Savitribai Phule Pune University

Faculty of Science and Technology

Syllabus for

B.E. Electronics Engineering (VLSI Design & Technology)

(Course 2019)

(w.e.f. June 2026)

Savitribai Phule Pune University, Pune

B.E. (VLSI Design & Technology Engineering)2019 Course

(With effect from Academic Year 2026-27)

Semester-VII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
404401	IoT and Embedded Systems	03	-	-	30	70	-	-	-	100	03	-	-	03
404402	Advanced RTL Simulation and Synthesis	03	-	-	30	70	-	-	-	100	03	-	-	03
404403	MOS Device Modeling and Characterization.	03	-	-	30	70	-	-	-	100	03	-	-	03
404404	Elective - 3	03	-	-	30	70	-	-	-	100	03	-	-	03
404405	Elective - 4	03	-	-	30	70	-	-	-	100	03	-	-	03
404406	Lab Practice – 1 (IoT and Embedded Systems and Advanced RTL Simulation and Synthesis)	-	04	-	-	-	25	-	50	75	-	02	-	02
404407	Lab Practice - 2 (MOS Device Modeling and Characterization. & Elective -3)	-	04	-	-	-	25	50	-	75	-	02	-	02
404408	Project Stage - I	-	02	-	-	-	50	-	-	50	-	01	-	01
404191A	Mandatory Audit Course 7	-	-	-	-	-	-	-	-	-	-	-	-	-
	Total	**15**	**10**	**-**	**150**	**350**	**100**	**50**	**50**	**700**	-	-	-	-
	Total Credits										**15**	**05**	**-**	**20**

Elective - 3	Elective - 4
1. Industrial Drives & Automation	1. Electronics product Design
2. Reconfigurable computing	2. Semiconductor Packaging and Testing
3. Cloud Computing	3. Semiconductor Memory design
4. AI for VLSI	4. Deep Learning

Mandatory Audit Course - 7
1. Management Information System
2. Patent Search & Analysis
3. Knowledge Management
4. Energy Economics & Policy
5. Educational Leadership
6. Human Resource Development

Savitribai Phule Pune University, Pune
B.E. (VLSI Design & Technology Engineering) 2019 Course
(With effect from Academic Year 2026-27)

Semester-VIII

Course Code	Course Name	Teaching Scheme (Hours/Week)			Examination Scheme and Marks						Credit			
		Theory	Practical	Tutorial	In-Sem	End-Sem	TW	PR	OR	Total	TH	PR	TUT	Total
404409	Verification using SV and UVM	03	-	-	30	70	-	-	-	100	03	-	-	03
404410	Elective - 5	03	-	-	30	70	-	-	-	100	03	-	-	03
404411	Elective - 6	03	-	-	30	70	-	-	-	100	03	-	-	03
404412	Innovation & Entrepreneurship	-	-	02	-	-	50	-	-	50	-	-	02	02
404413	Digital Business Management	-	-	02	-	-	50	-	-	50	-	-	02	02
404414	Verification using SV and UVM Lab	-	02	-	-	-	25	-	50	75	-	01	-	01
404415	Lab Practice - 3 (Elective - 5)	-	02	-	-	-	25	50	-	75	-	01	-	01
404416	Project Stage - II	-	10	-	-	-	100	-	50	150	-	05	-	05
	Total	**09**	**14**	**04**	**90**	**210**	**250**	**50**	**100**	**700**	**-**	**-**	**-**	**-**
							Total Credits				**09**	**07**	**04**	**20**

Elective - 5	Elective - 6
1. Android Development	1. Nano Electronics
2. Mobile computing	2. Low Power CMOS
3. Fibre Optic Communication	3. Digital Marketing
4. Biomedical Signal Processing	4. System on Chip

Program Outcomes (PO’s)	
Engineering Graduates will be able to:	
1.	**Engineering knowledge**: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
2.	**Problem analysis**: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
3.	**Design/development of solutions**: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
4.	**Conduct investigations of complex problems**: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
5.	**Modern tool usage**: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
6.	**The engineer and society**: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
7.	**Environment and sustainability**: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
8.	**Ethics**: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
9.	**Individual and team work**: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
10.	**Communication**: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
11.	**Project management and finance**: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one’s own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
12.	**Life-long learning**: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

SEMESTER - VII

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404401: IOT and Embedded Systems		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Embedded Processor
2. Microcontrollers

Companion Course, if any:

1. Lab Practice -1

Course Objectives:

1. To learn and understand the basics of Embedded systems.
2. To be acquainted with interfacing of sensors and actuators with microprocessor.
3. To design embedded systems applications.
4. To understand Internet of Things and its usefulness for society.

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

CO1: Identify and understand the unique characteristics and components of embedded systems.
CO2: Compare various development boards Arduino, Raspberry pi, Beagle bone.
CO3: Implement interfacing of various sensors, actuators to the development boards.
CO4: Design, implement and test an embedded system application.
CO5: Configure U-Boot, Understand IoT building blocks.
CO6: Compare various IoT communication technologies and Design various IoT application.

Course Contents

Unit I	Embedded System Overview	6 Hrs.

Embedded Systems: Architecture & Characteristics of ES, Types of Embedded systems, Examples of Embedded Systems. Embedded System On Chip (SOC).
Components of Embedded System: Hardware and software
Hardware components of Embedded System: Power supply: types, characteristics, selection criteria, Processing Unit, Input devices, Output Devices.

Mapping of Course Outcomes for Unit I	CO1: Identify and understand the unique characteristics and components of embedded systems.

Unit II	Introduction to Embedded System Software	6 Hrs.

Introduction to Embedded operating Systems: Operating Systems Concepts, Real time operating systems, and, Task Scheduling, Different OS tasks, Introduction to **Real-Time Operating Systems**, characteristics, selection criteria, boot loader: U-boot.		
Mapping of Course Outcomes for Unit II	CO2: Compare various development boards Arduino, Raspberry pi, Beagle bone.	
Unit III	**Sensors, Actuators and Interfacing**	**6 Hrs.**
Sensors : Roles of Sensors & Actuators, Types of sensors ,Active and passive, analog and digital, Contact and no-contact, Absolute and relative **Working of Sensors**: Position, occupancy and motion, velocity and acceleration, force, pressure, flow, Acoustic, Humidity, light, radiation, temperature, chemical, biosensor, camera. **Development boards**: Types of boards - Arduino, Raspberry pi, Beagle bone, ESP8266, selection criteria. **Interfacing of sensors with development boards**.		
Mapping of Course Outcomes for Unit III	CO3: Implement interfacing of various sensors, actuators to the development boards.	
Unit IV	**Embedded System - Application Development**	**6 Hrs.**
Integrated Development Platforms for Application Development in ES environment, SDLC-Requirements, Architecture, Design, Components, Coding, Testing and Deployment. **Study of any two Open source IDE** for ES application development with respect to any of the two indicated Case studies like Object detection, Traffic Signal and Smart Metering.		
Mapping of Course Outcomes for Unit IV	CO4 Design, implement and test an embedded system application.	
Unit V	**Internet of Things Overview**	**6 Hrs.**
Introduction of IoT: Definition and characteristics of IoT, Technical Building blocks of IoT, Device, Communication Technologies, Data, Physical design of IoT, IoT enabling technologies, IoT Issues and Challenges- Planning, Costs and Quality, Security and Privacy, Risks		
Mapping of Course Outcomes for Unit V	CO5: Configure U-Boot, Understand IoT building blocks.	
Unit VI	**Communication under IoT**	**6 Hrs.**
IoT Protocols: MQTT, CoAP, XMPP and AMQT, IoT communication models, IoT Communication **technologies:** Bluetooth, BLE, Zigbee, Zwave, NFC, RFID, LiFi, Wi-Fi, Interfacing of wifi, RFID, Zigbee,NFC with development board.		
Mapping of Course Outcomes for Unit VI	CO6: Compare various IoT communication technologies and Design various IoT applications.	
Learning Resources		

Text Books:

1. Raj Kamal, “Embedded Systems: Architecture, programming and Design”, 2nd Edition, McGraw- Hill, ISBN: 13: 9780070151253
2. Lyla B. Das, “Embedded Systems: An Integrated Approach” Pearson , ISBN: 9332511675, 9789332511675.
3. Arshdeep Bahga, Vijay Madisetti, “Internet of Things – A hands-on approach”, Universities Press, ISBN: 0: 0996025510, 13: 978-0996025515.

Reference Books:

1. Sriram V. Iyer, Pankaj Gupta, “Embedded Real-time Systems Programming”, Tata McGraw-Hill, ISBN: 13: 9780070482845.

2. David Hanes, IoT Fundamentals: Networking Technologies, Protocols, and Use Cases for the Internet of Things, Cisco Press, ISBN-13: 978-1-58714-456-1, ISBN-10: 1-58714- 456-5, 2017.
3. Olivier Hersent, Omar Elloumi and David Boswarthick, “The Internet of Things: Applications to the Smart Grid and Building Automation”, Wiley, 2012, 97811199583453.

4. Olivier Hersent, David Boswarthick, Omar Elloumi , “The Internet of Things – Key applications and Protocols”, Wiley, 2012, ISBN:978-1-119-99435-0

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404402: Advanced RTL Simulation and Synthesis

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Basic Electronics
2. Digital Electronics

Companion Course, if any:

1. Lab Practice -1

Course Objectives:

1. To provide students an understanding of the concepts related to RTL Designing
2. To design and implement the advanced architectures on FPGA.
3. To explore Hardware Description Language (HDL) and respective digital design methodologies.
4. To realize importance of testability in logic circuit design.

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

CO1: Gain insights into VHDL design.
CO2: Apply knowledge of real time issues in digital design.
CO3: Model Combinational digital circuit with VHDL, simulate, synthesis and prototype in PLDs.
CO4: Model sequential digital circuit with VHDL, simulate, synthesis and prototype in PLDs.
CO5: Model FSM with VHDL, simulate, synthesis and prototype in PLDs.
CO6: Apply knowledge of testability in design and Build In Self-Test (BIST) circuit.

Course Contents

Unit I	Design with VHDL	7 Hrs.

Design Flow, Language constructs, Data objects, Data types, Entity, Architecture & types of modeling, Sequential statements, Concurrent statements, Packages, Sub programs, Attributes, synthesis, Simulations, Synthesis, Efficient coding styles, Hierarchical and flat designs, Partitioning for synthesis, Pipelining, Resource sharing.

Mapping of Course Outcomes for Unit I	CO1: Gain insights into VHDL design.

Unit II	Digital Design and Issues	6 Hrs.

Sequential synchronous machine design, Moore and Mealy machines, HDL code for Machines, FIFO. Meta-stability and solutions. Noise margin, Fan-out, Skew, Timing considerations, Hazards, Clock distribution, Clock jitter, Supply and ground bounce, Power distribution techniques, Power optimization. Interconnect routing techniques, Wire parasitic, Signal integrity issues. I/O architecture.

Mapping of Course Outcomes for Unit II	CO2: Apply knowledge of real time issues in digital design.

Unit III	**VHDL modeling of Combinational Circuits**	**6 Hrs.**
VHDL Implementation of: Half Adder, Full adder, Half Subtractor, Full Subtractor, Code converters (BCD to Gray, BCD to Excess-3), 2- bit Comparator, Multiplexers, Demultiplexers, and 3:8Decoders.		
Mapping of Course Outcomes for Unit III	CO3: Model Combinational sdigital circuit with VHDL, simulate, synthesis and prototype in PLDs. .	
Unit IV	**VHDL modeling of Sequential Circuits**	**6 Hrs.**
VHDL Implementation of: Clocked SR flipflop, J-K flipflop, D and T flip- flops. Shift registers, Counters (ring counters, twisted ring counters), ripple counters, Mod-ncounters, up/down counters, synchronous counters.		
Mapping of Course Outcomes for Unit IV	CO4: Model sequential digital circuit with VHDL, simulate, synthesis and prototype in PLDs.	
Unit V	**VHDL modeling of FSM**	**6 Hrs.**
Moore and Mealy machines, State diagram, State table, finite state machine implementation, VHDL Implementation of: Sequence Generator, Sequence detector.		
Mapping of Course Outcomes for Unit V	CO5: Model FSM with VHDL, simulate, synthesis and prototype in PLDs.	
Unit VI	**VLSI Testing and Analysis**	**6 Hrs.**
Types of fault, Need of Design for Testability (DFT), DFT Guideline, Testability, Fault models, Path sensitizing, Test pattern generation, Sequential circuit test, Built In Self Test, JTAG & Boundary scan, TAP Controller.		
Mapping of Course Outcomes for Unit VI	CO6: Apply knowledge of testability in design and Build In Self Test (BIST) circuit.	

Learning Resources

Text Books:

1. Charles H. Roth, “Digital Systems Design using VHDL”, 2nd Edition, Thompson Learning
2. Wyane Wolf, “Modern VLSI Design (IP-Based Design)”, 4th Edition, Prentice Hall.

Reference Books:

1. Cem Unsalan, Bora Tar, “Digital System Design with FPGA: Implementation Using Verilog and VHDL”, McGraw-Hill.
2. Steve Kilts, “Advanced FPGA Design Architecture, Implementation and Optimization” Wiley Interscience.

MOOC / NPTEL Courses:

1. NPTEL course on Digital System Design with PLDs and FPGAs, by Prof. Kuruvilla Varghese, IISc Banglore
   Link: https://nptel.ac.in/courses/117108040

2. NPTEL course on Synthesis of Digital Systems, by Prof. Preeti Ranjan Panda IIT Delhi
   Link: https://nptel.ac.in/courses/106102181

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404403: MOS Device Modeling and Characterization		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Digital CMOS Design
2. VLSI Design, Probability & Statistics / Basic Python Programming

Companion Course, if any:

1. Lab Practise -2

Course Objectives:

1. To introduce the electrostatic principles and operational modes of MOS structures.
2. To study scaling challenges and short-channel effects in MOSFETs.
3. To understand transistor modeling using SPICE equations.
4. To explore capacitance-based MOSFET models and their comparisons.
5. To analyse the frequency response of MOS devices.
6. To study advanced MOSFET modeling techniques and structures.

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

CO1: Explain MOS transistor operation, flat-band voltage, inversion, and small-signal capacitance.
CO2: Analyze short-channel effects and evaluate their impact on MOSFET performance.
CO3: Develop solution to overcome short channel issue.
CO4: Develop various compact models appropriate for industry
CO5: Analyse the frequency response of MOS devices.
CO6: Evaluate compact and advanced MOSFET models including FinFETs.

Course Contents

Unit I	**Electrostatic Principles and Operational Modes of MOS Structures**	**6 Hrs.**
A qualitative Description of MOS Transistor operation, contact potentials, MOS Capacitor ,Insulator charges ,two terminal MOS structure: Flat band voltage, Potential balance and charge balance, Effect of Gate-Substrate voltage on Surface Condition, Inversion, Small signal capacitance, Body effect		
Mapping of Course Outcomes for Unit I	CO1: Explain MOS transistor operation, flat-band voltage, inversion, and small-signal capacitance.	
Unit II	**MOSFET Scaling Challenges**	**6 Hrs.**
MOSFET – Regions of operation, Complete all region model, Strong inversion, weak inversion and moderate inversion, Effective mobility, Temperature effects, Short channel MOSFET, Small Dimension Effects, Channel length Modulation, Barrier lowing two dimensional charge sharing and threshold voltage, Punch through, Carrier velocity Saturation, Hot carrier Effects, Scaling, Effects due to thin oxides and high doping, mobility degradation		
Mapping of Course Outcomes for Unit II	CO2: To study scaling challenges and short-channel effects in MOSFETs.	

Unit III	Small-Dimension Effects	6 Hrs.
Small channel and thin oxide effects, Carrier velocity saturation, Channel length modulation, Charge sharing, Drain induced barrier lowering, Punch through, Hot carrier effects, Velocity Overshoot Ballistic Operation, Polysilicon depletion, Quantum mechanical effects, Junction leakages, Scaling		
Mapping of Course Outcomes for Unit III	CO3: Develop solution to overcome short channel issue.	
Unit IV	**Device Modeling for Circuit Simulation**	**6 Hrs.**
Small-Dimension Effects-Modelling for Circuits Simulation- Quantum-Mechanical Effects; Gate Current, Junction Leakage, Scaling and New Technologies, Approaches, and Properties of Good Models, Model Formulation Considerations, Parameter Extraction, Compact Models, Benchmark Tests		
Mapping of Course Outcomes for Unit IV	CO4: Develop various compact models appropriate for industry.	
Unit V	**MOSFET Models**	**6 Hrs.**
Small-Signal Modelling - Conductance Parameter Definitions and Equivalent Circuits, Conductance Parameters Due to Gate and Body Leakage, Transconductance, Source-Drain and Output Conductance, Capacitance Definitions and Equivalent Circuits, Capacitance Evaluation and Properties, y-Parameter Model, RF Models, Capacitance Models, Basic MOSFET models, Comparison of MOSFET Models		
Mapping of Course Outcomes for Unit V	CO5: Analyse the frequency response of MOS devices.	
Unit VI	**Advanced MOSFET Modeling Techniques**	**6 Hrs.**
Advanced MOSFET models for circuit simulators, Surface potential models, inversion charge based models, Compact MOSFET models, threshold voltage-based model models, advanced MOSFET structures such as FINFET		
Mapping of Course Outcomes for Unit VI	CO6: Evaluate compact and advanced MOSFET models including FinFETs.	

Learning Resources

Text Books:

1. Yannis Tsividis, "Operation and Modeling of the MOS transistor", Oxford University Press.
2. Kang S. M , "CMOS Digital Integrated Circuits", Tata Mc-Graw Hill.
3. Carlos Galup & Montoro, "MOSFET Modeling for Circuit Analysis and Design", World Scientific.
4. Donald Neamen, "Semiconductors Physics and Devices", Tata Mc-Graw Hill.
5. Sze S. M, "Physics of Semiconductor Devices, Second Edition, Wiley Publications

References Books:

1. T. A. Fjeldly, T. Yetterdal, and M. Shur, "Introduction to Device Modeling and Circuit Simulation", John Wiley, 1998.
2. Y. Taur and T. H. Ning, "Fundamentals of Modern VLSI Devices", Cambridge University Press, 1998. 3. Y. P. Tsividis, "Mixed

MOOC / NPTEL Courses:

1. NPTEL Course on "Semiconductor Device Modelling", by Prof. Shreepad Karmalkar, IIT Madras

   Link: http://kcl.digimat.in/nptel/courses/video/117106033/L38.html

2. NPTEL Course on “Semiconductor Device Modeling and Simulation”, by Prof. Vivek Dixit, IIT Kharagpur

Link: http://digimat.in/nptel/courses/video/108105188/L12.html

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404404(A): Industrial Drives & Automation (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 hrs. / week	**03**	**In-Sem (Theory): 30 Marks** **End-Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Basic Electrical Engineering
2. Electronic Circuits
3. Electrical Circuits
4. Power Devices and Converters

Companion Course, if any:

1. Lab Practice -2

Course Objectives:

1. To introduce components of electrical drives and its parameters.
2. To understand working, design and performance analysis of DC motor drives, Induction motor and stepper motor drives.
3. To know various protections circuit required for motor drives.

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

CO1: Understand significance and design of various components of electrical drives.

CO2: Develop, evaluate and analyze the performance of DC motor drives.

CO3: Design, estimate and examine the performance of chopper controlled DC drives.

CO4: Adapt, choose and categorize performance of PWM inverter drives for Induction motors.

CO5: Elaborate, interpret and analyze the performance of Synchronous motor drive.

CO6: Develop, explain and examine performance of stepper motor control.

Course Contents

Unit I	Components of Electrical Drives	6 Hrs.
Electric machines, Power converter, Controllers, Dynamics of electric drive - torque equation - equivalent values of drive parameters- components of load torques types of load – four-quadrant operation of a motor – steady state stability – load equalization – classes of motor duty determination of motor rating.		
Mapping of Course Outcomes for Unit I	CO1: Understand significance and design of various components of electrical drives.	
Unit II	**DC Motor Drives**	**6 Hrs.**
DC motors & their performance (shunt, series, compound, permanent magnet motor, universal motor, dc servomotor) – braking – regenerative, dynamic braking, plugging –Transient analysis of separately excited motor – converter control of dc motors – analysis of separately excited & series with 1-phase and 3-phase converters ,soft start and field failure protection in DC drives, BLDC motor drive		
Mapping of Course Outcomes for Unit II	CO2: Develop, evaluate and analyze the performance of DC motor drives.	

Unit III	Chopper Controlled DC Drives	6 Hrs.
Closed loop control – transfer function of self, separately excited DC motors – linear transfer function model of power converters – sensing and feeds back elements – current and speed loops, P, PI and PID controllers – response comparison – simulation of converter and chopper fed DC drive		
Mapping of Course Outcomes for Unit III	CO3: Design, estimate and examine the performance of chopper Controlled DC drives.	
Unit IV	**PWM Drives for Induction Motors**	**6 Hrs.**
Multi quadrant drives – rotor resistance control – slip torque characteristic – torque equations, constant torque operation – slip power recovery scheme – torque equation – torque slip characteristics – power factor – methods of improving power factor – limited sub synchronous speed operation – super synchronous speed operation		
Mapping of Course Outcomes for Unit IV	CO4: Adapt, choose and categorize performance of PWM inverter drives for Induction motors.	
Unit V	**Synchronous Motor Drives**	**6 Hrs.**
Synchronous motor drives – speed control of synchronous motors – adjustable frequency operation of synchronous motors – principles of synchronous motor control – voltage source inverter drive with open loop control		
Mapping of Course Outcomes for Unit V	CO5: Elaborate, interpret and analyze the performance of Synchronous motor drive.	
Unit VI	**Stepper Motors**	**6 Hrs.**
Constructional features, principle of operation, modes of excitation, single phase stepping motors, torque production in variable Reluctance (VR) stepping motor, Dynamic characteristics, Drive systems and circuit for open loop control, Closed loop control of stepping motor, microprocessor based controller.		
Mapping of Course Outcomes for Unit VI	CO6: Develop, explain and examine performance of stepper motor control.	

Learning Resources

Text Books:

1. R. Krishnan, “Electrical Motor Drives: Modeling, Analysis, and Control”, PHI
2. G. K.Dubey, “Fundamentals of Electrical Drives”, Narosa Publishers

Reference Books:

1. K.Dubey, “Power Semiconductor Controlled Drives”, Prentice Hall.
2. S.A. Nasar, Boldea, “Electrical Drives”, 2nd Edition, CRC Press.
3. M. A. ElSharkawi , “Fundamentals of Electrical Drives” , Thomson Learning.
4. W. Leohnard, “Control of Electric Drives”, Springer.
5. Murphy and Turnbull, “Power Electronic Control of AC motors”, Pergamon Press.
6. Vedam Subrahmaniam, “Electric Drives: Concepts and Applications”, McGraw Hill

MOOC / NPTEL Courses:

1. NPTEL Course on “**Power Electronics**”, Prof. D.Prasad, Prof. N.K. De, Dr. D.Kastha, Prof. Sabyasachi Sengupta, IIT Kharagpur

   Link of the Course: https://nptel.ac.in/courses/108105066

2. NPTEL Course on “**Power Electronics**”, Prof. G.Bhuvanseshwari, IIT Delhi

   Link of the Course: https://nptel.ac.in/courses/108102145

3. NPTEL Course on “**Advanced Power Electronics and Control**”, Prof. Avik Bhattacharya, IIT Roorkee

   Link of the Course: https://nptel.ac.in/courses/108107128

4. NPTEL Course on “**Industrial Drives: Power Electronics**”, Prof. K.Gopakumar, IISc Bangalore

   Link of the Course: https://nptel.ac.in/courses/108108077

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404404(B): Reconfigurable Computing (Elective - III)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. FPGA based system design .

Companion Course, if any:

1. Lab Practice -2

Course Objectives:

1. To understand various computing architectures.
2. To analyse the reconfigurable computing requirements.
3. To evaluate of FPGA design in view of reconfiguration.
4. To examine various applications of reconfigurable computing.

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

CO1: Explain the fundamentals and applications of reconfigurable computing.
CO2: Describe the architecture and design characteristics of reconfigurable devices.
CO3: Analyze different reconfigurable processing fabric architectures.
CO4: Evaluate reconfigurable computing systems and reconfiguration techniques.
CO5: Apply FPGA design flow and SoPC concepts for system implementation.
CO6: Assess reconfigurable computing solutions for various applications.

Course Contents

Unit I	**Introduction to Reconfigurable Computing**	**6 Hrs.**
Types of computing and introduction to RC: General Purpose Computing, Domain-Specific Processors, Application Specific Processors; Reconfigurable Computing, Fields of Application; General-Purpose Computing Issues;		
Mapping of Course Outcomes for Unit I	CO1: Explain the fundamentals and applications of reconfigurable computing.	
Unit II	**Architecture and Design Characteristics of Reconfigurable Devices**	**6 Hrs.**
Reconfigurable Device Characteristics, Configurable, Programmable, and Fixed-Function Devices; Metrics: Density, Diversity, and Capacity; Interconnects, Requirements, Delays in VLSI Structures; Partitioning and Placement, Routing; Computing Elements, LUTs, LUT Mapping, ALU and CLBs; Retiming.		
Mapping of Course Outcomes for Unit II	CO2: Describe the architecture and design characteristics of reconfigurable devices.	

Unit III	Reconfigurable Processing Fabric Architectures	6 Hrs.
Reconfigurable Processing Fabric Architectures: Fine-grained & Coarse-grained structures; RPF Integration into Traditional Computing Systems: Independent Reconfigurable Coprocessor Architectures, Loosely coupled RPF and processor architecture, Tightly coupled RPF and processor.		
Mapping of Course Outcomes for Unit III	CO3: Analyze different reconfigurable processing fabric architectures.	
Unit IV	**Reconfigurable computing systems and Reconfiguration management**	**7 Hrs.**
Early systems of Reconfigurable computing: PAM, VCC, Splash, PRISM, Teramac, Cray, SRC, non-FPGA research, Other issues**;** Reconfiguration Management: Reconfiguration, Configuration architectures, managing reconfiguration process, reducing reconfiguration time, configuration security.		
Mapping of Course Outcomes for Unit IV	CO4: Evaluate reconfigurable computing systems and reconfiguration techniques	
Unit V	**FPGA Design Flow and SoPC Implementation**	**7 Hrs.**
Implementation: Integration, FPGA Design Flow, System On A Programmable Chip; Introduction to SoPC, Adaptive Multiprocessing on Chip. Reconfiguration Project Design Approaches: J-Bit, Modular, Early Access, Vivado.		
Mapping of Course Outcomes for Unit V	CO5: Apply FPGA design flow and SoPC concepts for system implementation.	
Unit VI	**Applications of Reconfigurable Computing**	**6 Hrs.**
Reconfigurable devices for Rapid prototyping, Non-frequently reconfigurable systems, Frequently reconfigurable systems; Compile-time reconfiguration, Run-time reconfiguration; RC Applications: Implementing applications with FPGAs, various applications and use of reconfiguration; Video Streaming, Distributed arithmetic, Adaptive Controller, Adaptive cryptographic systems, Software Defined Radio, High-Performance Computing, Automatic target recognition systems.		
Mapping of Course Outcomes for Unit VI	CO6: Assess reconfigurable computing solutions for various applications.	

Learning Resources

Text Books:

1. Bobda Christophe, “Introduction to Reconfigurable Computing: Architectures, Algorithms, and Applications”, Springer.
2. Hauck Scott, Dehon A, “Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation”, Elsevier.

Reference Books:

1. Maya Gokhale, Paul Ghaham, “Reconfigurable Computing”, Springer Publication
2. Andre Dehon, “Reconfigurable Architectures for General Purpose Computing” PhD thesis.

MOOC / NPTEL Courses:

1. NPTEL Course on “Digital System Design with PLDs and FPGAs” by Prof. Kuruvilla Varghese, IISc Bangalore

   Link: https://nptel.ac.in/courses/117108040

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404404(C): Cloud Computing (Elective - III)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Database Management

Companion Course, if any:

1. Lab Practice – 2

Course Objectives:

1. To introduce the fundamentals of Cloud computing, its technologies, Challenges and Applications.
2. To give Insights into the virtualization technologies and Architecture.
3. To know the relationship between Cloud and SOA.
4. To classify and evaluate Cloud Security Issues.
5. To apply theory to practical knowledge through case Studies.

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

CO1: Understand the basic concepts of Cloud Computing.
CO2: Describe the underlying principles of different Cloud Service Models.
CO3: Classify the types of Virtualization.
CO4: Examine the Cloud Architecture and understand the importance of Cloud Security.
CO5: Develop applications on Cloud Platforms.
CO6: Evaluate distributed computing and the Internet of Things.

Course Contents

Unit I	Fundamentals of Cloud Computing	6 Hrs.

Introduction to Cloud Computing, History of Cloud Computing, Characteristics of Cloud Computing, Cloud Types: NIST, Cloud cube, Cloud service models, Cloud Computing deployment models, Exploring the Cloud Computing Stack, Advantages, Disadvantages and Applications of cloud computing.

Mapping of Course Outcomes for Unit I	CO1: Understand the basic concepts of Cloud Computing.

Unit II	Cloud Service Models	6 Hrs.

Introduction and benefits of Cloud services, Characteristics, benefits, applications of different cloud service models, Software as a service(SaaS), Platform as a service (PaaS), Infrastructure as a service (IaaS), Network as a service (NaaS), Identity as a service (IdaaS), Database as a service (DbaaS), Comparison of cloud services.

Mapping of Course Outcomes for Unit II	CO2: Describe the underlying principles of different Cloud Service Models.

Unit III	Virtualization	6 Hrs.
Introduction to Virtualization, Difference between Cloud Computing and Virtualization **Types of Virtualization:** Hardware, Software, Operating system, Server, Storage, Methods of implementing storage Virtualization, Network Virtualization Types, Advantages, Disadvantages, Virtualization Architecture and Software, Virtual Clustering, Applications of Virtualization.		
Mapping of Course Outcomes for Unit III	CO3: Classify the types of Virtualization.	
Unit IV	**Service Oriented Architecture and Cloud Security**	**7 Hrs.**
Cloud Computing Architecture (COA): Design principles, Cloud computing life cycle (CCLC), Cloud computing reference architecture, Service Oriented Architecture (SOA) characteristics and fundamental components. **Cloud Security:** Cloud CIA security model (Confidentiality, Integrity and Availability), Cloud computing security architecture, Service provider security issues, Cloud Security Issues and challenges, Security issues in virtualization, Host Security, Data Security, Firewalls.		
Mapping of Course Outcomes for Unit IV	CO4: Examine the Cloud Architecture and understand the importance of Cloud Security.	
Unit V	**Cloud Environment and Application Development**	**7 Hrs.**
Cloud Platforms: Google App Engine, Compute Services, Storage Services, Communication Services, Amazon Web Services Architecture and core concepts, Application Lifecycle, Cost Model, Microsoft Azure Cloud Services Azure core concepts, Windows Azure Platform Appliance.		
Mapping of Course Outcomes for Unit V	CO5: Develop applications on Cloud Platforms.	
Unit VI	**Distributed Computing and Internet of Things**	**6 Hrs.**
Distributed Computing: Need, distributed computing vs. Cloud computing, Enabling Technologies for the Internet of Things, Innovative Applications of the Internet of Things, Online Social and Professional Networking.		
Mapping of Course Outcomes for Unit VI	CO6: Evaluate Distributed Computing and the Internet of Things.	

Learning Resources

Text Books:

1. Kailash Jayaswal, Jagannath Kallakurchi, Donald J. Houde, Dr. Deven Shah, “Cloud Computing: Black Book”, Dreamtech Press.
2. Surbhi Rastogi, “Cloud Computing Simplified”, 2021 Edition, BPB Publications.
3. Kai Hwang, Geoffrey.C.Fox., Jack J. Dongarra, “Distributed and Cloud Computing: From Parallel Processing to Internet of Things”, MK Publications, Elsevier

Reference Books:

1. Kamal Kant Hiran, et al. "Cloud Computing: Master the concepts, Architecture and Applications with Real-world examples and Case Studies", 1st Edition, BPB Publication.
2. Judith Hurwitz, "Cloud Computing for dummies", 2nd Edition, Wiley India.
3. A. Srinavasan, J. Suresh, "Cloud Computing: A Practical Approach for Learning and Implementation", Pearson.
4. Anthony T. Velte Toby J. Velte, Robert Elsenpeter, "Cloud Computing: A Practical Approach", McGraw-Hill.
5. Barrie Sosinsky, "Cloud Computing Bible", Wiley Publishing Inc.
6. Rajkumar Buyya, Christian Vecchiola, S. Thamarai Selvi, "Mastering Cloud Computing", McGraw Hill Education

MOOC / NPTEL Courses:

1. NPTEL Course on "**Cloud Computing**", By Prof. Soumya Kanti Ghosh, IIT Kharagpur.

   Link: https://nptel.ac.in/courses/106105093

2. NPTEL Course on "**Google Cloud Computing Foundation Course**", By Prof. Soumya Kanti Ghosh, IIT Kharagpur.

   Link: https://nptel.ac.in/courses/106105223

Recommended Websites:

1. www.whatiscloud.com
2. www.cloudcomputingpatterns.org
3. www.w3schools.com

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404404(D): AI for VLSI (Elective - III)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Digital CMOS Design
2. VLSI Design
3. Probability & Statistics / Basic Python Programming

Companion Course, if any:

1. Lab Practice -2

Course Objectives:

1. To understand core concepts of Artificial Intelligence and Machine Learning.
2. To apply learning and optimization algorithms to engineering problems.
3. To understand AI techniques relevant to Electronic Design Automation (EDA).
4. To apply AI methods to VLSI design, testing, and physical design.
5. To analyze AI-based optimization for power, performance, and area.
6. To evaluate emerging AI-driven VLSI design methodologies

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

CO1**:** Explain fundamentals of Artificial Intelligence and intelligent systems.
CO2**:** Analyze supervised and unsupervised machine learning algorithms.
CO3**:** Apply deep learning and optimization techniques to engineering problems.
CO4**:** Apply AI techniques in VLSI synthesis and design space exploration.
CO5**:** Analyze AI-based approaches for VLSI testing and fault diagnosis.
CO6**:** Evaluate AI-driven physical design and intelligent VLSI systems.

Course Contents

Unit I	**Introduction to Artificial Intelligence**	**6 Hrs.**
Artificial Intelligence: definition, history, and scope, Types of AI: Narrow AI, General AI, Intelligent systems, AI applications in engineering and electronics, Intelligent agents: structure, environment, and performance measures, Problem formulation in AI, Basic uninformed and informed search techniques.		
Mapping of Course Outcomes for Unit I	CO1: Explain fundamentals of Artificial Intelligence and intelligent systems.	
Unit II	**Machine Learning Fundamentals**	**6 Hrs.**
Introduction to machine learning and data-driven modeling, Learning paradigms: supervised, unsupervised, and reinforcement learning, Regression techniques: linear and logistic regression, Classification algorithms: K-Nearest Neighbors, Decision Trees, Naive Bayes ,Model evaluation metrics: accuracy, precision, recall, confusion matrix, Over fitting, under fitting, and cross-validation.		

Mapping of Course Outcomes for Unit II	CO2: Analyze supervised and unsupervised machine learning algorithms.	
Unit III	**Deep Learning and Optimization Techniques**	**6 Hrs.**
Artificial Neural Networks: perceptron and multilayer perceptron, Back propagation algorithm, Deep learning architectures, Convolutional Neural Networks (CNNs), Recurrent Neural Networks (RNNs), Optimization techniques: Gradient Descent, Genetic Algorithms, Particle Swarm optimization, Regularization and hyper parameter tuning.		
Mapping of Course Outcomes for Unit III	CO3: Apply deep learning and optimization techniques to engineering problems.	
Unit IV	**AI in VLSI Design and Synthesis**	**7 Hrs.**
Role of AI in VLSI design automation ,AI-based logic synthesis and optimization ,Machine learning for design space exploration (DSE) ,AI-driven performance, power, and area optimization, AI-assisted high-level synthesis, Case studies of AI-enabled EDA tools		
Mapping of Course Outcomes for Unit IV	CO4: Apply AI techniques in VLSI synthesis and design space exploration.	
Unit V	**AI in VLSI Testing and Verification**	**7 Hrs.**
Challenges in VLSI testing and verification, Machine learning for fault detection and diagnosis, AI-based test pattern generation, Intelligent Built-In Self-Test (BIST) techniques, AI for yield prediction and defect classification		
Mapping of Course Outcomes for Unit V	CO5: Analyze AI-based approaches for VLSI testing and fault diagnosis.	
Unit VI	**AI-based Physical Design and Intelligent VLSI Systems**	**6 Hrs.**
AI for floor planning, placement, and routing, Machine learning for timing analysis and congestion prediction, AI-based power and thermal management, Hardware accelerators for AI (AI chips, NPUs, TPUs), AI-enabled adaptive and self-healing VLSI systems, Future trends: autonomous chip design and AI-native EDA tools.		
Mapping of Course Outcomes for Unit VI	CO6**:** Evaluate AI-driven physical design and intelligent VLSI systems.	

Learning Resources

Text Books:

1. Stuart Russell & Peter Norvig, Artificial Intelligence: A Modern Approach, Pearson.
2. Tom M. Mitchell, Machine Learning, McGraw-Hill.
3. Ian Goodfellow et al., Deep Learning, MIT Press.
4. Jan M. Rabaey et al., Digital Integrated Circuits, Pearson.
5. Ashok K. Sharma, Advanced Semiconductor Memories, Wiley (AI-based design references).

Reference Books:

1. Hennessy & Patterson, Computer Architecture: A Quantitative Approach.
2. IEEE Papers on AI in EDA and VLSI Design Automation

MOOC Courses Links:

1. NPTEL Course on “Introduction to Artificial Intelligence, Foundation & Algorithm” by Prof Mausam, IIT Delhi
   Link: https://nptel.ac.in/courses/106102220

2. Swayam NPTEL Course on “VLSI Physical Design” by Prof Indraneel SenGupta, IIT Kharagpur
   Link: https://onlinecourses.nptel.ac.in/e-learning/preview/noc21_cs12

3. Coursera course on “AI for Everyone (Andrew Ng)”
   Link: https://www.coursera.org/learn/ai-for-everyone

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404405(A): Electronics Product Design (Elective - IV)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Electronics Circuits
2. Digital Circuits

Companion Course, if any:

Course Objectives:

1. To understand the stages of product (hardware/ software) design and development.
2. To learn the different considerations of analog, digital and mixed circuit design.
3. To be acquainted with methods of PCB design and different tools used for PCB Design.
4. To understand the importance of testing in product design cycle.
5. To understand the processes and importance of documentation.

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

CO1: Understand and explain design flow of design of electronics product.
CO2: Associate with various circuit design issues and testing.
CO3: Inferring different software designing aspects and the Importance of product test & test specifications.
CO4: Summarizing printed circuit boards and different parameters.
CO5: Estimating assorted product design aspects.
CO6: Exemplifying special design considerations and importance of documentation.

Course Contents

Unit I	**Introduction to Electronic Product Design**	**6 Hrs.**

Overview of System Engineering, System Perspectives, Documentation, Concept Development, Requirements, Design Development, Rapid Prototyping and Field Testing, Validation, Verification and Integration, Maintenance and Life Cycle Costs, Failure, Iteration and Judgment, Good Engineering, Architecturing, Design Concerns and Heuristics, Teamwork and Trust.

Mapping of Course Outcomes for Unit I	CO1: Understand and explain design flow of design of electronics product.

Unit II	**Circuit Design and Testing Methods**	**6 Hrs.**

From Symbols to Substance, Convert Requirements into Design, Reliability, Fault Tolerance, High Speed Design, Low Power Design, Noise and Error Budget, Standard Data Buses and Networks, Reset and Power Failure Detection, Interface: Inputs, Outputs, Breadboards, Evaluation Boards and Prototypes.

Mapping of Course Outcomes for Unit II	CO2: Associate with various circuit design issues and testing.

Unit III	Software Design and Testing Methods	6 Hrs.
Types of Software, Traditional Software Life Cycle, Models, Metrics and Software Limitations, Risk Abatement and Failure Preventions, Software Bugs and Testing, Good Programming Practice, User Interface, Embedded, Real Time Software, Case Studies and Design Examples.		
Mapping of Course Outcomes for Unit III	CO3: Inferring different software designing aspects and the Importance of product test & test specifications.	
Unit IV	**PCB Design**	**6 Hrs.**
Circuit Boards, Component Placement, Routing Signal Traces, Grounds, Returns and Shields, Connectors and Cables, Design for Manufacture, Testing and Maintenance, Power Conversion Choices, Power Distribution, Line Conditioning, Electromagnetic Interference, Heat Transfer, Mechanisms For Cooling, Heat Sink Selection, Heat Pipes and Thermal Pillows, Fans and Forced Cooling, Liquid Cooling, Evaporation and Refrigeration, Trade-Offs In Design.		
Mapping of Course Outcomes for Unit IV	CO4: Summarizing printed circuit boards and different parameters.	
Unit V	**Product Debugging and Testing**	**6 Hrs.**
Steps of Debugging, Techniques for Troubleshooting, Characterization, Electromechanical Components, Passive Components, Active Components, Active Devices, Operational Amplifier, Analog-Digital Conversion, Digital Components, Inspection and Test of Components, Simulation, Prototyping and Testing, Integration, Validation and Verification. Procurement, Manufacturing, Maintenance and Repair.		
Mapping of Course Outcomes for Unit V	CO5: Estimating assorted product design aspects.	
Unit VI	**Documentation**	**6 Hrs.**
Definition, Need, Types of Documentation, Records, Accountability and Liability. Audience. Preparation, Presentation, Preservation of Documents. Methods of Documentation, Visual Techniques, Layout of Documentation, Bill of Material.		
Mapping of Course Outcomes for Unit VI	CO6: Exemplifying special design considerations and importance of documentation.	

Learning Resources

Text Books:

1. Kim Fowler, “Electronic Instrument Design”, Oxford University Press.
2. Robert J. Herrick, “Printed Circuit board design Techniques for EMC Compliance”, 2nd Edition, IEEE press.

Reference Books:

1. James K. Peckol, “Embedded Systems – A Contemporary Design Tool”, Wiley Publication
2. J.C. Whitakar, “The Electronics Handbook”, CRC press.

Udemy Courses :

1. Introduction to Product Management
   Link: https://www.udemy.com/product-management/
2. Fundamental Steps of Product Management
   Link: https://www.udemy.com/productmgt/
3. Digital Product Manufacturing: The Roadmap to Success
   Link: https://www.udemy.com/digital-product-manufacturing/
4. Agile Product Owner Career Guide
   Link: https://www.udemy.com/product-owner-career-guide/

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404405(B): Semiconductor Packaging and Testing (Elective - IV)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Semiconductor physics and devices (basic understanding of PN junctions, MOSFETs, and IC fabrication).
2. VLSI technology or microelectronics fundamentals, including basic IC manufacturing processes.
3. Electronic materials and their electrical and thermal properties.
4. Basic concepts of heat transfer and thermal analysis (desirable but not mandatory).
5. Fundamentals of electronic circuits and systems.

Companion Course, if any:

Course Objectives:

1. To understand fundamentals of semiconductor packaging and technologies.
2. To develop knowledge of advanced packaging interconnects materials, and substrates used in high-performance semiconductor devices.
3. To provide solutions to Thermal management challenges in advanced semiconductor packaging.
4. To familiarize students with testing methodologies, reliability considerations, and failure analysis techniques specific to advanced packaging,
5. To explore the emerging trends, industrial requirements, challenges, and future opportunities in advanced semiconductor packaging.

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

CO1: Understand the basics and evolution of semiconductor packaging.
CO2: Explain traditional semiconductor packaging technologies.
CO3: Understand advanced packaging concepts such as 2.5D and 3D.
CO4: Analyze advanced packaging interconnect technologies.
CO5: Explain advanced packaging materials and thermal management techniques.
CO6: Understand testing, reliability, and future trends in advanced packaging.

Course Contents

Unit I	**Introduction to Semiconductor Packaging**	**6 Hrs.**
Introduction to semiconductor packaging families – THP, SMP, CSP, BGA, QFP,DIP, WLP, 2.5D and 3D, and MEMS - Basic schematic , Definition , and comparisons with respect to mounting type, density, cost , applications etc. Front end and backend manufacturing process, OSAT Ecosystem.		
Mapping of Course Outcomes for Unit I	CO1: Understand the basics and evolution of semiconductor packaging.	
Unit II	**Traditional Packaging Technology**	**6 Hrs.**
Traditional Packaging Technologies: Exploring different packaging technologies, such as leaded and leadless packages, surface mount technology (SMT), and ball grid array (BGA). Discuss the purpose and characteristics of each technology and explain the factors influencing technology selection.		
Mapping of Course Outcomes for Unit II	CO2: Explain traditional semiconductor packaging technologies.	

Unit III	Advance Packaging Technology	6 Hrs.
Introduction to Advanced Packaging: Definition of advanced packaging and its importance in meeting evolving technology requirements. Explaining the benefits and challenges associated with advanced packaging. Exploring different integrated technologies of advanced packaging such as 2.5D, and 3D packaging.		
Mapping of Course Outcomes for Unit III	CO3: Understand advanced packaging concepts such as 2.5D and 3D.	
Unit IV	**Advance Packaging Interconnects and Materials**	**6 Hrs.**
Advanced Packaging Interconnects: Working principle and considerations on interconnect technologies used in advanced packaging, such as flip chip bumping, solder balls, and through-silicon vias (TSVs). Advanced Packaging Materials and Substrates: Detail of the substrates and materials used in advanced packaging- Organic substrate, build up substrates, Redistribution layers (RDLs), interposers and fan-out substrates. Properties and Applications of common material used in packaging- Ceramic, Plastic, Metal, Organic Substrate, and Ceramic-metal composite.		
Mapping of Course Outcomes for Unit IV	CO4: Analyze advanced packaging interconnect technologies.	
Unit V	**Thermal Management in Advanced Packaging**	**6 Hrs.**
Introduction to the importance of thermal management in advanced packaging. Discussion on various thermal management techniques such as heat sinks, thermal interface materials (TIMs), and thermal vias. Explanation of the design considerations for effective thermal management.		
Mapping of Course Outcomes for Unit V	CO5: Explain advanced packaging materials and thermal management techniques.	
Unit VI	**Testing and Reliability in Advanced Packaging**	**6 Hrs.**
The testing methodologies and reliability considerations specific to advanced packaging. Discussion on package-level testing, interconnect testing, and reliability testing. Explanation of various failure analysis techniques and strategies for ensuring package reliability.		
Mapping of Course Outcomes for Unit VI	CO6: Understand testing, reliability, and future trends in advanced packaging.	
Learning Resources		
Text Books: 1. Fundamentals of Device and Systems Packaging: Technologies and Applications by Rao R. Tummala, McGraw Hill Publications 2. Microelectronics Packaging Handbook by Rao R. Tummala, Eugene J. Rymaszewski, and Alan G. Klopfenstein 3. Semiconductor Advanced Packaging by John H. Lau (2021)		
Reference Books: 1. Materials for Advanced Packaging" (2nd Ed) by Daniel Lu and C.P. Wong (2016) 2. Semiconductor Packaging: Materials Interaction and Reliability" by Andrea Chen and Randy Hsiao Yu Lo (2017) 3. Advanced Electronic Packaging" (2nd Ed) by Richard K. Ulrich and William D. Brown (2006)		

MOOC / NPTEL Courses:

NPTEL / Free Online Video Courses

1. NPTEL course on “An Introduction to Electronics Systems Packaging”
   Link: https://archive.nptel.ac.in/courses/108/108/108108031/

2. NPTEL course on Supplementary Materials:
   Link: https://www.nptelprep.in/courses/108108031/materials

3. NPTEL course on “Electronic Packaging and Manufacturing” by Anandroop Bhattacharya, Prof. Gautam Chakraborty, IIT Kharagpur.
   Link: https://onlinecourses.nptel.ac.in/noc25_me18/preview

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404405(C): Semiconductor Memory Design (Elective - IV)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Analog and Digital CMOS Design

Companion Course, if any:

Course Objectives:

1. To understand the physical principles, device structures, and circuit operation of semiconductor memories.
2. To analyze and compare volatile and non-volatile memory technologies used in modern electronic systems.
3. To study memory fault mechanisms and apply design-for-testability and fault-tolerant techniques.
4. To understand reliability, radiation effects, and failure mechanisms in semiconductor memories.
5. To learn advanced memory technologies and high-density packaging techniques for future systems.
6. To develop the ability to evaluate memory technologies for specific applications such as embedded, space, and high-performance systems.

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

CO1: Understand SRAM and DRAM technologies.
CO2: Describe non-volatile memory technologies.
CO3: Apply appropriate testing techniques to improve memory reliability.
CO4: Analyze reliability issues and failure mechanisms in semiconductor memories.
CO5: Apply radiation-hardening and testing methods for memory systems.
CO6: Evaluate emerging memory technologies and high-density memory packaging techniques for next-generation electronic systems.

Course Contents

Unit I	Random Access Memory Technologies	7 Hrs.

Random Access Memory Technologies: Static Random Access Memories (SRAMs): SRAM cell structure-MOS SRAM architecture, MOS SRAM cell and peripheral circuit operation, bipolar SRAM technologies, silicon on insulator (SOI) technology, advanced SRAM architectures and technologies, application specific SRAMs.
Dynamic Random Access Memories (DRAMs): DRAM technology development, CMOS CRAMs, DRAMs cell theory and advanced cell structures- BiCMOS DRAMs-soft error failure in DRAMs, Advanced DRAM designs and architecture, application specific DRAMs.

Mapping of Course Outcomes for Unit I	CO1: Understand SRAM and DRAM technologies.	
Unit II	Nonvolatile Memories	7 Hrs.

Nonvolatile Memories **:** Masked Read, only memories (ROMs): High density ROMs, programmable read-only memories (PROMs)- bipolar PROMs, CMOS PROMs, erasable (UV)- Programmable read-only memories (EPROMs) - Floating Gate EPROM cell- one, time programmable (OTP) EPROM Electrically Erasable PROMs (EEPROMs), EEPROM technology and architecture, nonvolatile SRAM-Flash memories (EPROMs or EEPROM), Advanced flash memory architecture		
Mapping of Course Outcomes for Unit II	CO2: Describe non-volatile memory technologies.	
Unit III	**Testing and memory design for Testability and fault tolerance**	**6 Hrs.**
Memory fault modeling, testing and memory design for Testability and fault tolerance, RAM fault modeling, electrical testing, Pseudo random testing, megabit DRAM testing nonvolatile memory modeling and testing, IDDQ fault modeling and testing, application specific memory testing.		
Mapping of Course Outcomes for Unit III	CO3: Apply appropriate testing techniques to improve memory reliability.	
Unit IV	**Semiconductor memory reliability**	**6 Hrs.**
Semiconductor memory reliability and radiation effects: General Reliability issues, RAM failure modes and mechanism, nonvolatile memory reliability, reliability modeling and failure rate prediction, design for reliability, reliability test structures, reliability screening and qualification.		
Mapping of Course Outcomes for Unit IV	CO4: Analyze reliability issues and failure mechanisms in semiconductor memories .	
Unit V	**Radiation effects**	**6 Hrs.**
Radiation effects, single event phenomenon (SEP)- radiation hardening techniques, radiation hardening process and design issues, radiation hardened memory characteristics, radiation hardness assurance and testing, radiation dosimetry, water level radiation testing and test structures		
Mapping of Course Outcomes for Unit V	CO5: Apply radiation-hardening and testing methods for memory systems.	
Unit VI	**Advanced memory technologies and high-density memory packaging technologies**	**7 Hrs.**
Advanced memory technologies and high-density memory packaging technologies: Ferroelectric Random Access Memories (FRAMs), Gallium Arsenide (GaAs) FRAMs, Analog memories, magnetoresistive random access memories (MRAMs), Experimental memory devices. Memory hybrids and MCMs (2D), Memory stacks and MCMs (3D), Memory MCM test and reliability issues- memory cards- high density memory packaging future directions.		
Mapping of Course Outcomes for Unit VI	CO6: Evaluate emerging memory technologies and high-density memory packaging techniques for next-generation electronic systems.	
Learning Resources		

Text Books:

1. Ashok K. Sharma, Semiconductor Memories: Technology, Testing, and Reliability, Wiley-IEEE Press, 1st Edition.
2. Ashok K. Sharma, Advanced Semiconductor Memories: Architectures, Designs, and Applications, Wiley, 1st Edition.
3. Andrea Redaelli & Fabio Pellizzer (Eds.), Semiconductor Memories and Systems, Woodhead Publishing (Elsevier), 2022 Edition.
4. Chenming C. Hu, Modern Semiconductor Devices for Integrated Circuits, Prentice Hall, 1st Edition.
5. Artur Balasinski, ed., Nanoscale Semiconductor Memories, O'Reilly Media, 1st Edition.
6. Cristiano Calligaro & Umberto Gatti, Rad-hard Semiconductor Memories, CRC/Taylor & Francis, 1st Edition.
7. John L. Hennessy & David A. Patterson, Computer Architecture: A Quantitative Approach, Morgan Kaufmann, 7th Edition.

Reference Books:

1. John P. Uyemura, System on a Chip Design, Elsevier, 1st Edition.
2. Jan M. Rabaey, Anantha Chandrakasan & Borivoje Nikolic, Digital Integrated Circuits, Pearson, 2nd/3rd Edition.

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404405(D): Deep Learning (Elective - IV)		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1. Engineering Mathematics
2. Signal Processing

Companion Course, if any:

Course Objectives:

1. To comprehend the theoretical foundations, algorithms and methodologies of Neural Network.
2. To design and develop an application using specific deep learning models and know complexity of Deep Learning algorithms and their limitations.
3. To examine the case studies of deep learning techniques.

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

CO1: Classify machine learning algorithms and its types.
CO2: Discuss the concepts of deep learning and its Frameworks.
CO3: Identify the deep learning architectures with respect to the applications.
CO4: Demonstrate different architectures of Convolutional neural networks.
CO5: Discuss natural language processing architectures.
CO6: Make use of various case studies and deep learning applications.

Course Contents

Unit I	Machine Learning	6 Hrs.

Introduction to Machine Learning, Types of Machines Learning, Linear Regression, Classification and Logistic Regression, Decision Tree and Random Forest, Naïve Bayes and Support Vector Machine. Applications of machine learning

Mapping of Course Outcomes for Unit I	CO1: Classify machine learning algorithms and its types.

Unit II	Introduction to Deep Learning and Frameworks	6 Hrs.

Deep Learning Basics: Intro, History, capabilities, the perceptron, Multi Layer Perceptron, ANN architecture. Tensor Flow, Creating and Manipulating Tensor Flow Variables, Tensor Flow Operations, Placeholder Tensors, Managing Models over the CPU and GPU, Specifying the Logistic Regression Model in Tensor Flow, Logging and Training the Logistic Regression, Introduction to Keras, PyTorch.

Mapping of Course Outcomes for Unit II	CO2: Discuss the concepts of deep learning and its Frameworks.

Unit III	Deep Learning Architecture	6 Hrs.

Width and Depth of Neural Networks, Different Activation Functions, Batch-normalization, Overfitting and generalization., Dropout, regularization Unsupervised Training of Neural Networks, Restricted Boltzmann Machines, Auto Encoders, Deep Learning Applications

Mapping of Course Outcomes for Unit III	CO3: Identify the deep learning architectures with respect to the applications**.**	
Unit IV	**Computer Vision**	**6 Hrs.**
Architectural Overview, Motivation, Layers, Filters, Parameter sharing, Regularization, Convolution neural networks (CNNs), convolution, pooling and its variations, different deep CNN architectures - LeNet, AlexNet, VGG, PlacesNet, DenseNet, training a CNNs: weights initialization, batch normalization, hyperparameter tuning. **Popular CNN Architectures:** ResNet, AlexNet – Applications.		
Mapping of Course Outcomes for Unit IV	CO4: Demonstrate different architectures of Convolutional neural networks.	
Unit V	**Natural Language Processing**	**6 Hrs.**
Recurrent Neural Networks, Bidirectional RNNs, Encoder-decoder sequence to sequence architectures - BPTT for training RNN, Long Short Term Memory Networks. Advanced RNN: LSTM, GRU, introduction to Generative Adversarial Networks (GANs).		
Mapping of Course Outcomes for Unit V	CO5: Discuss natural language processing architectures.	
Unit VI	**Case Study and Applications**	**6 Hrs.**
Computer Vision: Image Classification, Image net- Detection-Audio Wave Net. **Natural Language Processing:** Sentimental Analysis, Text preprocessing and chatBot		
Mapping of Course Outcomes for Unit VI	CO6: Make use of various case studies and deep learning applications.	

Learning Resources

Text Books:

1. Nikhil Buduma, “Fundamentals of Deep Learning Designing Next-Generation Machine Intelligence Algorithms”, 1st Edition, O’REILLY.
2. Michael Nielsen, “Neural Networks and Deep Learning”, Determination Press.
3. Ian Goodfellow, YoshuaBengio and Aaron Courville, “Deep Learning”, MIT Press.
4. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media.
5. Kevin P. Murphy "Machine Learning: A Probabilistic Perspective", The MIT Press.
6. Ethem Alpaydin,"Introduction to Machine Learning”, 3rd Edition, Prentice Hall of India.
7. Umberto Michelucci “Applied Deep Learning. A Case-based Approach to Understanding”, Deep Neural Networks” Apress, 2018.

Reference Books:

1. Goodfellow. I., Bengio.Y., and Courville, A.,“Deep Learning”, MIT Press.
2. Bishop, C.M., “Pattern Recognition and Machine Learning”, Springer.
3. Satish Kumar, “Neural Networks: A Classroom Approach”, Tata McGraw-Hill Education.

MOOC / NPTEL Courses:

1. NPTEL Course on "**Deep Learning**", by Prof. Prabir Kumar Bhiswas, IIT Kharagpur.
   Link of the Course: https://nptel.ac.in/courses/106105215

2. NPTEL Course on "**Deep Learning - Part I**", by Prof. Sudarshan Iyengar, Prof Sanatan Sukhija IIT Ropar
   Link of the Course: https://nptel.ac.in/courses/106106184

Savitribai Phule Pune University **Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)** **404406: Lab Practice - 1**		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Practical: 04 Hrs. / Week	**02**	**Practical: 50 Marks** **Termwork: 25**

Companion Course, if any:

1. IOT and Embedded Systems
2. Advanced RTL Simulation and Synthesis

Guidelines for Student's Lab Journal

The student's Lab Journal can be experimental write-ups. It should include following as applicable: Assignment No, Title of Assignment, Date of Performance, Date of Submission, Aims & Objectives, Theory, Description of data used, Results, Conclusion.

Guidelines for Lab /TW Assessment

The oral examination will be based on the work carried out by the student in the Lab course. Suitable rubrics can be used by the internal & external examiner for assessment.

Subject: IOT and Embedded Systems

Student should perform at least 8 experiments. Any two experiments from group A and any five assignments from group B and one from group C.

(Use suitable programming language/Tool for implementation)

List of Experiments

Group A

1.	Study of Raspberry Pi 4, Arduino board and Operating systems for the same. Understand the process of OS installation on the Raspberry Pi.
2.	Study of different sensors:- temperature sensor, bio-sensor, IR sensor, chemical sensor(PH), gauge sensor, ultrasonic sensor etc.
3.	Understand the connection and configuration of GPIO and its use in programming. Write an application of the use of push switch and LEDs.
4.	Write an application to read temperature from the environment. If temperature crosses threshold value, then it notifies with buzzer.

Group B

5.	Interface IR sensor to Raspberry Pi/ Arduino. Write a program to detect obstacle using IR sensor and notify it using LED.
6.	Understanding and connectivity of Raspberry-Pi /Beagle board with a Zigbee module. Write a network application for communication between two devices using Zigbee to on and off remote led.
7.	Interface stepper motor and seven segment display with Raspberry Pi/Arduino and write a program to control the motion of motor and display number of rotation made by motor on 7 segment display.

8.	Write an application using Raspberry Pi/Arduino for streetlight control system. System consists of smart street lights that have external light sensing that automatically turns on at desired intensity based on amount of lighting needed.
9.	Write an application using Raspberry Pi/Arduino for traffic signal monitoring and control system.
10.	Write an application using Raspberry Pi/Arduino for smart health monitoring system which records heart beat rate and temperature and also sends sms alerts if readings are beyond critical values.
11.	Implement a weather monitoring system using humidity, temperature and raindrop sensor and Raspberry Pi/Arduino board.
12.	Create a simple web interface for Raspberry-Pi/Beagle board to control the connected LEDs remotely through the interface.
Group C	
13.	Internet of things enabled real time water quality monitoring system.
14.	Implement smart home automation system. The system automates home appliances and control them over internet from anywhere.
15.	Develop a Real time application like a smart home security. **Description**: When anyone comes at door the camera module automatically captures his image and sends a notification to the owner of the house on his mobile phone using GSM modem.

Subject: Advanced RTL Simulation and Synthesis Laboratory

List of Experiments

1.	16:1 Multiplexer using two 8:1 Multiplexers.
2.	4 bit ALU for Add, Subtract, AND, NAND, OR, XOR & XNOR.
3.	Universal shift register with mode selection input for SISO, SIPO, PISO, & PIPO.
4.	Mod - N Counter
5.	Ring and twisted ring counter
6.	FIFO Memory
7.	Sequence generator
8.	Sequence detector.

Virtual Lab:

1. https://vlsi-iitg.vlabs.ac.in (Digital VLSI Design Lab.)
2. https://cse14-iiith.vlabs.ac.in/ (VLSI Lab.)

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404407: Lab Practice - 2		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Practical: 04 Hrs. / Week	**02**	**Practical: 50 Marks** **Teamwork: 25 Marks**

Companion Course, if any:

1. MOS Device Modeling and Characterization
2. Industrial Drives & Automation (Elective - III)
3. Reconfigurable Computing (Elective - III)
4. Cloud Computing (Elective - III)
5. AI for VLSI (Elective – III)

Guidelines for Student's Lab Journal

The student's Lab Journal can be experimental write-ups. It should include following as applicable: Assignment No, Title of Assignment, Date of Performance, Date of Submission, Aims & Objectives, Theory, Description of data used, Results, Conclusion.

Guidelines for Lab /TW Assessment

The oral examination will be based on the work carried out by the student in the Lab course. Suitable rubrics can be used by the internal & external examiner for assessment.

Subject: MOS Device Modeling and Characterization

List of Experiment

Student should perform at least 8 experiments. Any Four experiments from group A and group B

Group A	
1.	Study and comparison of MOSFET SPICE models (Level-1, Level-2, BSIM) using SPICE simulator.
2.	Study Extraction of threshold voltage (Vth) of MOSFET using different extraction methods.
3.	Study Mobility extraction of MOSFET from Id–Vg characteristics using SPICE simulation.
4.	Study Extraction of trans conductance (gm) and its variation with gate voltage.
5.	Study Extraction of output resistance (ro) from Id–Vd characteristics in saturation region.
Group B	
6.	Study of channel length modulation and extraction of λ parameter.
7.	Study of temperature effect on MOSFET parameters using SPICE simulator.
8.	Study Effect of oxide thickness on threshold voltage and drain current using device simulator.
9.	Study CMOS inverter characterization at device level (switching threshold, noise margin, delay).

10.	Study Characterization of MOSFET for different W/L ratios and current scaling analysis.

Subject: Industrial Drives and Control (Elective - III)	
List of Experiments	
1.	DC motor control using full single phase converter.
2.	Dual converter single phase controlled dc drives
3.	Microprocessor/microcontroller based single phase controlled dc drives.
4.	Four quadrant chopper reversible dc drives.
5.	Three phase induction motor control using PWM inverters.
6.	Microprocessor/microcontroller based single phase control AC drive.
7.	Simulation of DC drives using of power SIM.
8.	Simulation of AC drives using of power SIM.
9.	Case study on drive application **(Industrial Visit)** Industrial visit to company dealing with Variable Speed DC Drive replacing an existing troublesome DC control system, resulting in increased production and reduced downtime.

Subject: Reconfigurable Computing (Elective - III)

List of Experiments

1.	Implement Boolean function using LUT concept.
2.	To Implement Half adder/Full using FPGA Configurable Logic Blocks.
3.	Implement multiplier using bit-level logic
4.	To Observe and analyze placement report and routing delay after synthesis
5.	To design and implement a multicontext (4) 4 LUT and implement using HDL and Download on FPGA.
6.	Top level modular and hierarchical designs of Adder and Subtractor such that they can be replaced.
7.	An adaptive design of LED shifter (Right & Left shift)
8.	Implementation of ALU block
9.	Implement and study complete FPGA Design Flow using Vivado

Subject: Cloud Computing (Elective - III)	
List of Experiments (Any 6 to be performed)	
1.	Install Google App Engine. Create hello world app and other simple web applications using python / java.
2.	Use GAE launcher to launch the web applications.
3.	Simulate a cloud scenario using CloudSim and run a scheduling algorithm that is not present in CloudSim.
4.	Find a procedure to transfer the files from one virtual machine to another virtual machine.
5.	Find a procedure to launch virtual machine using try stack (Online Openstack Demo Version)
6.	Design and deploy a PaaS environment.
7.	Design and develop custom Application (Mini Project) using Cloud (like Salesforce/GCP/AWS.)
8.	Design an Assignment to retrieve, verify, and store user credentials using Firebase Authentication, the Google App Engine standard environment, and Google Cloud Data store.
Case Studies (Any 2 to be performed)	
1.	Data storage security in private cloud.
2.	Application of IoT / Ubiquitous based on cloud.
3.	Tools for building private cloud.
4.	Instance creation in cloud environment.

Subject: AI for VLSI (Elective - III)	
List of Experiments (Any 8 to be performed)	
1.	Implementation of basic AI search algorithms using Python
2.	Supervised learning algorithms for classification
3.	Power or delay prediction of CMOS circuits using ML
4.	Neural network-based fault classification in VLSI
5.	Genetic algorithm-based VLSI floor planning
6.	ML-based design space exploration for PPA optimization
7.	AI-based yield prediction using process data
8.	CNN-based pattern recognition for layout or lithography
9.	AI-based timing violation prediction
10.	Mini-project on AI applications in VLSI

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)
404408: Project Phase – I

Teaching Scheme:	Credit	Examination Scheme:
Practical: 02 Hrs. / Week	01	Term Work: 50 Marks

Course Objectives:

1. To understand the basic concepts & broad principles of projects.
2. To understand the value of achieving perfection in project implementation & completion.
3. To apply the theoretical concepts to solve real life problems with teamwork and Multidisciplinary approach.
4. To demonstrate professionalism with ethics; present effective communication skills and relate engineering issues to broader societal context.

Course Outcomes:

CO1: Demonstrate a sound technical knowledge in field of E&TC in the form of project.
CO2: Undertake real life problem identification, formulation and solution.
CO3: Design engineering solutions to complex problems utilizing a systematic approach.
CO4: Demonstrate the knowledge, effective communication skills and attitudes as professional engineer.

Project phase 1 is an integral part of the project work. The project work shall be based on the knowledge acquired by the student during the graduation and preferably it should meet and contribute towards the needs of the society. The project aims to provide an opportunity of designing and building complete system or subsystems in the field of Electronics and communication where the student likes to acquire specialized skills. The student shall prepare the duly certified Fourth report of project work in standard format for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

Guidelines:

1. Group Size: The student shall carry the project work individually or by a group of students. Optimum group size shall be 3 students. However, if project complexity demands a maximum group size of 4 students, the project committee should be convinced about such complexity and scope of the work. Projects selected should meet and contribute towards the needs of the society.
2. Selection and approval of topic: Topic should be related to real life application in the field of Electronics and Telecommunication engineering.
3. The topic may be based on: Investigation of the latest development in a specific field of Electronics or Communication / The investigation of practical problem in manufacture and / or testing of electronics or communication equipment/ Software based projects related to VHDL, Communication, Instrumentation, Signal Processing Agriculture Engineering etc. with the justification for techniques used / any topic in the field of E&TC may be allowed.
4. Interdisciplinary projects should be encouraged. The examination of Interdisciplinary projects shall be conducted independently in respective departments.
5. The term work assessment of project phase 1 shall be based on Innovative Idea of selected project, literature survey, Depth of understanding, Applications, Individual contributions, presentation, project report, timely completion of work.
6. The department should prepare project planner and should follow accordingly
7. A log book of work carried out during the semester should be maintained with weekly review remarks by the guide and committee.
8. A certified copy of report preferably using LATEX is required to be presented to external examiner at the time of Fourth examination.
9. The project report must undergo by plagiarism check and the similarity index must be less than 15%. The plagiarism report should be included in the project report.

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404191A: Mandatory Audit Course - 7		
Teaching Scheme:	**Credit**	**Examination Scheme:**
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GUIDELINES FOR CONDUCTION OF AUDIT COURSE

In addition to credits courses, it is mandatory that there should be audit course (non-credit course) from second year of Engineering. The student will be awarded grade as AP on successful completion of audit course. The student may opt for two of the audit courses (One in each semester). Such audit courses can help the student to get awareness of different issues which make impact on human lives and enhance their skill sets to improve their employability. List of audit courses offered in the semester is provided in the curriculum. Student can choose one of the audit course from list of courses mentioned. Evaluation of audit course will be done at institute level.

The student registered for audit course shall be awarded the grade AP and shall be included such grade in the Semester grade report for that course, provided student has the minimum attendance as prescribed by the Savitribai Phule Pune University and satisfactory in-semester performance and secured a passing grade in that audit course. No grade points are associated with this 'AP' grade and performance in these courses is not accounted in the calculation of the performance indices SGPA and CGPA. Evaluation of audit course will be done at institute level itself.

Selecting an Audit Course:

Using NPTEL Platform:

NPTEL is an initiative by MHRD to enhance learning effectiveness in the field of technical education by developing curriculum based video courses and web based e-courses. The details of NPTEL courses are available on its official website www.nptel.ac.in

- Student can select any one of the courses mentioned above and has to register for the corresponding online course available on the NPTEL platform as an Audit course.
- Once the course is completed the student can appear for the examination as per the guidelines on the NPTEL portal.
- After clearing the examination successfully; student will be awarded with certificate.

Assessment of an Audit Course:

- The assessment of the course will be done at the institute level. The institute has to maintain the record of the various audit courses opted by the students. The audit course opted by the students could be interdisciplinary.
- During the course students will be submitting the online assignments. A copy of same students can submit as a part of term work for the corresponding Audit course.
- On the satisfactory submission of assignments, the institute can mark as “Present” and the student will be awarded the grade AP on the mark sheet.

SEMESTER - VIII

<table>
<tr><td colspan="3">Savitribai Phule Pune University
Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)
404409: Verification using SV and UVM</td></tr>
<tr><td>Teaching Scheme:</td><td>Credit</td><td>Examination Scheme:</td></tr>
<tr><td>Theory: 03 hrs. / week</td><td>03</td><td>In-Sem(Theory): 30 Marks
End-Sem(Theory): 70 Marks</td></tr>
</table>

Prerequisite Courses, if any:

1. Verilog, HDL test bench,
2. Digital Design

Companion Course, if any:

1. **Verification using SV and UVM Lab**

Course Objectives:

1. To describe the concepts and features of SystemVerilog for functional verification.
2. To demonstrate the use of Universal Verification Methodology (UVM) in developing reusable verification environments.
3. To analyze the architecture and operation of UVM verification components.
4. To develop reusable and scalable UVM verification components.
5. To construct complete verification environments using SystemVerilog and UVM.
6. To evaluate digital designs using self-checking and coverage-driven UVM testbenches

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

CO1: Explain the fundamental concepts of SystemVerilog.
CO2: Apply UVM methodology to develop verification environments.
CO3: Develop UVM verification components.
CO4: Integrate UVM verification components to build verification environments.
CO5: Model verification environments using UVM and implement Register Abstraction Layer (RAL).
CO6: Design self-checking UVM testbenches for digital designs.

Course Contents

Unit I	System Verilog Overview	6 Hrs.

Overview of System Verilog : Data Types, System Verilog Strings, System Verilog Structure, System Verilog typedef and alias, System Verilog Constants, System Verilog Arrays, System Verilog Queue, System Verilog Dynamic Array, Classes, Control flow statements.

Mapping of Course Outcomes for Unit I	CO1: Explain the fundamental concepts of SystemVerilog.

Unit II	Introduction of UVM	6 Hrs.

Introduction to UVM: The Typical UVM Test bench Architecture- The UVM Class Library- Transaction-Level Modeling (TLM) -Overview- TLM, TLM-1, and TLM-2.0 -TLM-1 Implementation- TLM-2.0 Implementation

Mapping of Course Outcomes for Unit II	CO2: Apply UVM methodology to develop verification environments

Unit III	**Developing reusable verification components**	**6 Hrs.**

Modeling Data Items for Generation – Transaction-Level Components – Creating the Driver – Creating the Sequencer – Connecting the Driver and Sequencer -Creating the Monitor – Instantiating Components- Creating the Agent – Creating the Environment -Enabling Scenario Creation -Managing of Test-Implementing Checks and Coverage.

Mapping of Course Outcomes for Unit III	CO3: Develop UVM verification components

Unit IV	**UVM using verification components**	**6 Hrs.**

Creating a Top-Level Environment- Instantiating Verification Components – Creating Test Classes

Verification Component Configuration – Creating and Selecting a User-Defined Test – Creating Meaningful Tests- Virtual Sequences- Checking for DUT Correctness- Scoreboards Implementing a Coverage Model.

Mapping of Course Outcomes for Unit IV	CO4:. **:** Integrate UVM verification components to build verification environments.

Unit V	**UVM using the register layer classes**	**6 Hrs.**

Using The Register Layer Classes – Back-Door Access -Special Registers -Integrating a Register-Model in a Verification Environment- Integrating a Register Model- Randomizing Field Values Pre-Defined Sequences.

Mapping of Course Outcomes for Unit V	CO5: Model verification environments using UVM and implement Register Abstraction Layer (RAL).

Unit VI	**Assignment in testbenches**	**6 Hrs.**

Test bench: Architecture, Driver and Sequencer, Monitor, Agent and Env; Creating Sequences, Building Test, Design and Testing of Top Module.
Examples.

Mapping of Course Outcomes for Unit VI	CO6: Design self-checking UVM testbenches for digital designs.

Learning Resources

Text Books:

1. The UVM Primer, An Introduction to the Universal Verification Methodology, Ray Salemi, 2013.
2. SystemVerilog for Verification: A Guide to Learning the Testbench Language Features, Chris Spear, Greg Tumbush, 3rd edition, 2012.
3. Ashok B. Mehta, *Digital VLSI Design and Verification*, **1st Edition**, McGraw-Hill Education (India), **2014**.
4. Mark Glasser and Rob Mathews," *A Practical Guide to Adopting the Universal Verification Methodology (UVM)*, 1st Edition **Publisher:** Cadence Design Systems, **Year:** 2010

Reference Books:

1. Stuart Sutherland, Simon Davidmann, and Peter Flake, *SystemVerilog for Design*, 2nd Edition, Springer.
2. Jamie Cook, *UVM Cookbook*, Siemens EDA.
3. Accellera Systems Initiative," *Universal Verification Methodology (UVM) 1.2 User's Guide* **Version:** UVM 1.2, **Publisher:** Accellera Systems Initiative **Year:** 2015
4. Chris Spear and Greg Tumbush, *SystemVerilog for Verification*, 4th Edition, Springer International Publishing, 2018.
5. Janick Bergeron, *Writing Testbenches Using SystemVerilog*, 1st Edition, Springer, 2006.

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404410(A): Android Development (Elective - V)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 hrs. / week	03	In-Sem (Theory): 30 Marks End-Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Object Oriented Programming

Companion Course, if any:

1. **Lab Practice -3**

Course Objectives:

1. To understand the Android Operating System.
2. To study Android Apps Development Cycle.
3. To learn to create Android Applications.

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

CO1: Describe the process of developing mobile applications.

CO2: Create mobile applications on the different android platform.

CO3: Design and implement mobile applications involving data storage in databases.

Course Contents

Unit I	Introduction to JAVA and Android	6 Hrs.

Overview of Java, XML and SQL, History of Android, Android Stack, Android Project Structure, Android OS, Features of Android, Android Architecture and building blocks, Android App build process, Android UI– resources, themes, threads etc.,

Mapping of Course Outcomes for Unit I	CO1: Describe the process of developing mobile applications.

Unit II	Introducing Android	6 Hrs.

SDK Overview, Android Emulator, Android Installation, setting up development environment using Eclipse/ Android Studio, DDMS, Activity Lifecycle, Manifest File, Locales, Drawable, Listeners, Supporting Multiple Screens.

Mapping of Course Outcomes for Unit II	CO1: Describe the process of developing mobile applications.

Unit III	Android Application Structure	6 Hrs.

Android basic building blocks: Activities, Services, Broadcast Receivers & Content providers, UI Components - Views & notifications, Components for communication -Intents & Intent Filters, Android API levels (versions & version names) AndroidManifest.xml, Uses-permission & uses-sdk, Dalvik Virtual Machine &. apk file extension, Resources & R.java, Assets, Layouts & Drawable Resources, Activities and Activity lifecycle, First sample Application.

Mapping of Course Outcomes for Unit III	CO2: Create mobile applications on the different android platform.

Unit IV	Activities, Fragments, Intents and Android User Interface	6 Hrs.
Introduction to Activities, Activity Lifecycle, Introduction to Intents, Linking Activities using Intents, calling built-in applications using Intents, Introduction to Fragments, Adding Fragments Dynamically, Lifecycle of Fragment, Toast, Understanding the components of a screen, adapting to Display Orientation, Split Screen / Multi-Screen Activities.		
Mapping of Course Outcomes for Unit IV	CO2: Create mobile applications on the different android platform.	
Unit V	**Designing User Interface with Widgets**	**6 Hrs.**
Using Basic Views: Text View, Button, ImageButton, EditText, CheckBox, Switch, ToggleButton, Radio Button, and Radio Group Views, ProgressBar View, AutoCompleteTextView View, Using Picker Views, Using RecyclerView to Display Long Lists, Understanding Specialized Fragments, Displaying Pictures and Menus, VideoView. **Multimedia, Animation and Graphics:** Playing Audio, Playing Video, Rotate Animation, Fade In / Fade Out Animation, Zoom Animation, Scale Animation, 2D and 3D Graphics.		
Mapping of Course Outcomes for Unit V	CO3: Design and implement mobile applications involving data storage in databases.	
Unit VI	**Databases, Location-Based Services and Google Map**	**6 Hrs.**
Data Storage: Shared Preferences, Internal Storage, External Storage, SQLite Databases, Content provider. and Remote Databases. Introduction to SQLite and Room library, SQLite Open Helper and SQLite Database, Creating, opening and closing database, Creating, opening and closing database, Building and executing queries, SMS Messaging, Sending E-mail, Web App**,** JSON Parsing, JSON Web Service, Display Google Maps, Getting Location Data, Monitoring a Location. Accessing Phone services (Call, SMS, MMS), Network connectivity services, Sensors, Bluetooth/Wi-Fi Connectivity.		
Mapping of Course Outcomes for Unit VI	CO3: Design and implement mobile applications involving data storage in databases.	

Learning Resources

Text Books:

1. David Griffiths and Dawn Griffiths, "Head First Android Development: A Brain-Friendly Guide", 2nd Edition, Shroff / O'Reily Publication
2. Barry Burd, "Java Programming for Android Developers for Dummies", 2nd Edition, Dummies.
3. Wei-Meng Lee, "Beginning Android 4 Application Development", WROX Publication

Reference Books:

1. Herbert Schildt, “Java: The Complete Reference”, 9th Edition, Tata McGraw Hill
2. Reto Meier, “Professional Android 4 Application Development”, John Wiley and sons
3. John Horton, “Android Programming for Beginners”, 3rd Edition, Packt Publication

MOOC / NPTEL Courses:

1. NPTEL Course on “**Introduction to Mobile Application Development**”, by Prof. G.Raina, T.Gopal , IIT Madras

   Link of the Course: https://nptel.ac.in/courses/106106156

2. Swayam Course on “**Android Mobile Application Development**”, by Dr. Himanshu.N.Patel, Dr. Babasaheb Ambedkar Open University Ahmedabad.

   Link of the Course: https://onlinecourses.swayam2.ac.in/nou21_ge41/preview

Ebooks:

1. https://enos.itcollege.ee/~jpoial/allalaadimised/reading/Android-Programming- Cookbook.pdf.
2. https://www.programming-book.com/download/?file=10988
3. https://www.programmer-books.com/professional-android-4th-edition-pdf/

Websites:

1. https://developer.android.com
2. https://www.javatpoint.com/android-tutorial

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404410(B): Mobile Computing (Elective - V)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Basics of Communication Technologies.
2. Fundamental of Networking

Companion Course, if any:

1.Lab Practice -3

Course Objectives:

1. To learn Wireless technologies and planning Ad-hoc Network.
2. To study the basics of wireless, cellular technology and the working of Mobile IP, ad hoc network, features of mobile operating systems.
3. To understand the use of M-Commerce application.

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

CO1: Understand concepts of Mobile Communication.
CO2: Analyse next generation Mobile Communication System.
CO3: Understand network layers of Mobile Communication.
CO4: Understand IP and Transport layers of Mobile Communication.
CO5: Study of different mathematical models.
CO6: Understand different mobile applications.

Course Contents

Unit I	Introduction to Mobile Computing	6 Hrs.

Introduction to Mobile Computing: Applications of Mobile Computing- Generations of Mobile Communication Technologies, multiplexing: Spread spectrum, MAC Protocols: SDMA, TDMA, FDMA, and CDMA.

Mapping of Course Outcomes for Unit I	CO1: Understand concepts of Mobile Communication.

Unit II	Mobile Telecommunication System	7 Hrs.

Introduction to Cellular Systems, GSM architecture, Protocols, Connection Establishment, Frequency Allocation, Routing, Mobility Management, Security, GPRS and UMTS: Architecture, Handover, Security.
Introduction to 5G: Introduction, 5G network architecture, Applications, 5G enable technologies, Recent trends in Telecommunication Industries.

Mapping of Course Outcomes for Unit II	CO2: Analyse next generation Mobile Communication System.

Unit III	Network Layer	6 Hrs.

Mobile IP, DHCP, AdHoc, Proactive protocol-DSDV, Reactive Routing Protocols: DSR, AODV, Hybrid routing: ZRP, Multicast Routing: ODMRP, Vehicular Ad Hoc networks (VANET), MANET Vs VANET: Security.

Mapping of Course Outcomes for Unit III	CO3: Understand network layers of Mobile Communication.

Unit IV	**Mobile IP and Transport Layer**	**7 Hrs.**

Mobile IP: Need of mobile IP, IP packet delivery, Agent Discovery, Registration, Tunnelling and encapsulation, Route optimization, IP Handoff.

Transport Layer: Overview of Traditional TCP and implications of mobility control. Improvement of TCP: Indirect TCP, Snoop TCP, Mobile TCP, Fast Retransmit/fast recovery, Time-out freezing, Selective retransmission, Transaction-oriented TCP.

Mapping of Course Outcomes for Unit IV	CO4: Understand IP and TCP layers of Mobile Communication.

Unit V	**Fading Channels**	**7 Hrs.**

Rayleigh Fading and Statistical Characterization, Properties of Rayleigh Distribution, BER in Fading, Narrowband vs Wideband Channels, Characterization of Multipath Fading Channels, Choice of Modulation, Coherent versus Differential Detection, BER in Fading, Ricean Fading.

Mapping of Course Outcomes for Unit V	CO5: Study of different mathematical models.

Unit VI	**Operating System & Applications of Mobile Computing**	**8 Hrs.**

Operating System: A Few Basic Concepts, Special Constraints and Requirements of Mobile OS, A Survey of Commercial Mobile Operating Systems, Windows Mobile, Palm OS, Symbian OS, iOS, Android, Blackberry OS, A Comparative study of Mobile OS, OS for sensor Network.

Applications: M-Commerce, Business to Consumer (B2C) Applications, Business to Business (B2B) Applications. Structure of M-Commerce, Pros and Cons of M-Commerce, Mobile Payment System, Mobile Payment Schemes, Desirable properties of a Mobile Payment system, Mobile Payment solutions, Process of Mobile Payment, Security Issues.

Mapping of Course Outcomes for Unit VI	CO6: Understand different mobile applications.

Learning Resources

Text Books:

1. Clint Smith, Daniel Collins, “Wireless Networks”, 3rd Edition, McGraw Hill Publications,
2. Share Conder, Lauren Darcey, “Android Wireless Application Development”, Volume I, 3rd Edition, Pearson.

Reference Books:

1. Jochen Schiller, “Mobile Communications”, 2nd Edition, Pearson.
2. Paul Bedell, “Cellular networks: Design and Operation – A real world Perspective”, Outskirts Press.
3. Zigurd Mednieks, Laird Dornin, G, Blake Meike and Masumi Nakamura, “Programming Android”, O”Reilly.
4. Alasdair Allan, “iPhone Programming”, O”Reilly.
5. Donny Wals, “Mastering iOS 12 Programming”.
6. Reza B”Far, “Mobile Computing principles”, Cambridge University Press.

MOOC / NPTEL Courses:

1. NPTEL Course **“**Mobile Computing**”b**y Prof. Sridhar Iyer and Prof. Pushpendra Singh IIT Madras

   Link of the Course: https://nptel.ac.in/courses/106106147

2. NPTEL Course **“Funadamentals of MIMO Wireless Communication”** by Prof. Suvra Sekhar Das IIT Kharagpur

   Link of the Course: https://nptel.ac.in/courses/117105132

3. NPTEL Course **“Principles of Modern CDMA/MIMO//OFDM Wireless Communications”** by Prof. Aditya. K. Jagannatham IIT Kanpur

   Link of the Course: https:// nptel.ac.in/courses/117104115

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404410(C): Fiber Optic Communication (Elective V)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	**03**	**In-Sem (Theory): 30 Marks** **End Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

1.Digital Communication
2.Electromagnetics Field Theory

Companion Course, if any:

1.Lab Practice -3

Course Objectives:

1. To familiarize learners with various components & equipments used in fiber optic communication systems.
2. To study the impact of choice of components on system design.
3. To introduce students to the WDM components and their role in capacity upgrade.
4. To extend the fundamentals to design and analysis of fiber optic communication links.
5. Expose students to the measurement standards, specifications and state of art developments in optical networks.

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

CO1: Explain the working of components and measurement equipments in optical fiber networks.

CO2: Calculate the important parameters associated with optical components used in fiber optic telecommunication systems.

CO3: Compare and contrast the performance of major components in optical links.

CO4: Evaluate the performance viability of optical links using the power and rise time budget analysis.

CO5: Design digital optical link by proper selection of components and check its viability using simulation tools.

CO6: Compile technical information related to state of art components, standards, simulation tools and current technological trends by accessing the online resources to update their domain knowledge.

Course Contents

Unit I	Optical Fibers for Telecommunication	6 Hrs.

Fundamentals of Optical Communication: EM spectrum - Optical Spectral bands, Shannon channel capacity, power units (watts, dB & dBm), Block diagram of optical fiber communications link, advantages of optical fibers.

Optical Fiber Waveguides: Introduction, Total internal reflection, acceptance angle, numerical aperture, fiber types, mode theory for circular waveguides: overview of modes & key modal concepts (V number, number of modes, power in clad), single mode fibers, cutoff wavelength

Transmission characteristics of optical fibers: attenuation - material absorption, scattering losses, fiber bend loss, loss due to fiber misalignment, splices and connectors; **signal distortion** - intermodal delay, intramodal dispersion or chromatic dispersion, modal delay, bit rate-distance product, plot of material & waveguide dispersions for standard single mode, dispersion shifted and dispersion flattened fibers; optical fibers for 5G networks, comparison.

Mapping of Course Outcomes for Unit I	CO1: Explain the working of components and measurement equipments in optical fiber networks. CO2: Calculate the important parameters associated with optical components used in fiber optic telecommunication systems. CO3: Compare and contrast the performance of major components in optical links.	
Unit II	**Optical Sources**	**7 Hrs.**
Optical Sources: Introduction, wavelength and material consideration (direct & indirect bandgap semiconductors); requirements from optical sources for telecommunication. **LED:** principle of working, quantum efficiency, optical output power characteristics, spectral width, effect of temperature on characteristics, modulation bandwidth, analog modulation, digital modulation, LED analog transmitter; **Semiconductor Laser Diodes:** absorption, spontaneous emission, stimulated emission, concept of population inversion and optical feedback, output power characteristics of LASER; Bias point and amplitude modulation range for analog applications of LEDs & laser diodes, comparison of LEDs & Lasers.		
Mapping of Course Outcomes for Unit II:	CO1: Explain the working of components and measurement equipments in optical fiber networks. CO2: Calculate the important parameters associated with optical components used in fiber optic telecommunication systems. CO3: Compare and contrast the performance of major components in optical links.	
Unit III	**Photodetectors**	**6 Hrs.**
Introduction, requirements from optical detectors, material considerations, types: p-n, pin, Avalanche photodiode, photo transistor, principle of working, quantum efficiency, responsivity, long cutoff wavelength, detector response time, comparison of photodetectors, thermal noise, dark current noise, quantum noise and receiver sensitivity, bit error rate		
Mapping of Course Outcomes for Unit III	CO1: Explain the working of components and measurement equipments in optical fiber networks. CO2: Calculate the important parameters associated with optical components used in fiber optic telecommunication systems. CO3: Compare and contrast the performance of major components in optical links.	
Unit IV	**Fiber Optic Link Design & WDM Systems**	**6 Hrs.**
Point to point optical link: Choice of components, system design considerations, optical power budget, rise time budget, bit rate for RZ and NRZ pulse format. Optical system design and performance analysis using software tools. **WDM Concepts & Components:** Overview of WDM, WDM components: 2 x 2 fiber coupler, isolator, circulator, basics of fiber grating filters, optical add/drop multiplexer, architecture of optical amplifiers (SOA, EDFA & FRA), Noise figure, OSNR & system impact of ASE.		

Mapping of Course Outcomes for Unit IV	CO1: Explain the working of components and measurement equipments in optical fiber networks. CO4: Evaluate the performance viability of optical links using the power and rise time budget analysis. CO5: Design digital optical link by proper selection of components and check its viability using simulation tools.

Unit V	Optical Networks	6 Hrs.

Optical Network concepts: fundamentals, network terminology, desirable properties, elements of an optical network, optical network topology types, advantages of optical network.
Overview of Optical Networks: FDDI, SONET/SDH, FTTX, FTTP, FTTH, PON, **GPON,** Long haul, Metro, Access, Submarine optical networks, role of fiber optic network in the 5G networks.
Current technology trends, standards and challenges.

Mapping of Course Outcomes for Unit V	CO6: Compile technical information related to the state of art components, standards, simulation tools and current technological trends by accessing the online resources to update their domain knowledge.

Unit VI	Optical Fiber Measurements	6 Hrs.

Overview of Measurement Standards for fiber optics:
Test Equipments for field work: Test support lasers, visual fault indicator, optical power meter, Optical Time Domain Reflectometry (OTDR), optical spectrum analyzer (OSA), BER test equipment **Measurements:** measurement of: optical power, numerical aperture of fiber, fiber attenuation (cutback method, insertion loss method, OTDR), macrobending loss, fiber dispersion
System performance evaluation: Eye Diagram Test, study of OTDR.

Mapping of Course Outcomes for Unit VI	CO1: Explain the working of components and measurement equipments in optical fiber networks. CO6: Compile technical information related to state of art components, standards, simulation tools and current technological trends by accessing the online resources to update their domain knowledge.

Learning Resources

Text Books:

1. Gerd Keiser, "Optical Fiber Communications" 4th Edition, Tata McGraw Hill.
2. John M Senior, "Optical Fiber Communications" 2nd Edition, PHI.

Reference Books:

1. Djafar K Mynbaev and Lowell L Scheiner, "Fiber Optic Communications Technology", 1st Edition, Pearson Education.
2. Uyless Black, "Optical Networks- Third Generation Transport Systems", Pearson Education.
3. Govind P Agrawal, "Fiber Optic Communication Systems", 3rd Edition, Wiley India.
4. Fredrick C Allard, "Fiber Optics Handbook for Engineers & Scientists", MH International

MOOC / NPTEL Courses:

1. NPTEL Course on "**Advanced Optical Communication**", by Prof R K Shevgaonkar, IIT Madras

   Link of the Course: https://nptel.ac.in/courses/117101002

2. NPTEL Course on "Fiber Communication Technology", by Prof Deepa Venkitesh, IIT Madras

   Link of the Course: https://nptel.ac.in/courses/108106167

3. NPTEL Course on "Fiber- Optic Communication Systems & Techniques", by Dr Pradeep Kumar K, IIT Kanpur
   Link of the Course: https://nptel.ac.in/courses/108104113

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404410(D): Biomedical Signal Processing (Elective - V)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End-Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Digital Signal Processing

Companion Course, if any:

1. Lab Practice -3

Course Objectives:

1. To understand the basic biomedical signals.
2. To study origins and characteristics of most commonly used biomedical signals, including ECG, EEG, Evoked potentials, and EMG.
3. To Study the signal acquisition and preprocessing of physiological signals.
4. To study the extraction of meaningful information to identify patterns and trends within the signals.
5. To understand the Sources and characteristics of noise and artifacts in bio signals

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

CO1: Describe the origin of various biomedical signals and Interpret the meaning of various parameters associated with biomedical signals

CO2: Analyze ECG Signals with extraction of meaningful information

CO3: Explain Processing of EEG signals for Diseases of Central Nervous System

CO4: Analyze EMG signals for understanding Neuromuscular Diseases

CO5: Analyze various Biomedical Signals

CO6: Process the biomedical signals to remove adaptive interference and noise

Course Contents

Unit I	Introduction to Biomedical Signals	6 Hrs.

Introduction and Overview, Ion Transport in Biological Cells, Trans membrane Potential, Electric Characteristics of Cell Membrane, Membrane Resistance, Membrane Capacitance, Cell Membrane's Equivalent Electric Circuit, Action Potential, Electric Data Acquisition, Propagation of Electric Potential as a Wave , Some Practical Considerations on Biomedical Electrode Summary

Mapping of Course Outcomes for Unit I	CO1: Describe the origin of various biomedical signals and Interpret the meaning of various parameters associated with biomedical signals

Unit II	Cardio logical Signal Processing	7 Hrs.

Function and Structure of the Heart- Cardiac Muscle, Cardiac Excitation Process

Electrocardiogram: Signal of Cardiovascular System - Origin of ECG, ECG Electrode Placement, Modeling and Representation of ECG, Periodicity of ECG Heart Rate, Cardiovascular Diseases and ECG- Atrial Fibrillation, Ventricular Arrhythmias, Ventricular Tachycardia, Ventricular Fibrillation, Myocardial Infarction, Atrial Flutter, Cardiac Reentry, Atrioventricular Block, Wolf–Parkinson–White Syndrome, Extrasystole Processing and Feature Extraction of ECG- Time-Domain Analysis, Frequency-Domain Analysis, Wavelet-Domain Analysis

Mapping of Course Outcomes for Unit II	CO2: Analyze ECG Signals for extraction of meaningful information

Unit III	**Neurological Signal Processing**	**6 Hrs.**
Brain and Its Functions **Electroencephalogram:** Signal of the Brain- EEG Frequency Spectrum, Significance of EEG, Evoked Potentials- Auditory-Evoked Potentials, Somatosensory-Evoked Potentials, Visual-Evoked Potentials, Event-Related Potentials, Diseases of Central Nervous System and EEG- Epilepsy, Sleep Disorders, Brain Tumor Processing and Feature Extraction of EEG- Sources of Noise on EEG, Frequency-Domain Analysis, Time-Domain Analysis, Wavelet-Domain Analysis		
Mapping of Course Outcomes for Unit III	CO 3: Explain use of EEG signals for Diseases of Central Nervous System.	
Unit IV	**Electromyogram (EMG)**	**7 Hrs.**
Muscle- Motor Unit, Muscle Contraction, Muscle EMG: Signal of Muscles- Significance of EMG Neuromuscular Diseases and EMG- Abnormal Enervation, Pathological Motor Units~~,~~ Neuromuscular Transmission in Motor Units, Defects in Muscle Cell Membrane Processing and Feature Extraction of EMG- Sources of Noise on EMG, Time-Domain Analysis, Frequency- and Wavelet-Domain Analysis		
Mapping of Course Outcomes for Unit IV	CO 4: Analyze EMG signals for understanding Neuromuscular Diseases.	
Unit V	**Other Biomedical Signals**	**6 Hrs.**
Introduction and Overview, Blood Pressure and Blood Flow, Electrooculogram, Respiratory Signals Magneto encephalogram,		
Mapping of Course Outcomes for Unit V	CO5: Analyze the various Biomedical Signals.	
Unit VI	**Adaptive interference / Noise Cancellation**	**6 Hrs.**
Types of noise in bio signals: **Digital filters:** IIR and FIR, Notch filters, Optimal and adaptive filters, Weiner filters. LMS adaptive algorithm, Steepest descent algorithm **Adaptive noise canceller:** Cancellation of 50 Hz signal in ECG		
Mapping of Course Outcomes for Unit VI	CO6: Process the biomedical signals to remove adaptive interference and noise.	

Learning Resources

Text Books:

1. Kayvan Najarian, Robert Splinter, “Biomedical Signal and Image Processing”, 2nd Edition, CRC Press
2. R. Rangayan, “Biomedical Signal Analysis”, Wiley

Reference Books:

1. R.S.Khandpur, “Handbook of Biomedical Instrumentation”, 2nd Edition,Tata McGraw Hill,
2. C.Reddy “Biomedical Signal Processing: Principles and techniques”, Tata McGraw Hill.
3. Joseph J. Carr and John M. Brown, “Introduction to Biomedical Equipment Technology”, 4th Edition, Prentice Hall.

MOOC / NPTEL Courses:

1. NPTEL Course on "**Biomedical Signal Processing**", by Prof Sudipta Mukhopadhyay, IIT Kharagpur

   Link of the Course: https://nptel.ac.in/courses/108105101

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404411(A): Nano Electronics (Elective - VI)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 hrs. / week	**03**	**In-Sem (Theory): 30 Marks** **End-Sem (Theory): 70 Marks**

Prerequisite Courses, if any:

Companion Course, if any:

Course Objectives:

1. To understand the processes in Nanoelectronic devices manufacturing.
2. To understand the construction, characteristics, and operation of Nanoelectronic devices.
3. To get acquainted with Nano-CMOS technology.
4. To gain the concepts of Nanomaterial and Nanodevice fabrication.
5. To understand the Nanomachines and nanodevice fabrication.
6. To get acquainted with applications of Nanoelectronics in the electronics industry.

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

CO1: Understand the fundamental knowledge behind nanotechnology.
CO2: Understand to Nano-CMOS technology.
CO3: Explore various Nanoelectronics material.
CO4: Understand the importance of carbon nanotubes.
CO5: Understand Nanomaterial and Nanodevice fabrication.
CO6: Understand various applications of Nanotechnology in Electronics.

Course Contents

Unit I	Introduction to Nanotechnology	6 Hrs.

Introduction to Nanotechnology: Fundamental science behind Nanotechnology, Tools for measuring Nanostructures, Tools to make nanostructures and imagine nano behaviors, Limitations of Silicon Material

Mapping of Course Outcomes for Unit I	CO1: Understand the fundamental knowledge behind nanotechnology.

Unit II	Nano CMOS Devices	6 Hrs.

Silicon Nanocrystal non-volatile memories, Novel dielectric materials for future transistors, NanoCMOS devices, and applications, AFM, scanning probe instrument, nanoscale lithography.

Mapping of Course Outcomes for Unit II	CO2: Understand to Nano-CMOS technology.

Unit III	Nanoparticles and Nanotubes	6 Hrs.

Properties of Nanoparticles: Metal nanostructures and semiconducting nanoparticles.
Carbon nanostructures: Carbon molecules, Clusters, Nanotubes.
Properties of Nanotubes: Strength and Elasticity, Applications of Nanotubes.

Mapping of Course Outcomes for Unit III	CO3: Explore various Nanoelectronics material. CO4: Understand the importance of carbon nanotubes.

Unit IV	Nanoelectronics	6 Hrs.
Introduction, the tools of manufacturing of micro and nano fabrication optical lithography, electron beam lithography, atomic lithography. Nano-Electronics for advanced computation and communication.		
Mapping of Course Outcomes for Unit IV	CO3: Explore various Nanoelectronics material. CO4: Understand the importance of carbon nanotubes.	
Unit V	**Nanomachine and Nanodevice Fabrications**	**6 Hrs.**
Nanomachines and Nanodevices, NEMS and MEMS and their fabrication, molecular and supermolecular switches, Lithography.		
Mapping of Course Outcomes for Unit V	CO5: Understand Nanomaterial and Nanodevice fabrication.	
Unit VI	**Applications of Nanotechnology**	**6 Hrs.**
Use of Nanotechnology in Electronics: Application of nanostructures in electronics, sensors, optics, energy capture, transformation, and storage. Application of nanotechnology in biomedical electronics.		
Mapping of Course Outcomes for Unit VI	CO6: Understand various applications of Nanotechnology in Electronics.	

Learning Resources

Text Books:

1. Anatoli Korkin, Jan Labanowski, Evgeni Gusev, Serge Luryi, "Nanotechnology for Electronic Materials and Devices", Springer.
2. Mark Ratner, Daniel Ratner, "Nanotechnology: A Gentle introduction to a next big Idea", 1st Edition, Pearson Education.
3. Gregory Timp, "Nanotechnology", Springer.
4. Charles P. Poole Jr., Frank J. Owens, "Introduction to Nanotechnology" John Wiley and sons

Reference Books:

1. K. Goser P. Glosekotter, J. Dienstuhl, "Nanoelectronics & Nanosystems"; Springer

MOOC / NPTEL Courses:

1. NPTEL Course on "**Nanostructured materials-synthesis, properties, self-assembly and applications**", by Prof. A.K.Ganguli IIT Delhi

   Link of the course: https://nptel.ac.in/courses/118102003

2. NPTEL Course on "**Nanoelectronics: Devices and Materials**", by Dr. Navkanta Bhat, Dr. S.N.Shivashankar, Prof. K.N.Bhat IISc Bangalore

   Link of the course: https://nptel.ac.in/courses/117108047

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404411(B): Low Power CMOS (Elective - VI)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 Hrs. / Week	03	In-Sem (Theory): 30 Marks End Sem (Theory): 70 Marks

Prerequisite Courses, if any:

1. Electronic Circuits
2. Digital Circuits

Companion Course, if any:

Course Objectives:

1. To identify sources of power in an IC.
2. To relate the power reduction techniques based on technology independent and technology. dependent power dissipation mechanism in various MOS logic style.
3. To describe suitable techniques to reduce the power dissipation.
4. To design memory circuits with low power dissipation.
5. To learn to use CAD tools for low power synthesis.

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

CO1: Explain the sources of power dissipation in CMOS.
CO2: Classify the special techniques to mitigate the power consumption in CMOS circuits.
CO3: Summarize the power optimization and trade off techniques in digital circuits.
CO4: Illustrate the power estimation at logic and circuit level.
CO5: Explain the software design for low power in various level.
CO6: Use the CAD tools for low power synthesis.

Course Contents

Unit I	Fundamentals of Power Dissipation in CMOS	06 Hrs.

Sources of power dissipation, Physics of power dissipation in MOSFET devices: The MIS structure, long channel MOSFET, Submicron MOSFET, gate induced drain leakage, Power dissipation in CMOS: short circuit dissipation, dynamic dissipation, load capacitance, Low power VLSI design: Limits, principles of low power design, hierarchy of limits, fundamental limit, material limit, device limit, system limit.

Mapping of Course Outcomes for Unit I	CO1: Explain the sources of power dissipation in CMOS.

Unit II	Power Optimization Techniques	07 Hrs.

Power Reduction in Clock Networks: Clock Gating, Reduced Swing Clock, Oscillator Circuit for Clock Generation, Frequency Division and Multiplication, Other Clock Power Reduction Techniques,
CMOS Floating Node: Tristate Keeper Circuit, Blocking Gate, Low Power Bus: Low Swing Bus, Charge Recycling Bus, Delay Balancing, Low Power Techniques for SRAM: SRAM Cell, Memory Bank Partitioning, Pulsed Word line and Reduced bit line Swing.
Introduction to Low-Power Design through Voltage Scaling: VTCMOS circuits, MTCMOS circuits, Architectural Level Approach –Pipelining and Parallel Processing Approaches. Switched Capacitance Minimization Approaches: System Level Measures, Circuit Level Measures, Mask level Measures.

Mapping of Course Outcomes for Unit II	CO2: Classify the special techniques to mitigate the power consumption in CMOS circuits.	
Unit III	**Design of Low Power Circuits**	**06 Hrs.**
Transistor and Gate Sizing : Sizing an Inverter Chain, Transistor and Gate Sizing for Dynamic Power Reduction, Transistor Sizing for Leakage Power Reduction, Network Restructuring and Reorganization: Transistor Network Restructuring, Transistor Network Partitioning and Reorganization, Special Latches and Flip-flops : Self-gating Flip-flop, Combinational Flip-flop, Double Edge Triggered Flip-flop, Low Power Digital Cell Library : Cell Sizes and Spacing, Varieties of Boolean Functions, Adjustable Device Threshold Voltage.		
Mapping of Course Outcomes for Unit III	CO3: Summarize the power optimization and trade off techniques in digital circuits.	
Unit IV	**Power Estimation**	**06 Hrs.**
Modelling of signals, signal probability calculation, Statistical techniques, estimation of glitching power, Sensitivity analysis, Power estimation using input vector compaction, power dissipation in Domino logic, circuit reliability, power estimation at the circuit level, Estimation of maximum power: test generation based approach, steepest descent, generic based algorithm based approach.		
Mapping of Course Outcomes for Unit IV	CO4: Illustrate the power estimation at logic and circuit level.	
Unit V	**Software Design for Low Power**	**06 Hrs.**
Sources of software power dissipation, software power estimation: Gate level, architecture level, bus switching activity, instruction level power analysis, software power optimization: minimizing memory access costs, instruction selection and ordering, power management, Automated low power code generation, Co-design for low power.		
Mapping of Course Outcomes for Unit V	CO5: Explain the software design for low power in various level.	
Unit VI	**Hardware Design for Low Power**	**06 Hrs.**
Adiabatic Switching Circuits, Battery-aware Synthesis, Variation tolerant design, CAD tools for low power synthesis.		
Mapping of Course Outcomes for Unit VI	CO6: Able to use the CAD tools for low power synthesis	

Learning Resources

Text Books:

1. Kaushik Roy and S. C. Prasad, “Low power CMOS VLSI Circuit Design”, Wiley Publication
2. Gary Yeap, “Practical Low Power Digital VLSI Design”, Springer
3. A. P. Chandrasekaran and R. W. Broadersen, “Low Power Digital CMOS Design”, Kluwer,1995

Reference Books:

1. J. B. Kulo and J.H Lou, “Low voltage CMOS VLSI Circuits”, Wiley Publication
2. Dimitrios Soudris, Christians Pignet, Costas Goutis, “Designing CMOS Circuits for Low Power”, Kluwer.
3. James B. Kulo, Shih-Chia Lin, “Low voltage SOI CMOS VLSI devices and Circuits”, John Wiley and sons.
4. Steven M. Rubin, “Computer Aids for VLSI Design”, Addison Wesley Publishing
5. Abdelatif Belaouar, Mohamed. I. Elmasry, “Low power digital VLSI design”, Kluwer.

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404411(C): Digital Marketing (Elective - VI)		
Examination Scheme:	**Credit**	**Examination Scheme:**
Theory: 03 Hrs. / Week	**03**	**In-Sem: 30 Marks** **End Sem: 70 Marks**

Prerequisite Courses, if any:

Companion Course, if any:

1. Digital Business Management

Course Objectives:

1. To understand digital marketing & process of website design.
2. To identify the keywords for a website & understand the SEO.
3. To study the various Digital Marketing Tools.
4. To learn the use of social media websites for Digital Marketing.
5. To be conversant with Linked In platform.
6. To know the recent trends in Digital Marketing.

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

CO1: Design websites using free tools like Wordpress and explore it for digital marketing.
CO2: Apply various keywords for a website & to perform SEO.
CO3: Understand the various SEM Tools and implement the Digital Marketing Tools.
CO4: Illustrate the use of Facebook, Instagram and Youtube for Digital Marketing in real life.
CO5: Use Linked in platform for various campaigning.
CO6: Understand the importance of recent trends in digital marketing.

Course Contents

Unit I	Digital Marketing Planning and Structure	7 Hrs.

Importance of Digital Marketing, Digital Marketing Vs. Traditional Marketing, Inbound vs Outbound Marketing, Understanding Demographics. WWW, buying a Domain, Core Objective of Website and Flow, One Page Website, Strategic Design of Products & Services Page, Strategic Design of Landing Page, Segmentation & Targeting and Positioning to Digital Marketing, Portfolio, Gallery and Contact Us Page, Google Analytics Tracking Code, Designing Wordpress Website. Mobile Friendly Website, Payment Gateway like UPI, e-Commerce

Mapping of Course Outcomes for Unit I	CO1: Design websites using free tools like Wordpress and explore it for digital marketing.

Unit II	Search Engine Optimization (SEO)	6 Hrs.

Fundamentals; Keywords and SEO Content Plan; SEO & Business Objectives; Writing SEO Content; On-site & off-site SEO; Optimize Organic Search Ranking, Website SEO Auditing, Web Analytics:
Data and Traffic Analysis. Study and analyze the Competitor's Website and their traffic sources.

Mapping of Course Outcomes for Unit II	CO2: Apply various keywords for a website & to perform SEO.	
Unit III	**Search Engine Marketing**	**7 Hrs.**

Importance of Adwords, Google Ad Types, PPC Cost Formula, Ad Page Rank, Billing and Payments, Adwords User Interface, Keyword Planner, Creating Ad Campaigns, Creating Text Ads, Creating Ad Groups, Search Engine Marketing (SEM) Tools, Bidding Strategy for CPC, Case Studies. Conversion Tracking Code, Designing Image Ads, Creating Video Ads, Youtube Video Promotion, Hi-Jack

Competitor's Video Audience, Case Studies. Remarketing Strategies, Remarketing Tracking Code, Website or Blog Linking Google Analytics, Designing Remarketing Images, Shared Budget, Mobile Advertising.

Mapping of Course Outcomes for Unit III	CO3: Understand the various SEM Tools and implement the Digital Marketing Tools.	
Unit IV	**Social Media Marketing (SMM) Part 1**	**6 Hrs.**

B to C Perspective, B to B Perspective:
Introduction; Major Social Media Platforms for Marketing; Developing Data-driven Audience & Campaign Insights; Social Media for Business;
Facebook & Instagram Marketing: Understanding of Facebook Marketing, Types of Facebook Advertising, creating first ad on Facebook, Setting Campaign and optimization, Facebook Power Editor, Facebook Video Marketing, Facebook App & Shopping Marketing
Youtube Marketing: YouTube Account Setup (Create a business account with a personal account), YouTube Monetization, YouTube Ads, YouTube Analytics.

Mapping of Course Outcomes for Unit IV	CO4: Illustrate the use of Facebook, Instagram and Youtube for Digital Marketing in real life.	
Unit V	**Social Media Marketing (SMM) Part 2**	**6 Hrs.**

LinkedIn Advertising: How to use Linkedin Professionally, Types of LinkedIn Advertising, LinkedIn New feed Advertising, LinkedIn Message Pitching, Traffic and Leads Generation, Billing and Report.
Email Marketing: Email Software and Tools, Importing Email Lists, Planning Email Campaign, Email Templates and Designs, Sending HTML Email Campaigns, Web Forms Lead Importing, Integrating Landing Page Forms, Campaign Reports and Insights, Segmentation Strategy, Responder Tracker

Mapping of Course Outcomes for Unit V	CO5: Use Linked in platform for various campaigning.	
Unit VI	**Upcoming Trends in Digital Marketing**	**6 Hrs.**

Podcast, OTT Platforms, Mob-Ad, No Click Searches, Google Verified Listing, Voice Search, Visual Search, Online Reviews, Automated and Smart Bidding, Chatbots, Affiliate Marketing

Mapping of Course Outcomes for Unit VI	CO6: Understand the importance of recent trends in digital marketing.

Learning Resources

Text Books:

1. Cory Rabazinsky, “Google-Ad words for Beginners: A Do-It-Yourself Guide to PPC Advertising”
2. Ian Brodie, “Email Persuasion: Captivate and Engage Your Audience, Build Authority and Generate More Sales With Email Marketing”
3. Jan Zimmerman and Deborah, “Social Media Marketing All-In-One for Dummies”
4. Dave Chaffey, Fiona Ellis-Chadwick, Kevin Johnston, Richard Mayer, “Internet Marketing”, Pearson Education.
5. Oliver J Rich, “Digital Marketing”
6. Gerry T. Warner and Joe Wilson Schaefer “Online Marketing”

Reference Books:

1. Prof. Seema Gupta, “Digital Marketing”, Mcgraw Hill Publications.
2. Judy Strauss, Adel Ansary, Raymond Frost, Prentice Hall, “E- Marketing”
3. Dr. Andy Williams ,“WordPress for Beginners 2020: A Visual Step-by-Step Guide to Mastering WordPress”
4. Cecilia Figueroa, “Introduction to Digital Marketing 101”, BPB Publications.

MOOCs / NPTEL:

1. Digital Tools Certification- By Google
   Link of the Course: https://skillshop.exceedlms.com/student/catalog

2. Swayam Certification course on, “**Digital Marketing**”, by Dr. Tejindarpal Singh Panjab University Chandigarh
   Link of the Course: https://swayam.gov.in/nd2_ugc19_hs26/preview

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404411(D): System on Chip (Elective - VI)

Teaching Scheme:	Credit	Examination Scheme:
Theory: 03 hrs. / week	03	In-Sem (Theory): 30 Marks End-Sem (Theory): 70 Marks

Prerequisite Courses, if any:

Companion Course, if any:

Course Objectives:

1. To understand the basic concepts and architecture of SOC.
2. To understand the basic terminology of Verilog HDL programming.
3. To apply the various Verilog modeling styles in writing the design and testbench codes.
4. To understand the basic steps used in the VLSI Physical Design.
5. To understand the basic architecture of various processors used in SOC.
6. To understand the working principle of various Buses and memory used in SOC.

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

CO1: Understand the basic concepts and architecture of SOC.
CO2: Understand the basic terminology of Verilog HDL programming.
CO3: Apply the various Verilog modeling styles in writing the design and testbench codes.
CO4: Understand the basic steps used in the VLSI Physical Design.
CO5: Understand the basic architecture of various processors used in SOC.
CO6: Understand the working principle of various Buses and memory used in SOC.

Course Contents

Unit I	Introduction to SOC	6 Hrs.

System Architecture; System Complexity; Components of the system; Hardware & Software; An approach for SOC Design; SOC definition, benefits, and challenges; Application of SOC; SOC components: Processor, Accelerators, Memory and Peripherals, On-chip interconnects, and various signal processing units.

Mapping of Course Outcomes for Unit I	CO1: Understand the basic concepts and architecture of SOC.

Unit II	Verilog HDL - I	7 Hrs.

Evolution and need of CAD tools; HDL tools; Why Verilog; Verilog: datatypes, system tasks, compiler directives; Hierarchical Modeling Concepts: Top-down and bottom-up design methodology; modules and module instances; Modules and Ports: Module definition, port declaration, connecting ports, hierarchical name referencing, and timescale.

Mapping of Course Outcomes for Unit II	CO2: Understand the basic terminology of Verilog HDL programming.

Unit III	Verilog HDL-II	7 Hrs.
Gate-level modeling: Modeling using basic Verilog gate primitives, description of AND/OR and BUF/NOT type gates; Dataflow Modeling: Continuous assignments, delay specification, expressions, operators; Behavioral Modeling: Structured procedures, initial and always blocks, blocking and nonblocking statements, delay control, conditional statements, multiway branching, loops, sequential and parallel blocks; Tasks and Functions: tasks vs functions, declaration, invocation, automatic tasks and functions; testbench		
Mapping of Course Outcomes for Unit III	CO3: Apply the various Verilog modeling styles in writing the design and testbench codes.	
Unit IV	**Physical Design**	**8 Hrs.**
Floor planning: Abutted and Non-abutted floorplan techniques, floorplan control parameters, input and outputs of the floorplan; Partitioning; need of partitioning, rules of partitioning, methods of partitioning; Placement: goal of placement, coarse placement, legalization, placement blockage, keep-out margin; Routing: netlist, congestion, fixed-die routing, variable-die routing.		
Mapping of Course Outcomes for Unit IV	CO4: Understand the basic steps used in the VLSI Physical Design.	
Unit V	**SOC Processors**	**6 Hrs.**
Introduction to SOC processors; Processor selection for SOC; Basic concepts in processor architecture and processor micro architecture; Basic elements in Instruction handling; Buffers: minimizing pipeline delays, Branches; More Robust Processors: Vector processors and vector instructions extensions, VLIW Processors, Superscalar Processors.		
Mapping of Course Outcomes for Unit V	CO5: Understand the basic architecture of various processors used in SOC.	
Unit VI	**SOC Buses and Memory**	**6 Hrs.**
AMBA: Generation of AMBA (ASB, AHB, APB), Architecture of AMBA, Specification; Core Connect bus: PLB, OPB, DCR; ST bus protocols: Type I, II, III; SOC memory; Cache memory: performance, partitioning, multi-level cache; Memory chip technology: On die or Off die.		
Mapping of Course Outcomes for Unit VI	CO6: Understand the working principle of various Buses and memory used in SOC.	

Learning Resources

Text Books:

1. Michael J. Flynn, Wayne Luk, "Computer System Design: System on Chip", John Wiley and sons.
2. Samir Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", 2nd Edition, Prentice Hall.

Reference Books:

1. M.Wolf, "Principles of Embedded Computing System Design", 4th Edition, Morgan Kaufmann Publications.
2. Michael .D. Ciletti, "Advanced Digital Design with the Verilog(TM) HDL", 2nd Edition, Pearson.
3. J.Bhasker, " A Verilog HDL Primer", 3rd Edition, Star Galaxy Press.

MOOC / NPTEL Courses:

1. NPTEL Course on "**Hardware modeling using Verilog**", by Prof. Indranil Sengupta IIT Kharagpur

   Link of the course: https://nptel.ac.in/courses/106105165

2. NPTEL Course on "**VLSI Physical Design**", by Prof. Indranil Sengupta IIT Kharagpur

   Link of the course: https://nptel.ac.in/courses/106105161

3. NPTEL Course on "**Embedded Systems**", by Prof. Santanu Choudhary IIT Delhi

   Link of the course: https://nptel.ac.in/courses/106105161

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404412: Innovation and Entrepreneurship		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Tutorial: 02 Hrs. / Week	**02**	**Term Work: 50 Marks**

Prerequisite Courses, if any:

1. Project Management

Companion Course, if any:

Course Objectives:

1. To know innovation and entrepreneurship.
2. To be trained in design thinking.
3. To comprehend idea generation.
4. To gain knowledge of starting a venture.
5. To study about patents and patent filing.
6. To become skilled at digital marketing

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

CO1: Understand Innovation, Entrepreneurship and characteristics of an entrepreneur.

CO2: Develop a strong understanding of the Design Process and its application in variety of business settings.

CO3: Generate sustainable ideas.

CO4: Explore various processes required to be an entrepreneur.

CO5: Understand patents and its process of filing.

CO6: Choose and use appropriate social media for marketing.

Course Contents

Unit I	Introduction to Innovation and Entrepreneurship	3 Hrs.
Role of innovation and entrepreneurship, what it takes to be an entrepreneur, Business fundamentals, Leadership & team building, relation between innovation and entrepreneurship.		
Mapping of Course Outcomes for Unit I	CO1: Understand Innovation, Entrepreneurship and characteristics of an entrepreneur.	
Unit II	**Design Thinking**	**3 Hrs.**
Introduction to Design Thinking, Design Research Strategies, Design Research - tools for observation and immersion, visualizing ideas, Communicating ideas.		
Mapping of Course Outcomes for Unit II	CO2: Develop a strong understanding of the Design Process and its application in variety of business settings.	
Unit III	**Idea Generation**	**3 Hrs.**
The seed of innovation, Innovation domains, Innovation sustainable conditions, Design factors, Types of innovations and their market impact.		
Mapping of Course Outcomes for Unit III	CO3: Generate sustainable ideas.	

Unit IV	Becoming an Entrepreneur	4 Hrs.
Creating a business plan, Preparing a Pitching presentation, Building business strategy		
Mapping of Course Outcomes for Unit IV	CO4: Explore various processes required to be an entrepreneur.	
Unit V	**Creating a Startup**	**3 Hrs.**
Types of companies, legal processes for registering companies, registering as startup		
Mapping of Course Outcomes for Unit V	CO5: Understand patents and its process of filing.	
Unit VI	**Indian Patents**	**2 Hrs.**
Fundamentals of IP, Patent basics, Patent analytics, Role in R&D and business planning, Patents to profits, IP asset management, Technology transfer.		
Mapping of Course Outcomes for Unit VI	CO6: Choose and use appropriate social media for marketing.	

Learning Resources

Reference Books:

1. Badhai, B, "Entrepreneurship for Engineers", Dhanpat Rai & Co. (p) Ltd.
2. "The Field Guide to Human-Centered Design", by IDEO.org
3. Kalyan C. Kankanala, A.K. Narasani, V. Radhakrishnan, "Indian Patent Law and Practice", Oxford Press.
4. Eric Ries, "The Lean Startup", Penguin Books Limited **(E-Book).**

MOOCs / NPTEL:

1. Swayam Course on "**Entrepreneurship**" by Prof. C. Bhaktvatsala Rao IIT Madras **Link of the Course:** https://onlinecourses.nptel.ac.in/noc21_mg70/preview

2. Swayam Course on "**Design Thinking-A Primer**" by Prof. A. Mahalingam, Prof. B. Ramadurai IIT Madras
Link of the Course: https://onlinecourses.nptel.ac.in/noc22_mg32/preview

3. Swayam Course on "Patent Law for Scientists and Engineers" by Prof. Feroz Ali IIT Madras
Link of the Course: https://onlinecourses.nptel.ac.in/noc20_hs55/preview

4. NPTEL Course on " Innovation, Business Models and Entrepreneurship" by Prof. Rajat Agarwal, Prof. Vinay Sharma IIT Roorkee
Link of the Course: https://nptel.ac.in/courses/110107094

List of Tutorials to be carried out

1.	Design a strategy by writing steps to market the project you are building.
2.	Generate an idea having novelty.
3.	Prepare a business plan.
4.	Create a pitching deck.
5.	Preparing a business strategy.
6.	Write a patent draft.

Savitribai Phule Pune University Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course) 404413: Digital Business Management		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Tutorial: 02 Hrs. / Week	**02**	**Term Work: 50 Marks**

Prerequisite Courses, if any:

1. Project Management

Companion Course, if any:

1. Digital Marketing

Course Objectives:

1. To familiarize with digital business concept.
2. To acquaint with E-commerce.
3. To give insights into E-business and its strategies.

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

CO1: Identify drivers of digital business.

CO2: Illustrate various approaches and techniques for E-business and management.

CO3: Prepare E-business plan.

Course Contents

Unit I	Introduction to Digital Business	4 Hrs.

Introduction, Background and current status, E-market places, structures, mechanisms, economics and impacts. Difference between physical economy and digital economy.

Drivers of digital business: Big Data & Analytics, Mobile, Cloud Computing, Social media, BYOD, and Internet of Things (digitally intelligent machines/services), Opportunities and Challenges in Digital Business,

Mapping of Course Outcomes for Unit I	CO1: Identify drivers of digital business.

Unit II	Overview of E-Commerce	8 Hrs.

E-Commerce: Meaning, Retailing in e-commerce-products and services, consumer behavior, market research and advertisement, B2B-E-commerce-selling and buying in private e-markets, public B2B exchanges and support services, e-supply chains, Collaborative Commerce, Intra business EC and Corporate portals. Other E-C models and applications, innovative EC System-From E- government and learning to C2C, mobile commerce and pervasive computing EC Strategy and ImplementationEC strategy and global EC, Economics and Justification of EC, Using Affiliate marketing to promote your e-commerce business, Launching a successful online business and EC project, Legal, Ethics and Societal impacts of EC

Mapping of Course Outcomes for Unit II	CO2: Illustrate various approaches and techniques for E-business and management.

Unit III	Digital Business Support Services	3 Hrs.

e-CRM, e-SCM, ERP as e –business backbone, Knowledge Tope Apps, Information and referral system: Application Development: Building Digital business Applications and Infrastructure

Mapping of Course Outcomes for Unit III	CO2: Illustrate various approaches and techniques for E-business and management.

Unit IV	Managing E-Business	4 Hrs.
Managing Knowledge, Management skills for e- business, Managing Risks in e –business. Security Threats to e-business -Security Overview, Electronic Commerce Threats, Encryption, Cryptography, Public Key and Private Key Cryptography, Digital Signatures, Digital Certificates, Security Protocols over Public Networks: HTTP, SSL, Firewall as Security Control, Public Key Infrastructure (PKI) for Security, Prominent Cryptographic Applications.		
Mapping of Course Outcomes for Unit IV	CO2: Illustrate various approaches and techniques for E-business and management.	
Unit V	**E-Business Strategy**	**3 Hrs.**
E-business Strategic formulation- Analysis of Company's Internal and external environment, Selection of strategy, E-business strategy into Action, challenges and E-Transition		
Mapping of Course Outcomes for Unit V	CO2: Illustrate various approaches and techniques for E-business and management. CO3: Prepare E-business plan.	
Unit VI	**Materializing e-business:**	**2 Hrs.**
From Idea to Realization-Business plan, Case Studies.		
Mapping of Course Outcomes for Unit VI	CO3: Prepare E-business plan.	

Learning Resources

Text Books:

1. Urmi Dutta, Neha Somani, "E-Commerce & Business Communication", Oxford University Press
2. Elias M. Awad, "E-commerce from vision to fulfilment" 3rd Edition, Prentice Hall India
3. Dave Chaffey, "Digital Business and E-Commerce Management", 6th Edition, Pearson
4. Colin Combe, "Introduction to E-business: Management and Strategy", 1st Edition , Elsvier
5. Eloise Coupey, "Digital Business Concepts and Strategy", 2nd Edition , Pearson

Reference Books:

1. Vinocenzo Morabito, "Trend and Challenges in Digital Business Innovation" Springer
   Erika Darics, "Digital Business Discourse", Palgrave Macmillan
2. "E-Governance-Challenges and Opportunities", Proceedings in 2nd International Conference theory and practice of Electronic Governance
3. "Perspectives the Digital Enterprise –A framework for Transformation", TCS Consulting Journal Vol. 5
4. "Measuring Digital Economy-A new perspective" , OECD Publishing **DOI: 10.1787/9789264221796-en**

MOOCs / NPTEL:

1. Coursera Course on "**Digital Business Specialization**"
   Link of the course: www.coursera.org/specializations/digital-business

2. NPTEL Course on "**E-Business**" by Prof. Mamta Jenamani IIT Kharagpur **Link of the course:** https://nptel.ac.in/courses/110105083

<u>List of Tutorials to be carried out</u>

1.	Compare conventional business with e- business based on structure, mechanisms and economics.
2.	Discuss the role of Big Data and Data Analytics in Digital Business Management.
3.	Review various Opportunities and Challenges in Digital Business.
4.	Prepare a report on societal impacts of Digital Business.
5.	Review various security aspects of Digital Business.
6.	Discuss the various steps for executing the business plan digitally.
7.	Develop a strategy for E-Business for selling a product online.
8.	Discuss a typical case study of any one Digital Business.

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404414: Verification using SV and UVM Laboratory

Teaching Scheme:	Credit	Examination Scheme:
Practical: 02 Hrs. / Week	01	Oral: 50 Marks Term work: 25

Prerequisite Courses, if any:

Companion Course, if any:

Verification using SV and UVM

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a hands-on resource and reference. The instructor's manual need to include prologue (about University/program/ institute/ department/foreword/ preface etc), University syllabus, conduction & Assessment guidelines, topics under consideration-concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal consists of prologue, Certificate, table of contents, and handwritten write-up of each assignment (Title, Objectives, Problem Statement, Outcomes, software & Hardware requirements, Date of Completion, Assessment grade/marks and assessor's sign, Theory-Concept in brief, features of tool/framework/language used, Design, test cases, conclusion.

Program codes with sample output of all performed assignments are to be submitted as softcopy.

As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal may be avoided. Use of DVD containing students programs maintained by lab In-charge is highly encouraged. For reference one or two journals may be maintained with program prints at Laboratory.

Guidelines for Assessment

Continuous assessment of laboratory work is done based on overall performance and lab assignments performance of student. Each lab assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness.

Guidelines for Laboratory Conduction

1. The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic.
2. The assignment framing policy need to address the average students and inclusive of an element to attract and promote the intelligent students.
3. The instructor may set multiple sets of assignments and distribute among batches of students.
4. It is appreciated if the assignments are based on real world problems/applications. Encourage students for appropriate use of Hungarian notation, proper indentation and comments.
5. Use of open source software is to be encouraged.
6. In addition to these, instructor may assign one real life application in the form of a mini-project based on the concepts learned.
7. Instructor may also set one assignment or mini-project that is suitable to respective branch beyond the scope of syllabus.

List of Laboratory Assignments

1.	Simulate a simple UVM testbench and DUT.
2.	Examining the UVM testbench.
3.	Design and simulate sequence items and sequence
4.	Design and simulate a UVM driver and sequencer
5.	Design and simulating UVM monitor and agent
6.	Design, simulate and examine coverage
7.	Design and simulate a UVM scoreboard and environment, and verifying the outputs of a (faulty) DUT
8.	Design and simulate a test that runs multiple sequence
9.	Design and simulate a configurable UVM test environment

Savitribai Phule Pune University **Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)** **404415: Lab Practice – III**		
Teaching Scheme:	**Credit**	**Examination Scheme:**
Practical: 02 Hrs. / Week	**01**	**Practical: 50 Marks** **Term Work: 25 Marks**

Prerequisite Courses, if any:

Companion Course, if any:

1. Android Development (Elective - V)
2. Mobile Computing (Elective - V)
3. Fibre Optic Communication (Elective - V)
4. Biomedical Signal Processing ((Elective - V)

Subject: Android Development (Elective - V)

Guidelines for Instructor's Manual

The instructor's manual is to be developed as a hands-on resource and reference. The instructor's manual need to include prologue (about University/program/ institute/ department/foreword/ preface etc), University syllabus, conduction & Assessment guidelines, topics under consideration-concept, objectives, outcomes, set of typical applications/assignments/ guidelines, and references.

Guidelines for Student Journal

The laboratory assignments are to be submitted by student in the form of journal. Journal consists of prologue, Certificate, table of contents, and handwritten write-up of each assignment (Title, Objectives, Problem Statement, Outcomes, software & Hardware requirements, Date of Completion, Assessment grade/marks and assessor's sign, Theory-Concept in brief, features of tool/framework/language used, Design, test cases, conclusion.

Program codes with sample output of all performed assignments are to be submitted as softcopy.

As a conscious effort and little contribution towards Green IT and environment awareness, attaching printed papers as part of write-ups and program listing to journal may be avoided. Use of DVD containing students programs maintained by lab In-charge is highly encouraged. For reference one or two journals may be maintained with program prints at Laboratory.

Guidelines for Assessment

Continuous assessment of laboratory work is done based on overall performance and lab assignments performance of student. Each lab assignment assessment will assign grade/marks based on parameters with appropriate weightage. Suggested parameters for overall assessment as well as each lab assignment assessment include- timely completion, performance, innovation, efficient codes, punctuality and neatness.

Guidelines for Laboratory Conduction

1. The instructor is expected to frame the assignments by understanding the prerequisites, technological aspects, utility and recent trends related to the topic.
2. The assignment framing policy need to address the average students and inclusive of an element to attract and promote the intelligent students.
3. The instructor may set multiple sets of assignments and distribute among batches of students.
4. It is appreciated if the assignments are based on real world problems/applications. Encourage students for appropriate use of Hungarian notation, proper indentation and comments.
5. Use of open source software is to be encouraged.
6. In addition to these, instructor may assign one real life application in the form of a mini-project based on the concepts learned.
7. Instructor may also set one assignment or mini-project that is suitable to respective branch beyond the scope of syllabus.

List of Laboratory Assignments (Any 10 to be Performed)

1.	Download Install and Configure Eclipse / Android Studio on Linux/windows platform.
2.	Design a mobile application using implicit intent and explicit intent
3.	Design a mobile application to create two fragment and pass the data from one fragment to another
4.	Design a mobile application to create home page using grid layout
5.	Design a mobile application to create the login page using sqlite / firebase
6.	Design a mobile application to share data in the app.
7.	Design a mobile application to create registration application which having spinner (subject), radio button (gender), qualification (check box), first insert the value and then show the data in show activity.
8.	Design a mobile application to create different dialog boxes and menu (popup, option , context)
9.	Design a mobile application to show list using Recycler View
10.	Design a mobile application to Show any website using web view
11.	Design a mobile application to Activity using fragment
12.	Design a mobile application using imageslider to show images.
13.	Design a mobile application for media player.
14.	Design a mobile app to store data using internal or external storage.
15.	Design a mobile app using Google Map and GPS to trace the location.

Subject: Mobile Computing (Elective - V)

List of Experiments (Any 8 to be performed)

1.	Simulate to elaborate operation of multiple access techniques for CDMA.
2.	Study of GSM architecture and signaling techniques.
3.	Study of GPRS services.
4.	Simulate BER performance over Rayleigh Fading wireless channel with BPSK transmission for SNR 0 to 60 dB.
5.	Configuring a Cisco Router as a DHCP Server.
6.	To understand the handover mechanism. **http://vlabs.iitkgp.ernet.in/fcmc/exp8/index.html**
7.	To study the outage probability, LCR & ADF in SISO for Selection Combining and MRC (Flat Fading). **http://vlabs.iitkgp.ernet.in/fcmc/exp9/index.html**
8.	To Perform File Transfer in Client & Server Using TCP/IP.
9.	Case Study on different real time mobile computing services.

Virtual LAB Links:

1. **http://vlabs.iitkgp.ernet.in/fcmc/** **(Fading Channels and Mobile Communication Lab.)**

Subject: Fibre Optic Lab (Elective - V)

List of Laboratory Experiments (Hardware/Programs/Simulation Software)

Group A	
1.	To estimate the numerical aperture of given MMSI optical fiber.
2.	To plot electrical and optical characteristics of any one optical source LED/Laser.
3.	To measure attenuation coefficient and bending losses in optical fibers.
4.	To plot characteristics of any one photo detector pn/pin/phototransistor.
5.	Tutorial on optical key components: numerical on optical fiber, optical source and photodetector.
Group B	
1.	Establish a digital optical link.
2.	Simulate optical power budget and rise time budget analysis of optical fiber systems.
3.	Study of any one field instrument such as optical power meter, OTDR, splicing machine etc
4.	Tutorial on optical link budget: Optical power budget & rise time budget analysis to comment on the viability of the systems.
Group C	
1.	Simulation of WDM system to compute OSNR using *any* simulation software.
2.	Study of current trends in: optical sources, detectors, fibers for telecommunication, ux-demux, filters, isolators, circulators, couplers, connectors, optical amplifiers etc and the measuring instruments and standards.

Virtual LAB Links:

http://vlabs.iitb.ac.in/vlabs-dev/labs/physics-basics/labs/numerical-aperture-measurement- iitk/index.html

(**Physical Sciences Lab)**

Subject: Biomedical Signal Processing (Elective - V)	
Part A (All Compulsory)	
1.	Use discrete Fourier transform (DFT) to describe the signals in the frequency domain. Determine the dominant frequency.
2.	Determine the PP interval and the RR interval for ECG signals. Use DFT to describe the signals in the frequency. Determine the heart rate using the ECG signal
3.	Import the EMG signal. Determine the dominant frequency in the signal.
4.	Import the EEG signal and plot the 10 channels. Determine the dominant frequency of channel 0 and compare this to the dominant frequency of channel 8
Part B (Any 2 to be performed)	
1.	Import the EMG signal Calculate the AVR value of the EMG signal.
2.	Import the EMG signal Determine the frequency spectrum or power spectrum.
3.	Isolate one typical period of the signal, i.e., one cycle containing P-QRS-T. Calculate the duration of P, T, and QRS waves. For ECG signal.
Part C (Any 1 to be Performed)	
1.	Import the EEG signal and Determine the onset of the epileptic EEG pattern. Plot the power spectrum of the signal.
2.	Design a Filter to remove the noise in the ECG signal.
3.	Implement LMS adaptive algorithm for noise cancellation.

VIRTUAL LAB LINKS:

1. **https://bmsp-coep.vlabs.ac.in/List%20of%20experiments.html** **(Biomedical and Signal Processing Lab.)**
2. **https://bmi-iitr.virtuallabs.ac.in/** **(Biomedical Instrumentation Lab.)**

Savitribai Phule Pune University

Fourth Year of Electronics Engineering (VLSI Design & Technology) (2019 Course)

404416: Project Phase – II

Teaching Scheme:	Credit	Examination Scheme:
Practical: 10 Hrs. / Week	05	Term Work: 100 Marks Oral: 50 Marks

Project phase 2 is extension of Project phase 1 carried out in seventh semester. The student shall prepare the duly certified Fourth report of project work in standard format preferably in LATEX for satisfactory completion of the work by the concerned guide and head of the Department/Institute.

GUIDELINES

1.	The project TW/OR assessment shall be based on Live Project Demonstration and presentation by the students. The assessment parameters shall be Innovative Idea of selected project, literature survey, Depth of understanding, Applications, Individual contributions, presentations, project report, timely completion of work (Project review presentations), participation in project competition, publication of research work in journal/conference, publication in the form of patent and copyright etc. The college can prepare the rubrics based on these parameters.
2.	Certified hard bound project report to be submitted by the students in prescribed format.
3.	Students must preferably publish at least one technical paper on project work in the conference or peer reviewed Journals or publish patent or copyright or should participate into one of the project competition at university/State/National/International level.
4.	A log book of work carried out during the semester should be maintained with weekly review remarks by the guide and committee.
5.	A certified copy of report preferably using LATEX is required to be presented to external examiner at the time of Fourth examination.
6.	The project report must undergo by plagiarism check and the similarity index must be less than 10%. The plagiarism report should be included in the project report.