Syllabus: ***M. Tech. in VLSI Design and Microelectronics Technology***

Semester - I					
Course Code	**Subject**	**Scheme / Mode**			**Credits**
		L	**T**	**P**	
RCC- PCT-MVLSI-101	Digital VLSI Circuits and Systems	3	0	0	3
RCC-PCT-MVLSI-102	Microelectronics Technology	3	0	0	3
RCC-PET-MVLSI-101A/B	VLSI Architecture Quantum Computing	3	0	0	3
RCC-PET-MVLSI-102A/B	Advanced DSP and System Design RFIC and MEMS	3	0	0	3
RCC-PROJ-MVLSI-181	Research Methodology and IPR	2	0	0	2
RCC-AU-MVLSI-181	Techniques and Languages for Research Paper Writing	2	0	0	0
RCC-PCL-MVLSI-191	Digital VLSI Design Lab	0	0	4	2
RCC-PCL-MVLSI-192	Microelectronics Technology Lab	0	0	4	2
Total Credit		**18**			

Semester - II					
Course Code	**Subject**	**Scheme / Mode**			**Credits**
		L	**T**	**P**	
RCC-PCT-MVLSI-201	Analog VLSI Design	3	0	0	3
RCC-PCT-MVLSI-202	Quantum and Nano Device	3	0	0	3
RCC-PET-MVLSI-201A/B	Embedded System CAD Tools for VLSI Design	3	0	0	3
RCC-PET-MVLSI-202A/B	Testing and Verification in VLSI Systems Silicon Photonics	3	0	0	3
RCC-AU-MVLSI-281	Pedagogical Practices for Teaching	2	0	0	0
RCC-PCL-MVLSI-291	Analog VLSI Design Lab	0	0	4	2
RCC-PEL-MVLSI-291A/B	Embedded System Lab CAD Tools for VLSI Design Lab	0	0	4	2
RCC-PROJ-MVLSI-281	Term Paper leading to Dissertation	0	0	4	2
Total Credit					**18**

<table>
<tr><th colspan="6">Semester - III</th></tr>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Subject</th><th colspan="3">Scheme / Mode</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>T</th><th>P</th></tr>
<tr><td>RCC-PCT-MVLSI-301</td><td>Physical VLSI Design</td><td>3</td><td>0</td><td>0</td><td>3</td></tr>
<tr><td rowspan="2">RCC-PET-MVLSI-301A/B</td><td>IoT and Edge Computing</td><td rowspan="2">3</td><td rowspan="2">0</td><td rowspan="2">0</td><td rowspan="2">3</td></tr>
<tr><td>Mixed Signal Circuit Design</td></tr>
<tr><td rowspan="3">RCC-OET-MVLSI-301A/B</td><td>Machine Learning Applications</td><td rowspan="3">3</td><td rowspan="3">0</td><td rowspan="3">0</td><td rowspan="3">3</td></tr>
<tr><td>Algorithms for VLSI Design</td></tr>
<tr><td>Sustainable Development Goals</td></tr>
<tr><td>RCC-PROJ-MVLSI-381</td><td>Industrial Training/Internship</td><td>0</td><td>0</td><td>4</td><td>2</td></tr>
<tr><td>RCC-PROJ-MVLSI-382</td><td>Dissertation-I</td><td>0</td><td>0</td><td>10</td><td>5</td></tr>
<tr><td colspan="2">Total Credit</td><td colspan="4">16</td></tr>
</table>

<table>
<tr><th colspan="6">Semester-IV</th></tr>
<tr><th rowspan="2">Course Code</th><th rowspan="2">Subject</th><th colspan="3">Scheme / Mode</th><th rowspan="2">Credits</th></tr>
<tr><th>L</th><th>T</th><th>P</th></tr>
<tr><td>RCC-PROJ-MVLSI-481</td><td>Dissertation-II</td><td>0</td><td>0</td><td>20</td><td>10</td></tr>
<tr><td>RCC-PROJ-MVLSI-482</td><td>Defense of Dissertation</td><td>0</td><td>0</td><td>12</td><td>6</td></tr>
<tr><td colspan="2">Total Credit</td><td colspan="4">16</td></tr>
</table>

Course Name	Digital VLSI Circuits and Systems	**Course Code**	RCC-PCT-MVLSI-101
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	3:0:0	**Total Hours**	36Hrs

Course Pre-requisite:

- Digital Electronics
- Microelectronics and Semiconductor Devices
- Introduction to VLSI Design
- Hardware Description Language (VHDL/Verilog)

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PCT-MVLSI-101.CO1	Recognize the fundamentals of VLSI design and its importance in the electronics industry.	Remembering
RCC-PCT-MVLSI-101.CO2	Design digital circuits using various design methodologies.	Creating
RCC-PCT-MVLSI-101.CO3	Apply optimization techniques for power, speed, and area efficiency in digital VLSI circuits.	Applying
RCC-PCT-MVLSI-101.CO4	Implement digital VLSI circuits using hardware description languages (HDLs).	Applying
RCC-PCT-MVLSI-101.CO5	Evaluate the performance of VLSI circuits through simulation and testing.	Evaluating
RCC-PCT-MVLSI-101.CO6	Analyze advanced trends and technologies in VLSI systems.	Analyzing

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	**Introduction to VLSI Design** • VLSI Design Flow • Design Abstraction Levels: Behavioral, Structural, Physical • Fabrication Process and Technology Scaling • Design Metrics: Power, Speed, Area, and Reliability	6LHrs	CO1
2	**CMOS Technology** • CMOS Transistor Theory: nMOS and pMOS Transistors • CMOS Logic Design: Inverters, Logic Gates	6LHrs	CO2

	• Static and Dynamic Behavior of CMOS Circuits • CMOS Fabrication and Layout Design Rules		
3	**Combinational and Sequential Circuit Design** • Design of Combinational Circuits: Adders, Subtractors, Multipliers • Design of Sequential Circuits: Flip-Flops, Latches, Registers, Counters • Timing Analysis and Clocking Strategies • Low Power Design Techniques in CMOS	7LHrs	CO2, CO3
4	**VLSI Design Methodologies** • Design Methodologies: Full-Custom, Semi-Custom, and FPGA-Based Design • Design for Testability (DFT) • Design Verification and Validation	6LHrs	CO3, CO5
5	**Advanced VLSI Topics** • Interconnects and Signal Integrity Issues • Power Dissipation and Management • Introduction to Analog and Mixed-Signal VLSI Design • Emerging Trends: 3D ICs, FinFETs, Quantum Computing	5LHrs.	CO6
6	**Electronic Design Automation (EDA) for Digital VLSI Design** • Overview of EDA Tools: Simulation, Synthesis, and Timing Analysis • Logic Synthesis • Physical Synthesis • Case Studies on EDA Flow for Digital VLSI RCC-PROJ-ects	6LHrs.	CO4, CO5, CO6

Text Books:

1. Kang, S. M., & Leblebici, Y. (2003). CMOS Digital Integrated Circuits: Analysis and Design. McGraw-Hill Education.
2. Weste, N., & Harris, D. (2010). CMOS VLSI Design: A Circuits and Systems Perspective. Addison-Wesley.

Reference Books:

1. Rabaey, J. M., Chandrakasan, A., & Nikolic, B. (2002). Digital Integrated Circuits: A Design Perspective. Prentice Hall.
2. Sutherland, I., Sproull, R. F., & Harris, D. (1999). Logical Effort: Designing Fast CMOS Circuits. Morgan Kaufmann.
3. Smith, M. J. S. (1997). Application-Specific Integrated Circuits. Addison-Wesley.
4. Veendrick, H. J. M. (2017). Nanometer CMOS ICs: From Basics to ASICs. Springer.

Course Name	**Microelectronics Technology**	**Course Code**	RCC- PCT-MVLSI-102
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	3-0-0	**Total Hours**	36

Course Pre-requisite:

- CMOS VLSI
- Basic Device physics

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PCT-MVLSI-102.CO1	**Identify** the material properties, crystalline structure of Silicon , different crystal growth techniques	Remembering
RCC-PCT-MVLSI-102.CO2	**Associate** the kinetics of Silicon dioxide growth for thick, thin and ultra-thin films and oxidation modelling	Understanding
RCC-PCT-MVLSI-102.CO3	**Illustrate** the Deposition techniques, Importance of High K and Low K dielectrics	Applying
RCC-PCT-MVLSI-102.CO4	**Articulate** the techniques for introducing dopants into the bulk material, comparison of diffusion	Applying
RCC-PCT-MVLSI-102.CO5	**Correlate** the Etching, Photolithography	Analyzing
RCC-PCT-MVLSI-102.CO6	**Review** the Metallization, ion implantation modelling methods	Analyzing

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	**Microelectronics Technology Overview:** Crystal Growth and Wafer Preparation, Electronic grade Silicon, Czochralski Crystal Growing -Crystal Structure, Float-zone method, Silicon Shaping -Shaping operations and Processing Consideration. Wafer cleaning	8L	CO1
2	**Epitaxy and Oxidation:** Vapour Phase Epitaxy- Basic Transport Processes and Reaction Kinetics, Doping and Autodoping,Buried Layers, Epitaxial Defects, Microscopic Growth Process, CVD Methods and Molecular Beam Epitaxy. Growth Mechanism and Kinetics- Thin Oxides, Oxidation Techniques and Systems and Oxidation induced defects	6L	.CO2
3	**Lithography & Etching :**Optical lithography, Electron lithography, X-Ray lithography and Ion lithography ,Plasma	8L	CO5

	Properties, Feature size control and Anisotropic Etch mechanism, other properties of Etchprocesses, Reactive Plasma Etch techniques and equipment and specific Etch processes.		
4	**Deposition:**Di-electric & Polysilicon Film deposition, Polysilicon deposition, Silicon dioxide deposition, Silicon nitrite deposition and Plasma assisted depositions.	4L	CO3
5	**Diffusion-** Fick's one-dimensional diffusion equation, Atomic diffusion mechanism,Diffusivities of B, P, As and Sb.	5L	CO4
6	**Ion Implantation and Mettalization**: Ion Implantation, Range Theory, Implantation equipment, Annealing, Shallow junctions and High Energy Implantations. Metallization application and choices.	5L	CO6

Text Books:

1. T1: Semiconductor devices physics and technology, Author: S.M. Sze, M. K. Lee, John Wiley & Sons Inc,3rd edition
2. T2: VLSI Technology, Author: SZE S.M.2nd Edition, McGraw Hill / Asia
3. T3: Silicon VLSI Technology: Fundamentals, Practice and Modelling: James D. Plummer Michael D. Deal, Peter B. Griffin,1st edition, Pearson India

Reference Books:

1. R1: The science and engineering of microelectronics: Stephen Cambell, Oxford University Press

Course Name	VLSI Architecture	**Course Code**	RCC-PET-MVLSI-101A
Semester	1^{st}	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P `	3:0:0	**Total Hours**	36

Course Pre-requisite: Fundamentals of VLSI Design & Computer Architecture

Course Outcome (CO):

CO Number	**Statement**	**Knowledge Level**
RCC-PET-MVLSI-101A.CO1	Investigating different VLSI Processes and Methodologies	Analyzing
RCC-PET-MVLSI-101A.CO2	Explain pipeline architecture for different processors for multi-cycle operations	Understanding
RCC-PET-MVLSI-101A.CO3	Synthesize system-level design	Evaluating
RCC-PET-MVLSI-101A.CO4	Design Complex Digital Systems	Creating
RCC-PET-MVLSI-101A.CO5	Compare different VLSI based Architecture / Systems	Evaluating
RCC-PET-MVLSI-101A.CO6	Analyze different VLSI based Architecture / Systems	Analyzing

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	**Introduction to VLSI:** Overview of VLSI Design, Historical Development and Future Trends in VLSI, Design Hierarchy: System-Level, RTL, Gate-Level, and Layout **VLSI Design Methodologies :** Design Flow and Tools (CAD tools overview) , Top-Down vs. Bottom-Up Design Approaches, Hardware Description Languages: VHDL and Verilog System Verilog: Assertions and Test benches.	4	CO1
2	**Digital Circuit Design:** Combinational and Sequential Circuit Design Optimization Techniques (Area, Power, Speed) Power Dissipation: Dynamic vs. Static Power; Low-Power Design Techniques.	2	CO4
3	**VLSI Architecture:** Basics of Digital Processor Architecture Memory Hierarchy: Types of Memory, Cache Design , Pipelining Techniques and their Impact on Performance	5	CO2

	Architecture Design for FPGAs and ASICs **Digital Signal Processing Using Array Architectures:** Systolic and wave-front arrays, mapping dependence and signal flow graphs to systolic and wave-front arrays, Asynchronous communication protocols for wave-front arrays.		
4	**Advanced Topics in VLSI Design:** System on Chip (SoC) Design Principles , 3D IC Design and Technology , Emerging Technologies: MEMS, Quantum VLSI Hardware-Software Co-Design **Advanced Asynchronous Systems** : Integration of asynchronous architectures in low-power designs. Real-world applications of asynchronous data processing in high-speed communication Systems. **Systolic Arrays and AI Architectures** : Application of systolic arrays in AI, ML accelerators, and real-time processing. Deep dive into mapping AI workloads to array processors for enhanced parallelism.	7	CO5
5	**Verification, Testing, Low power Design, ASIC etc:** Verification Methodologies (UVM, formal methods) Testing Strategies for VLSI Circuits DFT (Design for Testability) Techniques; Yield and Reliability Considerations in VLSI Design **Design for Testability:** Testing Fundamentals Fault models and testing techniques , Design for Testability (DFT) concepts , Scan and BIST Techniques; Scan chains, boundary scan, built-in self-test (BIST) **Low Power VLSI Design :** Power Consumption in VLSI; Dynamic and static power dissipation; Techniques for power reduction: Clock gating, dynamic voltage scaling Energy-efficient Architectures Techniques for optimizing performance vs. power trade-offs **Advanced Topics in VLSI:** FPGA and ASIC Design; Overview of FPGA architecture and	9	CO6

	Programming; ASIC design flow and methodologies Emerging Trends; 3D ICs, heterogeneous integration, and quantum computing implications **Current Trends and Research Directions** : AI and Machine Learning in VLSI Design; Neuromorphic Computing Architectures; Security in Hardware Design , Industry Trends and Future Directions		
6	**CORDIC Based Architectures:** Introduction, CORDIC algorithm for hardware implementation, hardware mapping, time-shared architecture, C-slow time shared architecture, modified CORDIC algorithm, recording of binary representation as ±1, Hardware optimization, optimal hardware designs for CORDIC. **Emerging Topics in Digital Communication and VLSI:** Integration of VLSI with 5G and IoT systems. Quantum VLSI architectures: Current research and future trends. Digital Design of Communication Systems: Top-level design options: bus-based design, point-to-point design, network-based design, hybrid connectivity, point-point KPN-based top-level design, KPN with shared bus and DMA controller, network-on-chip (NoC) top- level design, design of a router for NoC, run-time configuration, NoC for software defined radio.	9	CO5

Text Books:

1. "CMOS VLSI Design: A Circuits and Systems Perspective" by Neil H. E. Weste and David Harris
2. H. Kaeslin, *Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication*, 2nd Ed. - G. Micheli, *Synthesis and Optimization of Digital Circuits*, McGraw Hill.
3. Hubert Kaeslin, “Digital Integrated Circuit Design: From VLSI Architectures to CMOS Fabrication”, Cambridge University Press (2009).
4. Giovanni De Micheli, “Synthesis and Optimization of Digital Circuits”, McGraw Hill (2012).
5. John L. Hennessey and David A. Patterson, “Computer Architecture: A Quantitative Approach”, 3rd Edition, Morgan Kaufmann, 2003

Reference Books:

1. M. Bayoumi, *VLSI Design for Digital Signal Processing*, Springer (2018).
2. D. Flynn, *ARM System Architecture*, Addison-Wesley (2018).
3. Magdy A. Bayoumi, “VLSI Design Methodologies for Digital Signal Processing Architectures”, Springer (2012)

Course Name	**Quantum Computing**	**Course Code**	RCC-PET-MVLSI-101B
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	3-0-0	**Total Hours**	30

Course Pre-requisite:

- CMOS VLSI
- Basic Device physics

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PET-MVLSI-101B.CO1	**Illustrate** quantum entanglement by temporal cohesion by violating Bell's state	Understanding
RCC-PET-MVLSI-101B.CO2	**Infer** problems with higher speed and accuracy incorporating the concepts of superposition, interference, and entanglement	Applying
RCC-PET-MVLSI-101B.CO3	**Design** quantum logic gates for processing of quantum information in quantum circuits	Applying
RCC-PET-MVLSI-101B.CO4	**Interpret** quantum algorithms for storing and manipulating quantum information	Applying
RCC-PET-MVLSI-101B.CO5	**Execute** algorithms of higher complexity for reducing noise in quantum channels and processors	Applying
RCC-PET-MVLSI-101B.CO6	**Inspect** transfer of quantum information by employing entangled states without suffering thermal decoherence	Analyzing

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	Differences between classical and quantum mechanics; Coherence; Joint probability function; Temporal correlations	4L	CO1
2	Qubits and multi-qubits states; Bra-ket notation; Bloch Sphere representation; Quantum Superposition; Quantum Entanglement; Bell state	6L	CO2
3	Quantum Logic gates and Circuit: Pauli, Hadamard, Phase shift, Controlled gates, Deutsch, Swap	6L	CO3

4	Quantum Algorithms: Oracles, Deutsch's Algorithm, Deutsch -Jozsa Algorithm, Grover's algorithm, Shor's algorithm	6L	CO4
5	Quantum Error Correction; Decoding problem; Fault tolerance: Encoded computations, Threshold theorem	3L	CO5
6	Entanglement Verification; Quantum Cryptography; Quantum Information Theory; Quantum Teleportation	5L	CO6

Text Books:

1. M. A. Nielsen, I. L. Chuang, "Quantum Computation and Quantum Information", Cambridge University Press, 10th d., 2010
2. M. Mosca, P. Kaye, R. Laflamme, "An Introduction to Quantum Computing", Oxford University Press, 1st d., 2006

Reference Books:

1. D. McMahon, "Quantum Computing Explained", Wiley-IEEE Computer Society, 1st d., 2008

Web Resources

1. https://nptel.ac.in/courses/106106232

Course Name	Advanced DSP and System Design	**Course Code**	RCC-PET-MVLSI-102A
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	3:0:0	**Total Hours**	30Hrs

Course Pre-requisite:

- Undergraduate level Signals and Systems
- Undergraduate level DSP

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PET-MVLSI-102A.CO1	**Explain** theory of different filters and algorithms	Remembering
RCC-PET-MVLSI-102A.CO2	**Illustrate** theory of multi rate DSP	Remembering
RCC-PET-MVLSI-102A.CO3	**Aanalyze** the Effects of finite word length effect in Filters	Analyzing
RCC-PET-MVLSI-102A.CO4	**Articulate** Different DSP sytems in HW blocks	Applying
RCC-PET-MVLSI-102A.CO5	**Design** the ideas of different DSP system realization	Creating
RCC-PET-MVLSI-102A.CO6	**Interpret** the applications of DSP	Understanding

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	**Digital filters** • FIR filter design techniques • Window-based design methods, Frequency sampling method, • signal processing using FIR filter, • IIR fiter design, • discrete time IIR system design. Filter realization.	5LHrs	CO1
2	**Multirate signal processing** • down sampling, antialiasing filter, • upsampling, anti-imaging filter, • sampling rate conversion.	5LHrs	CO2
3	**finite word length effect** • Number representation, quantization	5LHrs	CO3

	• fixed and floating point number, • coefficient quantization error, • coefficient sensitivity analysis of second order system, analysis of coefficient quantization effect in FIR filters.		
4	DSP architecture • FPGA architecture, • ARM architecture • CORDIC algorithm • system realization using FPGA/ARM • sampling of continuous time signal, • implementation of linear convolution and circular convolution, • FIR filter , IIR filter	5LHrs	CO4
5	**Time series analysis** • AR, MA, ARMA, and • ARIMA model.	5LHrs.	CO5
6		5LHrs.	CO6

Text Books:

1. Proakis, John G. - Digital signal processing: principles algorithms and applications, PHI.

2. Oppenheim, Alan V - Discrete-time signal processing, Pearson Education India.

3. Vaidyanathan, Parishwad P - Multirate systems and filter banks, Pearson Education India.

4. Li Tan –Digital signal processing, Fundamentals and applications, Elsevier, Academic Press, ISBN: 978-0-12-374090-8

Reference Books:

1. Vaidyanathan, Palghat P- The theory of linear prediction, Morgan and Claypool Publishers.
2. Haykin, Simon S. - Adaptive filter theory, Pearson Education India.

Course Name	RFIC AND MEMS	**Course Code**	RCC-PET-MVLSI-102B
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	3- 0 - 0	**Total Hours**	36Hrs

Course Pre-requisite:

- Electromagnetic Waves

Course Outcome (CO)

CO Number	Statement	Knowledge Level
RCC-PET-MVLSI-102B.CO1	**Illustrate** the mechanical, electrical and optical properties of basic microstructures for RF applications	Understanding
RCC-PET-MVLSI-102B.CO2	**Apply** the concept of bounded em wave propagation for estimating loss in micromachined transmission line	Applying
RCC-PET-MVLSI-102B.CO3	**Design** series and shunt MEMS switches for equivalent circuit modelling	Applying
RCC-PET-MVLSI-102B.CO4	**Interpret** the performance of micromachined mechanical filters at low and high frequency spectra for phase shifting applications	Applying
RCC-PET-MVLSI-102B.CO5	**Determine** the properties of MEMS based gas and pressure sensors for system level applications	Applying
RCC-PET-MVLSI-102B.CO6	**Integrate** the MEMS switch in package using micromachining techniques for higher reliability	Applying

Detailed Syllabus:

Module #	Contents	Contact Hours	CO Linked
1	Fundamental of MEMS: Introduction to MEMS principles, RF MEMS for microwave applications, fabrication technologies, fundamental MEMS structures, MEMS materials, Fundamental mechanical, electrical optical characteristics of the basic microstructures.	6LHrs	CO1
2	Transmission Lines: Micromachined transmission lines, losses in transmission lines, coplanar transmission lines, micromachined waveguide components.	5LHrs	CO2
3	MEMS Switches: Introduction to MEMS switches; Capacitive shunt and series switches: Physical		

	description, circuit model and electromagnetic modelling; Techniques of MEMS switch fabrication and packaging; Design of MEMS switches.	7 LHrs	CO3
4	RF Filters and Phase Shifters: Modeling of mechanical filters, micromachined filters, surface acoustic wave filters, micromachined filters for millimeter wave frequencies; Various types of MEMS phase shifters.	6LHrs	CO4
5	Sensors: Introduction, Properties of Piezoelectric Materials, Applications, Basic principle of Gas and pressure sensors.	6LHrs	CO5
6	Micromachining and Packaging: Anisotropic wet etching, Dry etching of silicon, Deep reactive ion etching (DRIE), Isotropic wet etching, Basic surface micromachining process- structural and sacrificial material. Role of MEMS packages, types of MEMS packages, module packaging, packaging materials and reliability issues.	6LHrs	CO6

Text Books:

1. Varadan, V.K., Vinoy, K.J. and Jose, K.J., "RF MEMS and their Applications", John Wiley & Sons. 2002.
2. Rebeiz, G.M., "MEMS: Theory Design and Technology", John Wiley & Sons. 1999.

Reference Books:

1. De Los Santos, H.J, "RF MEMS Circuit Design for Wireless Communications", Artech House. 1999
2. Sze, S.M., "Semiconductor Sensors", John Wiley & Sons. 1994.

Web-Resource:

1. https://nptel.ac.in/courses/108106165
2. https://www.me.iitb.ac.in/~gandhi/me645/05L1_coursecontents_mtvn.pdf

Course Name	Research Methodology and IPR	**Course Code**	RCC-PROJ-MVLSI-181
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	2-0-0	**Total Hours**	24 Hrs

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PROJ-MVLSI-181.CO1	**Understand** research problem formulation	Remembering
RCC-PROJ-MVLSI-181.CO2	**Analyze** research related information	Analyzing
RCC-PROJ-MVLSI-181.CO3	**Practice** research ethics	Applying
RCC-PROJ-MVLSI-181.CO4	**Identify** different types of intellectual property and their relevance in innovation and business contexts.	Remembering
RCC-PROJ-MVLSI-181.CO5	**Analyze** the legal framework and processes related to different IPRs	Analyzing
RCC-PROJ-MVLSI-181.CO6	**Evaluate** strategies for IP management, commercialization, and protection, including the Plant Variety Act and layout design of integrated circuits.	Evaluating

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	Meaning of research problem, Sources of research problem, Criteria Characteristics of a good research problem, Errors in selecting a research problem, Scope and objectives of research problem. Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, Necessary instrumentations	4 Hrs	CO1
2	Effective literature studies approaches, analysis Plagiarism, Research ethics,	4 Hrs	CO3
3	Effective technical writing, how to write report, Paper, Refrencing style and Bibliography, Developing a Research Proposal, Format of research proposal, a presentation and assessment by a review committee	4 Hrs	CO2
4	**Introduction to Intellectual Property:** Definition and Concept of Intellectual Property (IP); Types of Intellectual Property: Patents, Trademarks, Copyright, Trade Secrets,	4 Hrs	CO4

	Industrial Design, Geographical Indications, Overview of International IPR Laws and Treaties, Importance of IPR in Business and Innovation, IPR and its Role in Economic Development		
5	**Patents, Copyrights, Trademarks, and Other Forms of IP:** Detailed Overview of Patents: Application Process, Patentability Criteria, Patent Infringement; Copyright: Authorship, Registration, and Protection; Trademarks: Branding, Registration, and Infringement; Geographical Indication: Importance, Registration, and Legal Protection; Industrial Design: Concept, Registration, and Protection; Trade Secrets: Legal Framework and Protection; Case Studies: Patent, Copyright, Trademark, Industrial Design, and GI Disputes	4 Hrs	CO6
6	**IP Management, Plant Variety Act, and Commercialization:** Plant Variety Protection and Farmers' Rights Act: Scope and Legal Framework; Layout Designs of Integrated Circuits: Overview and Protection; IP Asset Management: Valuation and Licensing of IP; Technology Transfer and Commercialization of IP; Enforcement of IPR and Remedies for Infringement; Case Studies on IP Commercialization and Plant Variety Act Challenges	4 Hrs	CO5

Text Books:

1. Research Methodology Methods and Techniques (Second Revised Edition), C.R.Kothari
2. Stuart Melville and Wayne Goddard, "Research methodology: an introduction for science & engineering students'"
3. Halbert, "Resisting Intellectual Property", Taylor & Francis Ltd ,2007.
4. Mayall , "Industrial Design", McGraw Hill, 1992.
5. Niebel , "Product Design", McGraw Hill, 1974.Asimov ,
6. "Introduction to Design", Prentice Hall, 1962

Reference Books:

1. Wayne Goddard and Stuart Melville, "Research Methodology: An Introduction"
2. Ranjit Kumar, 2 nd Edition , "Research Methodology: A Step by Step Guide for beginners"
3. T. Ramappa, "Intellectual Property Rights Under WTO", S. Chand, 2008

4. Narayanan, P. (2007). Intellectual property law (4th ed.). Eastern Law House.
5. Ganguli, P. (2001). Intellectual property rights: Unleashing the knowledge economy. McGraw-Hill Education.
6. Cornish, W. R., & Llewelyn, D. (2010). Intellectual property: Patents, copyright, trademarks and allied rights (7th ed.). Sweet & Maxwell.
7. Gopalakrishnan, N. S., & Agitha, T. G. (2014). Principles of intellectual property. Eastern Book Company.

Web-Resource:

1. NPTEL SWAYAM: https://onlinecourses.nptel.ac.in/noc23_ge36/preview
2. NPTEL SWAYAM: https://onlinecourses.nptel.ac.in/noc22_ge08/preview

Course Name	Techniques and Languages for Research Paper Writing	**Course Code**	RCC-AU-MVLSI-181
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	2- 0 - 0	**Total Hours**	36Hrs

Course Pre-requisites:

- Rudimentary knowledge of modern English grammar

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-AU-MVLSI-181.CO1	Recall the importance of scientific research	Remembering
RCC-AU-MVLSI-181.CO2	Understand the elements of an academic research paper	Understanding
RCC-AU-MVLSI-181.CO3	Apply the key RW language skills	Applying
RCC-AU-MVLSI-181.CO4	Analyze the steps needed to complete a research paper	Analyzing
RCC-AU-MVLSI-181.CO5	Evaluate for clarity and fair practices	Evaluating
RCC-AU-MVLSI-181.CO6	Create a research paper on a chosen topic	Creating

Detailed Syllabus:

Module #	**Contents**	**Contact Hours**	**CO Linked**
1	**Introduction to Research:** Motivation to conduct research- importance of research in science and technology- meaning, purpose and significance of research paper writing- Introduction to Academic Writing - Language Proficiency Requirement- Objectivity- Clarity- Precision- Formal tone- Dos and Don’ts	2	CO1
2	**Reading and Writing:** Reading Strategies like Skimming and Scanning – How to read a research paper - Identifying Arguments-	6	CO2, CO3

	Key Skills for Writing Titles and Subtitles– Abstracts – Introductions – Literature Review - Research Methodology – Results - Discussion - Conclusions		
3	**Planning and Preparation**: Word Order in Title- Breaking up long sentences, Structuring Paragraphs– Removing Redundancy – Avoiding Ambiguity, Vagueness and Other Common Errors in Academic English	6	CO2, CO3, CO4
4	**Effective Revisions:** Restructuring Paragraph- Editing for Clarity and Coherence - Proofreading for Grammatical Precision – Spellings- Citations and References - Plagiarism and Ethical Considerations – Tools and Awareness – Fair Practices	6	CO5
5	**Technical Elements of Research Paper:** Hypothesis- Randomization- Population- Literature Review- Sampling Types- Variable- Validity- Consent- Risk- Field Work- Pictorial Depiction- Index- Annexures-End Notes- Footnotes	4	CO6

Text Books:

1. S. Bailey, "Academic Writing: A Handbook for International Students", Routledge, 5th d., 20

Course Name	Digital VLSI Design Lab	**Course Code**	RCC-PCL-MVLSI-191
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	0:0:4	**Total Hours**	48 Lab Hrs

Course Pre-requisite:

- Basic knowledge of Digital Logic Design.
- Familiarity with VHDL/Verilog programming.
- Understanding of Semiconductor Devices and Circuits.

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PCL-MVLSI-191.CO1	Design basic to advanced digital circuits using VHDL/Verilog.	Creating
RCC-PCL-MVLSI-191.CO2	Simulate and verify digital circuits using EDA tools.	Applying
RCC-PCL-MVLSI-191.CO3	Implement digital circuits on FPGA platforms.	Applying
RCC-PCL-MVLSI-191.CO4	Analyze timing, power, and area metrics of VLSI circuits.	Analyzing
RCC-PCL-MVLSI-191.CO5	Apply design for testability concepts to digital circuits.	Applying
RCC-PCL-MVLSI-191.CO6	Integrate digital components into a functional VLSI system.	Creating

Detailed Syllabus:

Module #	**Module Name**	**Experiment Topics**	**No of Labs Required**	**CO Linked**
1	Introduction to EDA Tools and Basic Circuit Design	**1:** Introduction to EDA Tools Setting up and exploring tools like ModelSim, Xilinx ISE, Synopsys Design Compiler, and Cadence. **2:** Design and Simulation of Combinational Circuits (Designing gates, multiplexers, demultiplexers, encoders, and decoders) using VHDL/Verilog.	2 Labs	CO1, CO2
2	Sequential Circuits and Arithmetic Circuit Design	**1:** Sequential Circuits Design	2 Labs	CO1, CO2

		(Flip-flops, latches, counters, and shift registers – behavioral and structural modeling.) **2:** Arithmetic Circuits Design and simulation (adders, subtractors, multipliers, and ALUs.)		
3	FSM and Memory Design	**1:** Finite State Machines (FSM) (Design of Moore and Mealy machines, coding, and simulation of FSM for real-time applications.) **2:** Memory Design (Designing and simulating RAM, ROM, and cache memory modules.)	2 Labs	CO1, CO2
4	FPGA Implementation and Optimization	**1:** FPGA-Based Circuit Design (Synthesize and implement combinational and sequential circuits on FPGA, including hardware verification.) **2:** Synthesis and Optimization (RTL synthesis, area, power, and timing optimization techniques.)	2 Labs	CO2, CO3, CO4
5	Timing and Power Analysis	**1:** Static Timing Analysis (STA)(Timing analysis using PrimeTime for verification.) **2:** Power Analysis (Estimating power consumption and analyzing power metrics in VLSI circuits.)	2 Labs	CO4
6	Advanced Design Concepts and RCC-PROJ-ect Work	**1:** Design for Testability (DFT) (Implementation of scan chains and Built-In Self-Test (BIST).) **2:** Floor planning and Placement (Floor planning, placement, DRC, and LVS verification.) **3:** Routing and Parasitic Extraction (Routing techniques, parasitic extraction, and analysis of effects on performance.) **4:** Design and Implementation of a Microprocessor on FPGA (Designing and simulating a microprocessor, FPGA implementation, and performance evaluation.)	6 Labs	CO3, CO5, CO6

		5.RCC-PROJ-ect Work: A complex digital VLSI system design and implementation.		

Text Books:

1. "Digital Integrated Circuits: A Design Perspective" by Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic.
2. "VHDL: Programming by Example" by Douglas L. Perry.
3. "Verilog HDL" by Samir Palnitkar.

Reference Books:

1. "FPGA Prototyping by VHDL Examples" by Pong P. Chu.
2. "Digital Design and Synthesis with Verilog HDL" by Eliezer Sternheim, Rajvir Singh, Rajeev Madhavan.

Course Name	Microelectronics Technology Lab	**Course Code**	RCC-PCL-MVLSI-192
Semester	1st	**Program Name**	M.Tech in VLSI Design and Microelectronics Technology
L:T:P	0-0-4	**Total Hours**	

Course Pre-requisite:

- Concept of MOSFET structure
- CMOS based circuit design
- SPICE modelling

Course Outcome (CO)

CO Number	**Statement**	**Knowledge Level**
RCC-PCL-MVLSI-192.CO1	**Categorizing** the layout of MOSFET using design rule checking process**.**	Understanding
RCC-PCL-MVLSI-192.CO2	**Design** the MOSFET using proper fabrication steps, creating n-well and p-well	Applying
RCC-PCL-MVLSI-192.CO3	**Compute** electrical characteristics of Four-terminal active devices (MOSFET) with required circuitry specifications**.**	Analyzing
RCC-PCL-MVLSI-192.CO4	**Inspect** the type of wafer (n-type and p-type) using Hall voltage measurement method**.**	Analyzing
RCC-PCL-MVLSI-192.CO5	**Validating** fabrication steps of CMOS, twin tub through simulation	Evaluating
RCC-PCL-MVLSI-192.CO6	**Simulating** layout for verifying the given logic functions**.**	Creating

Detailed Syllabus:

Module #	**Module Name**	**Experiment Topics**	**No of Labs Required**	**CO Linked**
1	Design rule checking for layout	1. Study the lambda rule related to the layout design (Layout design tools.). 2. Study the micron rule related to the layout design (Layout design tools).	2	CO1
2	Fabrication steps of MOSFET	1. Study the fabrication steps of nMOSFET, creating n-well virtually through simulation (using software). 2. Study the fabrication steps of pMOSFET, creating p-well virtually through simulation (using software).	2	CO2
3	MOSFET characteristics	Study of the nMOSFET and pMOSFET electrical characteristics through simulation (using SPICE software).	1	CO3

4	Wafer type identification	Study on wafer substrate using Hall voltage measurement method to determine whether the carrier conductivity type is N or P through simulation.	1	CO4
5	CMOS Fabrication steps and Layout	1.Study the fabrication steps of CMOS, twin tub, virtually through simulation (using software). 2.Design layout and verify the simulated outputs of CMOS inverter (Layout design tools).	2	CO5
6	Function verification	1.Design layout and verify the simulated outputs of given function (Layout design tools).	1	CO6

Text Books:

1. Basic VLSI Design, Pucknell D.A, PHI, 3rd Edition
2. CMOS Digital Integrated Circuits, Yusuf Leblebici, Sung-Mo Kang, Tata Mac Graw Hill, Fourth Edition

Reference Books:

1. Fundamentals of Layout Design for Electronic Circuits, Jens Lienig , Juergen Scheible, Springer,