNIT – V: Hybrid Vehicles**

Configurations of hybrid, Series and parallel, advantages and limitations, Hybrid drive trains, sizing of components Initial acceleration, rated vehicle velocity, Maximum velocity and maximum gradeability, Hydrogen: Production, Hydrogen storage systems, reformers.

**Fuel Cell Vehicles:** Introduction, Fuel cell characteristics, Thermodynamics of Fuel cells, Fuell cell types; emphasis on PEM fuel cell.

### **Text Books:**

- 1 Internal Combustion Engine Fundamentals, J.B. Heywood, Mc Graw Hill Co, (ISBN: 978-1259002076)
- 2 Build your own electric vehicle, Seth Leitman and Bob Brant. McGraw Hill, Co, 3 rd edition, (ISBN: 978-0071770569)

### **Reference Books:**

- 1 Engineering Fundamentals of IC Engine, H.N. Gupta, 2nd edition PHI Pvt. Ltd. (ISBN: 9788120346802)
- 2 PEM Fuel Cells-Theory and Practice, F. Barbir Elsevier Academic Press, (ISBN: 9780128102398)

### **Web Links:**

- 1 <http://nptel.ac.in/courses/112101097/>
- 2 [www.thermopedia.com/content/786](http://www.thermopedia.com/content/786)

## CAD TOOLS FOR VLSI DESIGN

**Course Code: 2502EC24**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO1: Comprehend the insight of CAD Tools in modern design.
- CO2: Develop combinational logic circuits by using CAD tools
- CO3: Build sequential logic circuits using Verilog HDL operators
- CO4: Analyze the performance of logic schematics using CAD simulation tools
- CO5: Infer the performance of logic circuits in terms of DRC, LVS and PEX.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	3	1	2	2	1
<b>CO2:</b>	2	3	1	2	1	2
<b>CO3:</b>	2	2	3	2	2	1
<b>CO4:</b>	2	3	1	2	2	1
<b>CO5:</b>	2	3	2	2	2	1

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	2	3	1
<b>CO2:</b>	2	3	1
<b>CO3:</b>	2	3	1
<b>CO4:</b>	2	3	1
<b>CO5:</b>	2	3	1

**UNIT – I**

Understanding the working platform with Xilinx Vivado and its device, family and package Selection. Design and Implementation of Combinational Circuits Priority Encoder and Comparator using data flow & structural style.

**UNIT – II**

Design and Implementation of Sequential Circuits to detect a given sequence using with and without overlapping (mealy & Moore machines). Design and Implementation of a traffic light controller in three road & four road junctions.

**UNIT – III**

Exercise on Concatenation, Replication operators, Reduction and Conditional operators in Verilog HDL. Performance characteristics of an n-channel and p-channel MOSFET.

#### **UNIT – IV**

Working with Schematic for Ring Oscillator with variable amounts of Pull up to pull down ratios. Design a full adder by instantiating the logic gates. Make a comment on design style on its performance.

#### **UNIT – V**

Design a NAND gate by using NMOS, PMOS and CMOS technologies and make a comment on its performance. Design a Schematic, stick and layout for given logic.

#### **Text Books:**

1. S. M. Kang and Y. Leblebici, CMOS Digital Integrated Circuits : Analysis and Design, Third Edition, MH, (ISBN Number-0072460539)
2. Plummer, Deal , Griffin “Silicon VLSI Technology: Fundamentals, Practice & Modeling”PH, (ISBN Number-0130850373)

#### **Reference Books:**

1. P. VanZant , “Microchip Fabrication”, 5th Edition, MH, (ISBN Number-6053901308)
2. R. J. Baker, H. W. Li and D. E. Boyce, CMOS Circuit Design, Layout and Simulation, PH, (ISBN Number-1119481511)

#### **Web Links:**

1. <https://themosisservice.com/university-support>
2. <https://youtu.be/OF3Zwfu6Ngc>
3. <https://newsroom.ibm.com/2021-05-06-IBM-Unveils-Worlds-First-2->

## FPGA DESIGN FOR EMBEDDED SYSTEMS

<b>Course Code: 2502EC25</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

### Course Outcomes:

At the end of the Course, Student will be able to:

- CO1:** Outline the concepts of Embedded System and Hardware Description Languages
- CO2:** Develop an embedded system using FPGA
- CO3:** Explain FPGA platforms and cross development tools.
- CO4:** Illustrate Parallelism and scheduling concepts
- CO5:** Interpret the parallelism with in FPGA hardware core.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6
<b>CO1:</b>	1	1	3	1	-	-
<b>CO2:</b>	3	-	2	-	-	-
<b>CO3:</b>	1	-	2	-	-	-
<b>CO4:</b>	1	-	2	-	-	-
<b>CO5:</b>	1	-	2	-	-	-

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2	PSO3
<b>CO1:</b>	1	2	-
<b>CO2:</b>	-	2	2
<b>CO3:</b>	-	2	2
<b>CO4:</b>	2	-	2
<b>CO5:</b>	2	-	2

### UNIT – I: Embedded System Overview & Hardware Description Languages

H/W-FPGA-Embedded SoC and use of VLSI circuit technology-platform FPGA's-Altera, Cyclone, Hardware Description Languages - VHDL , Verilog , Other High-Level HDLs, From HDL to Configuration Bit-stream

### UNIT – II: System Design using FPGA:

Principles of system design-Design quality, Modules and interfaces, Abstraction and state, Cohesion and coupling, Designing and Reuse, Control flow graph, Design-Origins of platform FPGA designs.

### UNIT – III: FPGA Platform

Components, adding to platform FPGA systems, assembling custom compute cores. Software Design-System Software Options, Root File system, Cross-Development Tools, Monitors and Boot-loader.

**UNIT – IV: Partitioning, Scheduling & Communication**

Overview of Partitioning Problem, Analytical Solution to Partitioning-Basic definitions, expected performance gain, resource considerations, Analytical Approach, Communication-Invocation/Coordination, Transfer of State, Practical Issues- Profiling Issues, Data Structures Manipulate Feature Size.

**UNIT – V: Spatial Design**

Principles of Parallelism-Identifying Parallelism - Spatial Parallelism with Platform FPGAs Parallelism within FPGA Hardware Cores, Parallelism within FPGA Designs

**Text Books:**

1. Embedded Systems Design with Platform FPGAs, Ron Sass, Andrew G Schmidt Principles and Practices, First Edition, Tata McGraw Hill, India, ISBN Number-0123743338
2. Digital Systems design using VHDL, Charles H Roth. Jr, Re-Print, PWS publishing company (Thomson Books), USA, ISBN Number-9788131518304

**Reference Books:**

1. Design with VHDL, V A. Padroni Circuit First Edition, MIT Press Cambridge, England, ISBN Number-0262162245
2. FPGA Based System Design, Wayne Wolf, First Edition, Prentices Hall Modern Semiconductor Design Series, USA, ISBN Number-0131424610

**Web Links:**

1. <https://www.coursera.org/learn/intro-fpga-design-embedded-systems>
2. <https://www.colorado.edu/ali/fpga-design-embedded-systems-specialization>

## ARTIFICIAL INTELLIGENCE

**Course Code: 2502AI30**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO 1: Describe fundamentals of Artificial Intelligence and its applications
- CO 2: Solve basic AI based problems and construct logical building blocks for problem Formulation
- CO 3: Apply various logical systems inferencing different logical problems.
- CO 4: Illustrate knowledge representation using predicate logic and predicate rules.
- CO 5: Design expert systems that leverage domain knowledge effectively.

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	2	1	-	-	1	-
<b>CO2</b>	2	1	2	-	1	-
<b>CO3</b>	2	1	2	2	1	2
<b>CO4</b>	2	1	2		1	-
<b>CO5</b>	2	1	-	-	1	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT – I: Introduction to Artificial Intelligence:**

Introduction, History, Intelligent Systems, Foundations of AI, Applications, Tic-Tac-Toe Game playing, Development of AI Languages, Current trends in AI

**UNIT – II: Problem Solving: State-Space Search And Control Strategies:**

Introduction, General Problem Solving, Characteristics of problem, Exhaustive Searches, Heuristic Search Techniques, Iterative- Deepening A\*, Constraint Satisfaction.

**Problem Reduction and Game Playing:** Problem Reduction, Game Playing, Minimax algorithm, Alpha- Beta Pruning, Two-player perfect information games.

### **UNIT – III: Logic Concepts**

Introduction, Propositional calculus, Proportional logic, Representing facts in logic, functions and predicates, Axiomatic System, Semantic Tableau System in Proportional logic, Resolution Refutation in proportional logic, predicate logic.

### **UNIT – IV: Knowledge Representation**

Knowledge Representation Using Predicate logic, Knowledge Representation using Semantic Network, Knowledge Representation using Frames.

**Representing Knowledge Using Rules:** Procedural Versus Declarative knowledge, Logic Programming, Forward versus Backward Reasoning

### **UNIT – V: Expert System**

Representing and using Domain Knowledge, Reasoning with knowledge, Expert System Shells, Support for explanation examples, Knowledge acquisition-examples.

### **Text Books:**

1. Artificial Intelligence- Saroj Kaushik, 1<sup>st</sup> edition CENGAGE Learning, (ISBN: 9789355730428).
2. Artificial intelligence, A modern Approach, Stuart Russel, Peter Norvig, Pearson Education Ltd, 2<sup>nd</sup> ed, ( ISBN: 97881203238)
3. Artificial Intelligence- Elaine Rich, Kevin Knight, Shivashankar B Nair, 3<sup>rd</sup> ed, McGraw Hill Education, (ISBN-13. 9780070087705)

### **Reference Books:**

1. Artificial intelligence structures and strategies for complex problem solving, George F Lugar, 5<sup>th</sup> Edition, Addison Wesley. ISBN-13: 978-0321263186

### **Web Links:**

1. [https://www.tutorialspoint.com/artificial\\_intelligence/index.htm/](https://www.tutorialspoint.com/artificial_intelligence/index.htm/)
2. [https://www.slideshare.net/slideshow/logic-in-ai/5005940//](https://www.slideshare.net/slideshow/logic-in-ai/5005940/)
3. <https://www.slideshare.net/slideshow/artificial-intelligence-3638681/3638681/>

## MACHINE LEARNING TECHNIQUES

**Course Code: 2502AI31**

**L T P C**  
**3 0 0 3**

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO1: Describe the need for AI and ML, and the types of ML algorithms.
- CO2: Apply regression techniques and dimensionality reduction methods.
- CO3: Implement and evaluate various classification techniques.
- CO4: Describe and implement Artificial Neural Networks.
- CO5: Utilize unsupervised learning methods for clustering and dimensionality reduction

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	2	1	-	-	-	-
<b>CO2</b>	2	1	2	-	-	-
<b>CO3</b>	2	1	2	2	-	2
<b>CO4</b>	2	1	2	-	-	-
<b>CO5</b>	2	1	-	-	-	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT – I**

**Introduction:** Understanding the need for AI and Machine Learning (ML), AI & Data, Types of ML Algorithms: Supervised, Unsupervised Learning and semi supervised learning, reinforcement learning, evolutionary computation ML Model development life cycle Deep Learning for Human Like Learning

**UNIT – II**

**Regression Techniques:** Regression for prediction, Gradient Descent and Ascent, Learning with Momentum, Loss Functions, Over fitting and under fitting, Model evaluation techniques  
Types of Regression: Linear Regression,

### **UNIT – III**

**Classification Techniques:** Naïve Bayes Classification: Bayesian Learning, Naïve Bayes Classification, MAP, Bayesian Belief Networks, Decision Tree, K-Nearest Neighbors Support Vector Machines: Hard Margin and Soft Margin, Kernels and Kernel Trick, Evaluation Measures for Classification Techniques

### **UNIT – IV**

**Classification Techniques:** Naïve Bayes Classification: Bayesian Learning, Naïve Bayes Classification, MAP, Bayesian Belief Networks Decision Tree K-Nearest Neighbors Support Vector Machines: Hard Margin and Soft Margin, Kernels and Kernel Trick, Evaluation Measures for Classification Techniques

### **UNIT – V**

**Unsupervised Learning:** Uses in Clustering, associations and dimensionality reduction Clustering, Hierarchical Agglomerative Clustering, k-means Algorithm

#### **Text Books:**

- 1 Machine Learning, Tom Mitchell, McGraw-Hill international editions, TMH, (ISBN: 0071154671)
- 2 Pattern Recognition and Machine Learning C. Bishop, Springer, (ISBN: 9781493938438)
- 3 Elements of Artificial Neural Networks , Kishan Mehrotra, Chilukuri Mohan and Sanjay Ranka, Penram International, (ISBN: 9780262133289).

#### **Reference Books:**

- 1 Pattern Recognition, Techniques and Applications , Rajjan Shinghal, OXFORD Higher Education , (ISBN:9780195676853)
- 2 Andrew Kelleher, Adam Kelleher, Applied Machine Learning for Data Scientist and Software engineers, Addison-Wesley Professional, (ISBN:9780134116549)

#### **Web Links:**

- 1 [https://onlinecourses.nptel.ac.in/noc21\\_cs24/preview/](https://onlinecourses.nptel.ac.in/noc21_cs24/preview/)
- 2 <https://www.udemy.com/course/machinelearning/>

## VALUE EDUCATION

**Course Code: 2502CE32**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
2	0	0	0

### Course Outcomes:

At the end of the Course, Student will be able to:

- CO 1: Understand value of education and self- development.
- CO 2: Explain the need of good values in students.
- CO 3: Developing the overall personality.
- CO 4: Explain the need of character in a student.

### Mapping of Course Outcomes with Program Outcomes:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	2	1	-	-	2	-
<b>CO2</b>	3	2	1	1	3	-
<b>CO3</b>	3	3	2	2	2	-
<b>CO4</b>	2	1	1	1	2	-
<b>CO5</b>	3	2	2	2	2	-

### Mapping of Course Outcomes with Program Specific Outcomes:

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

### UNIT – I

Values and self-development –Social values and individual attitudes. Work ethics, Indian vision of humanism, Moral and non- moral valuation. Standards and principles, Value judgements.

### UNIT – II

Importance of cultivation of values, Sense of duty, Devotion, Self-reliance, Confidence, Concentration. Truthfulness, Cleanliness, Honesty, Humanity. Power of faith, National Unity, Patriotism. Love for nature, Discipline

### UNIT – III

Personality and Behavior Development - Soul and Scientific attitude. Positive Thinking. Integrity and discipline, Punctuality, Love and Kindness, Avoid fault Thinking, Free from anger, Dignity of labour, Universal brotherhood and religious tolerance, True friendship.

**UNIT – IV**

Happiness Vs suffering, love for truth, Aware of self- destructive habits, Association and Cooperation, Doing best for saving nature.

**UNIT – V**

Character and Competence –Holy books vs Blind faith, Self-management and Good health, Science of reincarnation, Equality, Nonviolence, Humility, Role of Women, All religions and same message, Mind your Mind, Self-control, Honesty, Studying effectively.

**Text Books:**

1. Chakraborty, S.K. “Values and Ethics for organizations Theory and practice”, Oxford University Press, New Delhi. (ISBN: 9780195643077)

**Reference Books:**

1. Value Education and Professional Ethics by R.P. Shukla, **ISBN: 978-8183560995**
2. Value Education: A Textbook for Schools by Dr. N. Venkataiah, **ISBN: 978-8120731965**
3. Value Education: Theory and Practice by G. Rajagopal, **ISBN: 978-8182475191**

**Web Links:**

1. <https://nptel.ac.in/courses/109/104/109104068/>
2. <https://nptel.ac.in/courses/109/105/109105116/>
3. <https://nptel.ac.in/courses/109/104/109104107/>

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## RESEARCH METHODOLOGY

**Course Code: 2502CE33**

<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
2	0	0	0

**Course Outcomes:**

At the end of the Course, Student will be able to:

- CO 1: Explain the characteristics and process of research.
- CO 2: Choose the research problem by applying problem identification techniques.
- CO 3: Develop and execute research design process.
- CO 4: Show the results of research process adhering to professional ethics.
- CO 5: Analyze the results of research using statistical measures of central tendency & coefficient of variation, correlation and regression

**Mapping of Course Outcomes with Program Outcomes:**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6
<b>CO1</b>	2	1	-	-	2	-
<b>CO2</b>	3	2	1	1	3	-
<b>CO3</b>	3	3	2	2	2	-
<b>CO4</b>	2	1	1	1	2	-
<b>CO5</b>	3	2	2	2	2	-

**Mapping of Course Outcomes with Program Specific Outcomes:**

CO/PSO	PSO1	PSO2
<b>CO1</b>	-	-
<b>CO2</b>	-	-
<b>CO3</b>	-	-
<b>CO4</b>	-	-
<b>CO5</b>	-	-

**UNIT – I: Meaning of Research**

Function of Research - Characteristics of Research – Steps involved in Research – Research in Pure and Applied Sciences - Inter Disciplinary Research. Factors which hinder Research –Significance of Research - Research and scientific methods – Research Process– Criteria of good Research – Problems encountered by Researchers – Literature review.

**UNIT – II: Identification of Research Problem**

Selecting the Research problem – Necessity of defining the problem – Goals and Criteria for identifying problems for research. Perception of Research problem – Techniques involved in defining the problem.

**UNIT – III: Research Design**

Formulation of Research design – Need for Research design – Features of a good design – Important concepts related to Research design.

**UNIT – IV: Interpretation and Report Writing**

Meaning and Technique of interpretation – Precautions in interpretation, Significance of report writing – Different steps in writing a report – Layout of a Research report.

**UNIT – V: Statistical Techniques and Tools**

Introduction of statistics – Functions – Limitations – Measures of central tendency - Arithmetic mean – Median – Mode – Standard deviation – Co-efficient of variation (Discrete serious and continuous serious) – Correlation – Regression.

**Text Books:**

1. Research Methodology Methods & Techniques, C.R. Kothari – New Age international Publishers (ISBN: 9789386649225).
2. A Hand Book of Methodology of Research, Rajammall, P. Devadoss and K. Kulandaivel, RMMVidyalaya press.(ISBN: 9780367135720)

**Reference Books:**

1. Thesis and Assignment Writing, J. Anderson, Wiley Eastern Ltd.( ISBN: 9780471339274)
2. Research Methodology, Mukul Gupta, Deepa Gupta – PHI Learning Private Ltd., New Delhi. (ISBN: 9788120343818)
3. Fundamentals of Mathematical statistics, S.C. Gupta and V.K. Kapoor, Sultan Chand & Sons, New Delhi.( ISBN: 9788180545283)

**Web Links:**

1. <https://nptel.ac.in/courses/127106227>
2. <https://www.coursera.org/learn/research-methodologies>