ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 14

(Syllabi for Electronics and Communication Engineering Programme Courses)

SRM
INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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ACADEMIC CURRICULA

Engineering Science Course

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21CSS201T	**Course Name**	COMPUTER ORGANIZATION AND ARCHITECTURE	**Course Category**	S	ENGINEERING SCIENCES	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*School of Computing*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the Fundamentals of computers, Memory operations and Addressing Modes*
CLR-2:	*know about Functions of Arithmetic and Logic unit*
CLR-3:	*explore the Operations of Control Unit, Execution of Instruction and Pipelining*
CLR-4:	*classify the Need for Parallelism, Multicore and Multiprocessor Systems*
CLR-5:	*understand the Concepts and functions of Memory unit, I/O unit*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the computer hardware and how software interacts with computer hardware*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*apply Boolean algebra as related to designing computer logic, through simple combinational and sequential logic circuits*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*examine the detailed operation of Basic Processing units and the performance of Pipelining*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-4:	*analyze concepts of parallelism and multi-core processors*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*classify the memory technologies, input-output systems and evaluate the performance of memory system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*	-

Unit-1 – Introduction to Number System	***12 Hour***
Introduction to Number System and Logic Gates: Number Systems- Binary, Decimal, Octal, Hexadecimal; Codes- Grey, BCD, Excess-3, ASCII, Parity; Binary Arithmetic- Addition, Subtraction, Multiplication, Division using Sign Magnitude,1's compliment, 2's compliment, BCD Arithmetic; Logic Gates-AND, OR, NOT, NAND, NOR, EX-OR, EX-NOR.	
Unit-2 - Architectures	***12 Hour***
Basic structure of computers: Functional Units of a computer, Operational concepts, Bus structures, Memory addresses and operations, assembly language, Instructions, Instruction sequencing, Addressing modes. Case study: 8086.	
Unit-3 - Design of ALU	***12 Hour***
De Morgan's Theorem, Adders, Multiplier – Unsigned, Signed, Fast, Carry Save Addition of summands; Division–Restoring and Non-Restoring; IEEE 754 Floating point numbers and operations	
Unit-4 - Control Unit	***12 Hour***
Basic processing unit, ALU operations, Instruction execution, Branch instruction, Multiple bus organization, Hardwired control, Generation of control signals, Micro-programmed control; Pipelining: Basic concepts of pipelining, Performance, Hazards-Data, Instruction and Control, Influence on instruction sets.	
Unit-5 - Parallelism	***12Hour***
Need, types, applications and challenges, Architecture of Parallel Systems-Flynn's classification; ARM Processor: The thumb instruction set, Processor and CPU cores, Instruction Encoding format, Memory load and Store instruction, Basics of I/O operations. Case study: ARM 5 and ARM 7 Architecture.	

Learning Resources	*1. CarlHamacher,ZvonkoVranesic,SafwatZaky,Computer Organization,5thed.,McGraw-Hill,2015* *2. KaiHwang,FayeA.Briggs,Computer Architecture and Parallel rocessing",3rded.,McGrawHill,2016* *3. GhoshT.K.,Computer Organization and Architecture,3rded.,TataMcGraw-Hill,2011* *4. P.Hayes, Computer Architecture and Organization, 3rded.,McGrawHill,2015.*	*5. William Stallings, Computer Organization and Architecture–Designingf or Performance, 10thed., Pearson Education,2015* *6. DavidA. Patterson and JohnL. Hennessy Computer Organization and Design-A Hardware software interface, 5thed., Morgan Kaufmann,2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 2	*Understand*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 3	*Apply*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 4	*Analyze*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Saminath Sanjai, Borqs Technologies,Inc. Bengaluru		*1. Dr.K.Vijaya, , SRMIST*
		2. Dr.Anitha D, SRMIST

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ECC201T	Course Name	SOLID STATE DEVICES	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	ECE	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*learn the principles of semiconductors and PN junction*
CLR-2:	*apply the knowledge of PN and special diodes for electronic systems*
CLR-3:	*gain knowledge about basic operation of BJT and its applications*
CLR-4:	*acquire knowledge about basic concepts of FET and its applications*
CLR-5:	*identify and explore the various techniques of semiconductor fabrication*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*comprehend the basic properties of semiconductors and PN junction*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-2:	*analyze and experiment applications of special diodes and PN diode*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-3:	*articulate the construction, operation, characteristics and parameters of Bipolar Junction transistor and its Applications*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-4:	*demonstrate construction, operation, characteristics and parameters of Field Effect Transistor and its application*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*explain the fabrication techniques of semiconductor devices in integrated circuits*	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	*1*	-	-

Unit-1 - Semiconductor Junction Theory — *9 Hour*

Semiconductor: Fermi level, Electron and hole concentration at equilibrium, Temperature dependence of charge carrier, Drift and diffusion of carriers, Hall effect.PN junction theory: Current-Voltage relationship, Calculation of depletion width, potential barrier, diode current, Capacitive effects in PN junction, Energy band structure, PN diodes: Terminal characteristics and parameters, Diode modelling, DC load line and analysis

Unit-2 - Special Junction Diodes and PN Junction Diode Applications — *9 Hour*

Zener diode, Varactor diode, Step recovery diode, Tunnel diode, LED, Laser diode, Pin photodiode, Avalanche Photodiode. Half wave rectifier and Full wave rectifier: Center tapped and Bridge rectifier Operation and derivation of average values of output voltage and current, ripple factor and efficiency, Peak inverse voltage, Transformer Utilization factor. Filters: Inductor and capacitor filters, LC and CLC Filters, Clippers and Clampers, Voltage Multipliers

Unit-3 – Bipolar Junction Transistor — *9 Hour*

Physical structure and device operation of BJT, Current-Voltage characteristics of BJT configurations, Early effect, BJT circuit models: Ebers Moll, Gummel Poon, small signal & hybrid-π, Biasing circuits for BJT: Base bias, Emitter bias, Voltage-divider bias, Collector-feedback bias, BJT as an amplifier and as a switch

Unit-4 - Field Effect Transistor — *9 Hour*

Physical Structure, Device operation of E-MOSFET and D-MOSFET, I-V characteristics of D-MOSFET & E-MOSFET, Derivation drain current and Transconductance, Biasing circuits for MOSFET: Gate bias, Self-bias, Voltage divider bias, MESFET, HEMT, CMOSFET, MOSFET as an amplifier, MOSFET as a switch, FET Models

Unit-5 - Fabrication of Semiconductor Devices	***9 Hour***
Integrated Circuit: Advantages, Limitations, Classification. IC Manufacturing: Material Preparation, Crystal Growing and wafer preparation, Waferfabrication, Testing, Bonding and Packaging. Fabrication of PN diode, BJT and MOSFET	

Learning Resources	*1. Ben G. Streetman and Sanjay Kumar Banerjee, “Solid State Electronic Devices Pearson, 7th edition, 2016.* *2. Donald A Neamen, Dhrubes Biswas “Semiconductor Physicsand Devices”, 4th edition, McGraw-Hill Education, 2012.* *3. Robert L. Boylestad and Louis Nashelsky, “Electronic Devicesand Circuit Theory”, Pearson Education, 11th Edition, 2013.*	*4. R. S. Sedha, “Applied Electronics”, S. Chand, 2018.* *5. David A. Bell, “Electronic Devices and Circuits”, 5th edition, OxfordUniversity Press, 2015.* *6. Muhammad Rashid, “Microelectronic Circuits: Analysis & Design”,2nd edition, Cengage Learning, 2010.* *7. Thomas L. Floyd, “Electronic Devices”, Pearson, 9th edition, 2013.*

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	15%	-	25%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	5%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect@ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mrs. A. Ramya, SRMIST*
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com	*2. Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. J. Manjula, SRMIST*

Course Code	21ECC202T	**Course Name**	ANALOG AND LINEAR ELECTRONIC CIRCUITS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the operation and design of transistor amplifier circuits for a given specification*
CLR-2:	*discuss the elementary concepts and characteristics of an operational amplifier*
CLR-3:	*introduce the concepts of negative feedback on amplifier circuits, and investigate different feedback topologies to understand their properties, such as transfer gain, input resistances, and output resistances*
CLR-4:	*analyze and design RC and LC oscillator circuits*
CLR-5:	*analyze and design linear and non-linear applications of op-amp*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the small signal equivalent circuit in the analysis of single and multistage transistor amplifier circuits*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*infer the DC and AC characteristics of operational amplifier*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*classify and identify the suitable feedback topologies and oscillators as per application*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*elucidate and design linear and non-linear applications of op-amp*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*illustrate the function of application specific ICs*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Single and Multistage Amplifiers	***9 Hour***
Bipolar Linear amplifier: Load line analysis, small-signal models, analysis of common-emitter, common-base, common-collector amplifiers and multistage amplifiers (cascade, cascode and Darlington) using Hybrid-π model, low- and high-frequency response of BJT amplifiers. MOSFET Linear Amplifier: Load line analysis, small-signal model, analysis of common-source, common-gate and common-drain amplifiers using hybrid-π model, low and high Frequency response analysis of MOSFET amplifier.	
Unit-2 - Introduction to Linear IC's	***9 Hour***
BJT and MOSFET differential amplifier with passive and active loads, Internal Structure of Op-amp, output stages and power amplifiers (Class-A and Class-AB push-pull Complementary amplifier configuration), Ideal operational amplifier, IC 741 packages, characteristics of op-amp, open-loop configurations, non-ideal effects in op-amp, Frequency response of an op-amp.	
Unit-3 - Feedback Amplifiers and Oscillators	***9 Hour***
Negative feedback amplifier: Introduction to feedback and types, advantages and disadvantages of negative feedback, basic feedback concepts, ideal feedback topologies, voltage (shunt- series) amplifier, current (shunt-series) amplifier, trans conductance (series-series) amplifiers, transresistance (shunt-shunt) amplifiers, stability analysis of the feedback Circuit (BJT/MOSFET/Op-amp). Oscillators: Principles of oscillation, classification of oscillators, RC, LC and Crystal oscillators (BJT/MOSFET/Op-amp)	
Unit-4 - Applications of Linear ICs - I	***9 Hour***
Summing amplifier, subtractor, integrator, differentiator, difference amplifier, instrumentation amplifier, voltage-to-current converter, current-to-voltage converter, comparators, Schmitt triggers and Non sinusoidal oscillators, active filters, first order and second order low and high pass filters, band-pass filters, band-stop filters, waveform generators.	

Unit-5 - Applications of Linear ICs - II	***9 Hour***
Converters: Weighted -Resistor D/A and R-2R ladder D/A, Analog-to-Digital Converter: Successive approximation A/D Converters, precision rectifiers, clippers, and clampers. Specialized ICs: 555 Timer, functional block, 566 VCO and 565 PLL, Applications of PLL and 555 Timer, voltage regulators-LM78xx, LM79xx, LM723, LM380 power amplifiers.	

Learning Resources	1. *David A. Bell, "Electronic Devices and Circuits", 5th ed., Oxford University Press, 2015* 2. *Donald Neaman, "Electronic Circuits: Analysis and Design", 3rd ed., Mc-Graw-Hill Education, 2011* 3. *Muhammad Rashid, "Microelectronic Circuits: Analysis and Design", 2nd ed., Cengage Learning, 2010* 4. *Robert L. Boylestad Louis Nashelsky, "Electronic Devices and Circuit Theory", 11th ed., Pearson Education, 2013*	5. *D. Roy Choudhry, Shail Jain, "Linear Integrated Circuits", 5th ed., New Age International Pvt. Ltd., 2015* 6. *Ramakant A. Gayakwad, "Op-amp and Linear ICs", 4th ed., Printice Hall/Pearson, Education,2015* 7. *Sergio Franco, "Design with Operational amplifiers and Analog Integrated circuits", 4th ed., Tata McGraw-Hill, 2016*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*25%*	-	*25%*	-	*25%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*5%*	-	*5%*	-	*5%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect@ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. E. Sivakumar, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com*	2. *Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Mr. AVM. Manikandan, SRMIST*

Course Code	21ECC203T	**Course Name**	DIGITAL LOGIC DESIGN	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand binary codes, able to simplify Boolean logic expressions and understand the basic TTL and CMOS gates operate at the component level*
CLR-2:	*able to design simple combinational logics using basic gates and MSI circuits*
CLR-3:	*familiarize with basic sequential logic components: flip-flops, registers, counters and their usage, and able to design of sequential logic circuits*
CLR-4:	*able to design application level circuits and adopt systematic approach with the use of Sequence detector*
CLR-5:	*know how to implement logic circuits using PLDs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*simplify Boolean expressions; implement gates as well as other types of IC devices using two major IC technologies, TTL and CMOS*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*identify eight basic types of fixed-function combinational logic functions and demonstrate how the devices / circuits can be used in building complete digital systems such as computers*	-	*2*	*2*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*understand and design sequential circuits using several types of flip-flops*	-	*2*	*2*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*design of advanced circuit and Design the advanced sequential logic circuits*	-	*2*	*2*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*implement multiple output combinational logic circuits using PLDs; Explain the operation of a CPLD and FPGA*	-	*2*	*2*	-	*3*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Basics and Logic Family	***9 Hour***
Boolean algebra, Karnaugh Map - Quine McClusky minimization technique (4 -variable) - Logic Families: -Introduction - TTL NAND gate, Specifications, Noise margin, Propagation delay, fan-in, fan-out, CMOS	
Unit-2 - Combinational Circuits	***9 Hour***
Combinational logic circuits: Half adder – Full Adder – Half subtractor - Full subtractor – Parallel binary adder - 2's complement subtraction using parallel adders - Multiplexer/Demultiplexer – decoder - encoder - code converters - Magnitude Comparator	
Unit-3 - Sequential Circuits	***9 Hou***
Flip-flop and Latch: SR latches- JK flip-flop, T flip-flop, D flip-flop-Master-slave JK flip-flop- Register Counters- Ring counter, Johnson Counter-Shift registers (SISO, SIPO, PISO, PIPO) --Universal shift register-Counters: -Asynchronous/Ripple counters--Synchronous Counters-Modulus-n Counter -Up-Down counter- State Reduction-State assignment	
Unit-4 - Advanced Combinational & Sequential Logic	***9 Hour***
Advance sequential logic: -- Mealy and Moore model- Analyze and design synchronous sequential circuits - FSM - Sequence detector - Vending Machine – Advanced digital circuits: - Hamming code – Delay in a ripple carry adder - Carry Look Ahead adder -2 Bit Multiplier	
Unit-5 - PLD's and Memory	***9 Hour***

RAM Memory decoding-ROM--Basic concepts: -Programmable Logic Devices (PLDs):-Basic concepts-PROM as PLD-Programmable Array Logic (PAL)--Programmable Logic Array (PLA)-FPGA

Learning Resources	1. *Morris Mano M, Michael D. Ciletti, "Digital Design with an Introduction to the Verilog HDL", 5th ed., Pearson Education, 2014* 2. *Charles H Roth (Jr), Larry L. Kinney, "Fundamentals of Logic Design", 5th ed., Cengage Learning India Edition, 2010.* 3. *Thomas L. Floyd, "Digital Fundamentals", 10th ed., Pearson Education, 2013*	4. *Ronald J. Tocci, "Digital System Principles and Applications", 10th ed.Pearson Education, 2009.* 5. *Donald P Leach, Albert Paul Malvino, Goutam Saha, "Digital Principles and Applications", 6th ed., TataMcgraw Hill, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect@ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Mr. Maria Dominic Savio, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com*	2. *Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECC204T	Course Name	SIGNAL PROCESSING	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic concepts, operations and types of signals and systems*
CLR-2:	*analyse the periodic and aperiodic Continuous signals using Fourier transform and Laplace transform*
CLR-3:	*analyse the discrete time signal using DFT and discrete time system using Z-Transform*
CLR-4:	*design FIR filter using windowing technique*
CLR-5:	*design Analog IIR filter, Conversion of Analog filter to digital Filter*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the Classification of Signals and Systems and various operations on signals*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-2:	*apply Fourier transform and Laplace transform on solving continuous time signals and systems*	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*apply Discrete Fourier Transform and Z-Transform on Discrete time signals and systems*	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*design Finite Impulse Response Filters using different types of windowing techniques*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*design analog and digital Infinite Impulse Response Filters*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Classification of Signals and Systems	***9 Hour***
Introduction to signal and systems, Real time Applications of Signals, Fundamental Signals-Unit impulse, Step, Ramp Various operations on signals- Time Shifting. Time reversal, Time Scaling, Amplitude Scaling, Signal Addition and Multiplication. Classification of Continuous and Discrete time signals- Periodic and Aperiodic, Even and Odd, Energy and Power, Deterministic and Random, Types of Systems- Linear and Non-linear, Time Variant and invariant, Causal and Non-Causal, Static, and dynamic, Stable and unstable systems.	
Unit-2 - Analysis of Continuous Time (CT) Signals and Systems	***9 Hour***
Fourier Transform and Inverse Fourier Transform, Properties of Fourier Transform, Analysis of LTI CT system using Fourier Transform, Frequency Response, Impulse Response and Step response, Laplace Transform and Inverse Laplace Transform, Region of Convergence (RoC) and Properties, Analysis of LTI CT system using Laplace Transform, Problems solving using properties of Laplace transform	
Unit-3 - Analysis of Discrete Time (DT) Signals and Systems	***9 Hour***
Discrete Fourier Transform (DFT) and Inverse Discrete Fourier Transform (IDFT), Problems solving on DFT, Fast Fourier Transform (FFT) - Decimation in Time Fast Fourier Transform (DIT-FFT), Decimation in Frequency Fast Fourier Transform (DIF-FFT), Linear Convolution and Circular Convolution, Z- Transform, Region of Convergence (RoC) and Properties, Analysis of DT system using Z- transform, Stability of a system, Inverse Z Transform using Partial fraction method.	
Unit-4 - Finite Impulse Response (FIR) Filter Design	***9 Hour***
Design of Linear Phase FIR Filters, Frequency Response of FIR Filter- N Odd (symmetric), Frequency Response of FIR Filter- N Even (Symmetric), FIR Filter Design using Windowing Technique, Design of FIR low pass, High pass, Band pass and Band Stop filter Design- Rectangular Window, Hanning Window, Hamming Window and Blackman Window.	
Unit-5 - Infinite Impulse Response (IIR) Filter Design	***9 Hour***
Introduction to IIR Filters- Comparison between FIR and IIR Filters, Analog IIR Filter design – Butterworth and Chebyshev Filters, Comparison of Properties of Butterworth and Chebyshev Filters, Design of IIR low pass and High Pass filter using Butterworth method, Design of IIR low pass and High Pass filter using Chebyshev method, Conversion of Analog filter into Digital Filter- Bilinear Transformation and Impulse Invariance Method	

Learning Resources	1. *Alan V Oppenheim, Ronald W. Schafer, "Signals & Systems", 2nd Edition, Printice Hall of India, 2015.* 2. *John G. Proakis, Dimitris G.Manolakis, "Digital Signal Processing: Principles, Algorithms and Principles", 4th Edition, Printice Hall of India, 2001.*	3. *Alan V. Oppenheim, Ronald W. Schafer, John R. Buck., "Discrete-Time Signal Processing", 2nd Edition, Pearson, 2011.* 4. *B.P. Lathi and Rpger Green, "Linear Systems and Signals", 3rd Edition, Oxford University Press, 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Mr. B. Ananda Venkatesan, SRMIST*
2. *Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com*	2. *Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr. S. Dhanalakshmi, SRMIST*

Course Code	21ECC205T	**Course Name**	ELECTROMAGNETIC THEORY AND INTERFERENCE	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21PYB101J*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Clark's Table, IS:456-2000*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on the basic concepts and insights of Electric field*
CLR-2:	*gain knowledge on the basic concepts and insights of Magnetic field and emphasize the significance of Maxwell's equations*
CLR-3:	*interpret the wave propagation in guided waveguide*
CLR-4:	*acquire the fundamental knowledge on Transmission Line Theory and acquire the knowledge on transmission line parameter calculation*
CLR-5:	*acquire knowledge on theoretical concepts and analysis techniques to find solutions for problems related to electromagnetic wave propagation and Transmission line Theory*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts and knowledge to solve problems related to electric field*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the concepts of Magnetic field and Maxwell's equations in the real world application*	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*translate the phenomenon of guided wave propagation and its mode of propagation*	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*describe the importance of transmission line theory applicable to low frequency transmission lines*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*solve transmission line parameter and impedance matching through analytical and graphical methods*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 – Electrostatics	***9 Hour***
Introduction to electrostatics- rectangular co-ordinate- Cylindrical & Spherical Co-ordinate- Review of vector calculus- Coulomb's Law and field intensity- Problem based on coulomb's law- Electric field due to continuous charge distribution-Concept- Derivation of E due Infinite Line charge	
Unit-2 - Magnetostatics and Maxwells Equations	***9 Hour***
Energy density in electrostatic field- Problem discussion. - Biot savart law-Magnetic field intensity due to Infinite line charge- H- due finite and semi finite line charge- Ampere's circuital law and application: Infinite line current- Infinite Sheet current- Infinitely long coaxial Transmission line- Problem based on ACL.	
Unit-3 - Electromagnetic Waves and Waveguides	***9 Hour***
Introduction to EM waves- Waves in general- Plane wave in lossless dielectric- Plane wave in free space- Plane wave in good conductor- Problems based on plane waves in lossless, free space and good conductor-rectangular waveguide- rectangular waveguide-Problems	
Unit-4 - Transmission Line Theory and Introduction to Interference	***9 Hour***
Transmission line parameters- Transmission line equivalent circuit- Explanation- Transmission line equation derivation- Problem discussion. - Transmission line characteristics: lossless Line- Distortion less line - EMI/EMC- Types of EMI/EMC - SE, CE - Susceptibility	
Unit-5 - Transmission Line Calculator and Impedance Matching - Advanced EM Theory	***9 Hour***
Introduction to impedance matching- Smith chart Introduction- Reflection coefficient, Standing wave ratio Input impedance calculation in smith chart- Practice problems. - Single stub matching Introduction- Procedure for single stub matching- Problems solving in smith chart.	

Learning Resources	1. Matthew N. O. Sadiku., S. V. Kulkarni, “Elements of Electromagnetics”, 6th ed., Oxford University Press, 2015 2. G. S. N. Raju, “Electromagnetic Field Theory and Transmission Lines”, Pearson Education, 2006	3. Nannapaneni Narayana Rao, “Principles of Engineering Electromagnetics”,6th ed. Pearson Education, 2016 4. William H. Hayt, Jr., John A.Buck., “Engineering Electromagnetics”, 8th ed., Tata McGraw-Hill 2012. 5. John D.Ryder, “Networks, Lines and Fields”, PHI, 2009.

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	35%	-	35%	-	35%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. Sandeep Kumar P, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	2. Dr. C. T. Manimegalai, SRMIST

Course Code	21ECC211L	**Course Name**	DEVICES AND DIGITAL IC LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*21ECC101J*	**Co- requisite Courses**	*21ECC201T*	**Progressive Courses**	*21ECC202T*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*understand the principles of Zener diode and its application*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*gain knowledge about applications of PN*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*explore the characteristics and operation of BJT and MOSFET*															
CLR-4:	*acquire knowledge combinational circuits and its applications*															
CLR-5:	*familiarize operations of various sequential circuits*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*demonstrate the characteristics of Zener diode and its applications*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*analyze applications of PN diode*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	-	-	-
CO-3:	*articulate the characteristics and parameters of BJT and MOSFET*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*implement different combinational circuits*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*design various sequential circuits in real life*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Zener Diode and Application	***12 Hour***
Semiconductor principles- Properties of PN- Principle of Zener diode- Characteristics of Zener diode, Forward biasing, Reverse Biasing- Diodeparameters- I-V characteristics- Application in reverse Biasing - Voltage regulator- Series, Shunt- Load regulation, line regulation	
Unit-2 - PN Junction Diode Applications	***12 Hour***
Rectifiers- Half wave, Full wave centre tapped- Filters: Capacitive filter- Rectification with and without filter, Efficiency, ripple factor- Clipper: Principles, Series clipper, Shunt clipper, Biased clipper- Clamper: Positive clamper, Negative clamper, Biased clamper	
Unit-3 - Bipolar Junction Transistor and Metal Oxide Semiconductor Field Effect Transistor	***12 Hour***
BJT: Principle, Operation, Characteristics: Input characteristics, Output characteristics- Transistor parameters- DC load line- BJT biasing: Fixed bias, Collector feedback bias, Emitter bias, Voltage divider bias MOSFET: Principle, Operation, Characteristics: Transfer characteristics, Drain characteristics, FET parameters, MOSFET Switching	
Unit-4 - Combinational Circuits	***12 Hour***
Design of combinational circuits- Adders: Half adder, full adder, Full adder using half adder, 4-bit binary parallel adder- Encoder: 4×2, 8×3- Decoder: 2×4, 3×8-4:1 Multiplexer- 1:4 Demultiplexer	
Unit-5 - Sequential Circuits	***12 Hour***
Clock- Flip flop: RS, JK, D & T- Synchronous counters: Up, Down, Up/Down, Asynchronous counters: Up, Down, Up/Down, Mod-n Counters	

Learning Resources	1. *David A. Bell, “Electronic evices and Circuits”, 5th edition, Oxford University Press, 2015.* 2. *Donald A Neamen, Dhrubes Biswas “Semiconductor Physics and Devices”, 4th edition, McGraw-Hill Education, 2012.* 3. *Robert L. Boylestad and Louis Nashelsky, “Electronic Devices and Circuit Theory”, Pearson Education, 11th Edition, 2013.*	4. *Morris Mano M, Michael D. Ciletti, Digital Design with an Introduction to the Verilog HDL, 5th ed. Pearson Education, 2014.* 5. *Charles H Roth (Jr), Larry L. Kinney, Fundamentals of Logic Design, 5th ed., Cengage Learning India Edition, 2010.Thomas L. Floyd, Digital Fundamentals, 10th ed., Pearson Education, 2013.*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	-	-		-	-
Level 6	*Create*	-	-	-			-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect@ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Mrs. A. Ramya, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com*	2. *Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr. J. Manjula, SRMIST*

Course Code	21ECC222L	**Course Name**	ANALOG AND LINEAR ELECTRONIC CIRCUITS LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*21ECC201J*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the operation of BJT and MOSFET amplifier*
CLR-2:	*study the concept of multi stage amplifier and differential amplifier*
CLR-3:	*understand class C power amplifier and oscillator*
CLR-4:	*study various Op amp configurations and comparator applications*
CLR-5:	*design and implement filters and Digital to analog converters*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*compile the operation of BJT and MOSFET amplifier*	2	-	2	-	3	-	-	-	-	-	-	-	-	-	-
CO-2:	*design multistage amplifier and differential amplifier*	2	-	2	-	3	-	-	-	-	-	-	-	-	-	-
CO-3:	*implement class C power amplifier and oscillator in electronic application*	2	-	2	-	3	-	-	-	-	-	-	-	-	-	-
CO-4:	*design linear and nonlinear application of op amp*	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*illustrate filters and digital to analog converters*	2	-	2	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - BJT and MOSFET Amplifier	***12 Hour***
BJT configuration, input characteristics, output characteristics, transient analysis, frequency response, common source amplifier with current series feedback transient and frequency response, common source amplifier with voltage series feedback transient and frequency response.	
Unit-2 - Multistage Amplifier and Differential Amplifier	***12 Hour***
Cascode amplifier transient response and frequency response, Bandwidth calculation. Differential amplifier frequency response, common mode gain, differential mode gain, common mode rejection ratio.	
Unit-3 - Class C Power Amplifier and LC Oscillator.	***12 Hour***
Class C power amplifier transient response, Class C power amplifier frequency response, quality factor, Design of LC oscillator, feedback fraction, frequency of oscillation.	
Unit-4 - Linear and Non4linear Applications of OP Amp	***12 Hour***
Inverting amplifier noninverting amplifier, voltage follower, closed loop gain, Inverting comparator, non-inverting comparator, Schmitt trigger, upper threshold point, lower threshold point calculation, monostable multivibrator using IC 555, Astable multivibrator, duty cycle measurement.	
Unit-5 - Filters and Digital to Analog Converter	***12 Hour***
Butterworth low pass filter frequency response, Butterworth high pass filter frequency response, Bandpass filter, Band reject filter, R-2R ladder type digital to analog converter	

Learning Resources	1. David A. Bell, "Electronic Devices and Circuits", 5th ed., Oxford University Press, 2015 2. Donald Neaman,"Electronic Circuits: Analysis and Design", 3rd ed., Mc-Graw-Hill Education, 2011 3. Muhammad Rashid, "Microelectronic Circuits: Analysis and Design" 2nd ed., Cengage Learning, 2010 4. Robert L. Boylastaed Louis Nashelsky, "Electronic Devices and Circuit Theory", 11th ed.Peason Education, 2013	5. D. Roy Choudhry, Shail Jain, "Linear Integrated Circuits", 5th ed., New Age International Pvt. Ltd., 2015 6. Ramakant A. Gayakwad, "Op-amp and Linear ICs", 4th ed., Printice Hall/Pearson Education,2015 Sergio Franco, "Design with Operational amplifiers and Analog Integrated circuits", 4th ed., Tata Mcgraw-Hill, 2016

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	20%	-	20%	-	20%	-	-
Level 2	Understand	-	20%	-	20%	-	20%	-	-
Level 3	Apply	-	30%	-	30%	-	30%	-	-
Level 4	Analyze	-	30%	-	30%	-	30%	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100%		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect@ Google	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1 Dr. M.K. Srilekha, SRMIST
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com	2. Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	21ECC301P	**Course Name**	MICROPROCESSOR, MICROCONTROLLER, AND INTERFACING TECHNIQUES	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*21ECC203T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand Microcontroller internal architecture and its assembly language programming*
CLR-2:	*learn how to program microcontroller interfaces in ALP, C*
CLR-3:	*use ATMEGA 328P in their project designs*
CLR-4:	*understand microprocessor internal architecture and programming*
CLR-5:	*learn various interfacing hardware's for microprocessors*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe microprocessor internal architecture and programming*	-	*3*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*design and implement Microcontroller peripheral interface in ALP and C.*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*design and implement ATMEGA 328P based projects*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*describe microprocessor internal architecture and instructions set*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-5:	*identify correct interfacing hardware's for microprocessors*	-	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 - 8051 Microcontroller	***12 Hour***
Pin-diagram and architecture of 8051, instruction-sets of 8051, addressing modes of 8051. Assembly language programs in 8051.Case studies on addressing modes of 8051.	
Unit-2 - Peripheral Programming in 8051	***12 Hour***
8051 timer & its programming in ALP & C, 8051 Interrupts and its programming in ALP, C, 8051 serial port communication and its programming in ALP & C, Interfacing ADC, Interfacing DAC. Case studies on timers, interrupts, serial port communication.	
Unit-3 - ATMEGA 328P	***12 Hour***
ATMEGA 328P architecture, register file, memory, addressing mode, instruction sets, I/O ports, Case studies: interfacing with LCD, Temperature Sensor DHT11, High-Voltage Device and Relay, Bluetooth Module (HC-05), GSM Module (SIM900A), Using I2C Protocol, Using Zigbee to interface wireless sensors.	
Unit-4 - 8086 Microprocessor	***12 Hour***
Microprocessor (8086) Pin diagram, Architecture, internal registers, Interrupts, addressing mode, instruction sets.	
Unit-5 - Microprocessor Interfacing	***12 Hour***
Programmable peripheral interface-8255, Programmable Interval Timer-8254, USART-8251, DMA Controller – 8257/8237.	

Learning Resources	1. D. V. Hall, “Microprocessors and Interfacing” | 3rd Edition (SIE) 2. Muhammad Ali Mazidi and Janice GillispieMazidi, "The 8051 – Microcontroller and Embedded Systems", 7th Edition, Pearson Education, 2011. 3. K. M. Bhurchandi and A. K. Ray, "Advanced Microprocessors and Peripherals with ARM and an introduction to Microcontrollers and Interfacing", Tata MeGraw Hill, 3edition 2015. 4. Raj Kamal, ”Embedded systems”, Tata McGraw Hill, 2003	5. Dr. Yogesh Misra, “Programming and Interfacing with Arduino”, Taylor and Francis 6. Derek Molloy, "Exploring Raspberry PI, Interfacing with real world", Wiley, 2016 7. Subrata Ghoshal, “8051 Microcontroller Internals, Instructions”, Programming and Interfacing, Pearson, ISBN: 978-81-317-3143-7 8. Barry B. Brey, “The Intel Microprocessors” 8th Edition

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		Formative CLA-1 Average of unit test (20%)		Project Based Learning CLA-2 (60%)		Report and Viva Voce (20%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	-	10%	-	-	-	-
Level 2	Understand	25%	-	-	20%	-	-	-	-
Level 3	Apply	30%	-	-	25%	-	20%	-	-
Level 4	Analyze	25%	-	-	25%	-	30%	-	-
Level 5	Evaluate	-	-	-	10%	-	30%	-	-
Level 6	Create	-	-	-	-	-	20%	-	-
	Total	100 %		100 %		100%		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1 Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. Md. Jawaid Alam, SRMIST
2 Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2 Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	2. Dr. R. Manohari, SRMIST

Course Code	21ECC302T	Course Name	ANALOG AND DIGITAL COMMUNICATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21MAB203T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*introduce to the learners the basic concepts involved in Communication system*
CLR-2:	*comprehend the functionalities of various radio transmitters and receivers*
CLR-3:	*realize the process involved in digital communication systems*
CLR-4:	*explore the pass band transmission system and analyze its performance in terms of probability of error*
CLR-5:	*get exposed to Information theory and channel coding concepts*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the various analog modulation techniques*	*3*	-	-	-	-	-	-	-	-	-	-	2	2	-	-
CO-2:	*analyze the noise performance of radio transmitters and receivers*	*3*	*3*	-	-	-	-	-	-	-	-	-	2	-	*3*	-
CO-3:	*demonstrate the demodulation and detection of received digital data*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*apply the suitable passband techniques for real time applications*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*exposed to the concepts of information theory and channel capacity*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Analog Modulation Techniques	***9 Hour***
Need for Modulation - Types of Analog Modulation - Amplitude Modulation (AM) and its types - Generation of AM Waves - Linear Method (Collector Modulator) - Non Linear Method (Balanced Modulator) - Demodulation of AM waves (Envelop Detector) - Frequency Modulation (FM) – Types of FM –Narrow Band FM (NBFM) and Wide Band FM (WBFM) - Generation of NBFM (Varactor Diode Modulator) - Demodulation of NBFM waves (Foster Seely Method)- Phase Modulation (PM)- Generation of PM from FM and FM to PM	
Unit-2 - Radio Transmitters and Receivers	***9 Hour***
AM Transmitter (Low Level and High Level) - FM Transmitter (Direct and Indirect Method) - Characteristics and functions of a receiver - AM Superheterodyne Receiver and FM Super Heterodyne Receiver - Noise in AM and FM (Elementary Treatment) - Need for Pre-emphasis and De-emphasis circuits	
Unit-3 - Baseband and Digital Modulation Techniques	***9Hour***
Baseband Modulation Techniques (PAM, PWM and PPM) - Digital Modulation Techniques - Pulse Code Modulation (PCM) System) - Differential PCM (DPCM) System - Delta Modulation (DM) System - Matched Filter Receiver - Probability of error for Matched filter - Inter Symbol Interference (ISI) and Eye pattern	
Unit-4 - Passband Transmission System	***9 Hour***
Passband Transmission System Model – Passband Modulation Techniques- Generation, Signal Space diagram, Detection, Probability of Error for BFSK - BPSK – QPSK – M-ary PSK and FSK (Elementary Treatment) – QAM System	
Unit-5 - Information Theory and Channel Capacity	***9 Hour***
Entropy, Information rate, Source coding theorem, Shannon-Fano coding, Huffman coding, Mutual information – Shannon's channel capacity theorem	

Learning Resources	1. Simon Haykin and Michael Moher, Communication Systems," 5th edition, John Wiley & Sons, 2013 2. Singh. R. P & Sapre. S. D, "Communication Systems: Analog & Digital," 3rd edition, Mc GrawHill Education, Seventh Reprint, 2016. 3. Simon Haykin, "Communication Systems", John Wiley & Sons, 4th Edition, 2008	4. Bernard Sklar, "Digital Communication, Fundamentals and Application", Pearson Education Asia, 2nd Edition, 2001 5. Taub & Schilling, "Principle of Communication Systems", McGraw Hill Inc, 2nd Edition, 2003. 6. John G. Proakis, "Digital Communication", McGraw Hill Inc, 5th Edition, 2008.

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*25%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. M. Sangeetha, SRMIST*
2. *Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECC303T	**Course Name**	VLSI DESIGN AND TECHNOLOGY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC203T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*implement a given logic function using appropriate logic styles for improved performance*
CLR-2:	*understand the MOSFET operation and processes in IC fabrication, steps in the fabrication of MOS ICs, and as well the layout design rules*
CLR-3:	*understand Concepts of thermal oxidation and Si/SiO2 interface*
CLR-4:	*concepts of ion implantation, role of the crystals structures, high-energy implants, ultralow energy implants and ion beam heating methods*
CLR-5:	*use Verilog HDL as a design-entry language for FPGA in electronic design automation of digital circuits, Design, construct and simulate VLSI adders and multipliers*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*examine the characteristics of MOS transistors and Analyze CMOS inverter and other complex logic gates designed using different logic styles*	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*design and implement digital circuits using Verilog HDL, general VLSI system components, adder cells and multipliers to address the design of data path subsystem*	-	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*explain how the transistors are built, and understand the physical implementation of circuits and understand physics of the Crystal growth, wafer fabrication and basic properties of silicon wafers*	-	2	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*to learn the various lithography techniques and concepts of wafer exposure system, concepts of thermal oxidation and Si/SiO2 interface. Dopant solid solubility, diffusion macroscopic point, different solutions to diffusion equation*	-	3	1	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*to learn concepts of ion implantation, role of the crystals structures, high-energy implants, ultralow energy implants and ion beam heating methods*	-	2	2	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Introduction to Verilog HDL & Coding ***9 Hour***

Introduction to HDL & Verilog HDL - Introduction to Verilog HDL, modules and ports -Lexical Conventions: White Space and Comments, Operators - Numbers, Strings, Identifiers, System Names, and Keywords - Verilog Data Types: Nets, Register Variables, Constants Referencing Arrays of Nets or Regs -Arithmetic Operators, Bitwise Operators, Reduction Operators, Logical Operators, Relational Operators, Shift Operators, Conditional Operator, Concatenation Operator, Expressions and Operands, Operator Precedence -Verilog modeling: Gate-level modeling - Realization of Combinational and sequential circuits -Compilation and simulation of Verilog code -Test bench -Dataflow modeling -Realization of Combinational and sequential circuits -Behavioral modeling -Realization of Combinational and sequential circuits Switch-level modeling - Realization of MOS circuits -Design using FSM -Realization of sequential circuits

Unit-2 - MOS Transistor ***9 Hour***

Generic overview of the MOS device: MOS structure demonstrating (a) accumulation, (b) depletion, and (c) inversion; nMOS transistor demonstrating cutoff, linear, and saturation regions of operation - Static Conditions: The threshold voltage - Dynamic behavior: MOSFET Capacitances- Parasitic Resistances - Non-ideal I-V effects: Mobility Degradation, Velocity Saturation - Channel Length Modulation, Threshold Voltage Effects - Leakage, Temperature Dependence, Geometry Dependence, Subthreshold Current-Short-channel MOSFETs: Hot carriers, LDD - MOSFET scaling - Short-channel effects: NBTI, oxide breakdown - DIBL, GIDL, Gate Tunnel Current. CMOS Inverter Characteristics: Operation and properties of static CMOS inverter - Power Consumption - Dynamic Power Consumption, Total Power Consumption, PDP

Unit-3 - VLSI Subsystem Design and Introduction to CMOS Logic Styles	***9 Hour***
Decoders -Comparators -Adders: Standard adder cells -Ripple Carry Adder (RCA) -Carry Look-Ahead Adder (CLA) -Carry Select /Save/skip Adder (CSL/CSA/ CSK). Multipliers: Overview of multiplication- types of multiplier architectures -Braun multiplier -Baugh-Wooley multiplier -Wallace Tree multiplier -Booth multiplier CMOS Circuit Design Styles: Static CMOS logic styles -CMOS circuits, pseudo-nMOS, tristate circuits, clocked CMOS circuits -DCVSL, Pass Transistor Logic (PTL) -Dynamic CMOS logic styles: NORA, TSPC	
Unit-4 - Lithography and Relative Plasma Etching	***9 Hour***
Optical Lithography, Electron Lithography, X-Ray Lithography, Ion Lithography, Plasma properties, Feature Size control and Anisotropic Etch mechanism, reactive Plasma Etching techniques and Equipment. Deposition, Diffusion, Ion implementation and Metallization Deposition process, Poly silicon, plasma assisted Deposition, Models of Diffusion in Solids, Fick's one-dimensional Diffusion Equations – Atomic Diffusion Mechanism – Measurement techniques – Range theory- Implant equipment. Annealing Shallow junctions – High energy implantation – Physical vapor deposition– Patterning.	
Unit-5 - Process Simulation and VLSI Process Integration	***9 Hour***
Ion implantation – Diffusion and oxidation – Epitaxy – Lithography – Etching and Deposition- NMOS IC Technology – CMOS IC Technology – MOS Memory IC technology - Bipolar IC Technology – IC Fabrication - NMOS.CMOS Fabrication processor flow- Analytical Beams – Beam Specimen interactions	

Learning Resources	*1. S.M. Sze, "VLSI Technology", McGraw Hill fourth Edition. 2008.* *2. James D Plummer, Michael D. Deal, Peter B. Griffin, "Silicon VLSI Technology: Fundamentals Practice and Modeling", Prentice Hall India.2009.* *3. Wai Kai Chen, "VLSI Technology" CRC Press, 2013.* *4. Jan M. Rabaey, Anantha P. Chandrakasan, Borivoje Nikolić,*	*5. Digital Integrated Circuits: A Design Perspective", Pearson Education, 2015.* *6. CMOS VLSI Design: A Circuits and Systems Perspective, 4th Edison, Neil Weste, David Harris, Pearson publication, 2015.* *7. Douglas A. Pucknell, Kamran Eshraghian, "Basic VLSI Design, 3rd Edison, prentice Hall, 2016*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect@ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr.J. Selvakumar, SRMIST*
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software Pvt. Ltd. Gurgaon, kumaranuj.anii@gmail.com	*2. Dr Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECC304T	**Course Name**	MICROWAVE AND OPTICAL COMMUNICATION	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*21ECC302T*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*deliver in depth knowledge on microwave transmission and generation*
CLR-2:	*propose efficient methods to analyze S-parameters of microwave devices*
CLR-3:	*explore detailed awareness on measurement techniques and to provide complete knowledge on the techniques with associated equipment*
CLR-4:	*offer complete information on light transmission through optical fiber and their mechanism and characterization*
CLR-5:	*acquire detailed understanding on the methodologies and design considerations of link power budget in optical communication system and to grant mathematical formulation*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*familiarize the concept of microwave transmission and generation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*realize systematic methods to design, analyze S-parameters of microwave devices*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*identify different measurement techniques for determining various parameters and to gain knowledge on microwave measurements and the techniques with associated equipment*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*discover complete information on the fundamentals of light transmission through fiber and their characterization and mechanism*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*recognize the link power budget design considerations of optical communication system*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Microwaves and Sources	***9 Hour***
History of Microwave Engineering, Microwave transmission and Applications, Microwave Tubes, Klystron amplifier, Reflex Klystron oscillators, Magnetron oscillators, IMPATT, TRAPATT, Tunnel diode, Gunn diode.	
Unit-2 - S Parameters Analysis for N-port Microwave Devices	***9 Hour***
Scattering parameter, Directional coupler, E plane, H plane and Magic Tee Junctions, Microwave Circulators, Isolators, Phase shifters, Attenuators and Power dividers. Case study on Directional coupler	
Unit-3 - Microwave Measurements	***9 Hour***
npedance and Power measurement, Measurement of Frequency, Attenuation, Scattering parameters, Vector Network Analyzer, Signal Analyzer and Spectrum Analyzer Case study on VSWR and Impedance measurement	
Unit-4 - Optical Fiber Communication Systems	***9 Hour***
Introduction to Optical fiber communication, Ray theory transmission, Optical fiber modes and configurations, Fiber attenuation and dispersion mechanisms, Optical sources-LED and LASER Diode, Optical detectors-PIN and Avalanche photo diode	
Unit-5 - Optical Link Power Budget Analysis	***9 Hour***
Digital link-Point-to-Point link –System considerations, Link power budget and Risetime budget, Analog link and analysis, WDM and Passive devices, Case study on Point-to-Point link power budget analysis	

Learning Resources	1. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson Education, 2013. 2. Robert. E. Collin, "Foundations for Microwave Engineering", 2nd edition, Wiley, Reprint 2014. 3. Annapurna Das, Sisir K. Das, "Microwave Engineering", 3rd Ed., McGraw Hill, 2015. 4. David M. Pozar, "Microwave Engineering", 4th Edition, John Wiley & Sons, 2012	5. Keiser G, "Optical Fiber Communication Systems", 5th Edition, 6th Reprint, McGraw Hill Education (India), 2015. 6. John M. Senior, "Optical fiber Communications: Principles and Practice", Pearson Education, 3rd Edition, 2009. 7. Vivekanand Mishra, Sunita P. Ugale, "Fiber Optic Communication: Systems and Components", Wiley-India, 1st edition, 2013

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. Shanthi Prince, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	2. Dr. M. Neelaveni Ammal, SRMIST

Course Code	21ECC311L	**Course Name**	VLSI DESIGN LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*21ECC203T*	**Co- requisite Courses**	*21ECC303T*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn Hardware Descriptive Language (Verilog/VHDL)*
CLR-2:	*learn the fundamental principles of VLSI circuit design in digital and analog domain*
CLR-3:	*familiarize fusing of logical modules on FPGAs*
CLR-4:	*hands on design experience with professional design (EDA) platforms*
CLR-5:	*understand the concept of transistors are built, and the physical implementation of circuits*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design and implement digital circuits using Verilog HDL to simulate and verify the designs*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*design general VLSI system components, adder cells and multipliers to address the design of data path subsystem*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*examine the characteristics of MOS transistors*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*analyze CMOS inverter and other complex logic gates designed using different logic styles*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*use HSPICE computer analysis program and Verilog HDL for simulation, analysis of MOS circuits and building blocks*	*3*	*2*	-	-	*1*	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Combinational and Sequential Logic Circuit	***12 Hour***
Realization of Combinational and Sequential Circuits - Realization of digital circuits using behavioural modelling and Switch level Modelling - Design using FSM and ASM charts	
Unit-2 - Design of VLSI Subsystem -1	***12 Hour***
Design of ADDER- Ripple carry adder – carry save adder – carry select/skip adder- Implementation in HDL gate-level or behavioural modelling - synthesis report and analysis.	
Unit-3 - Design of VLSI Subsystem – 2	***12 Hour***
Realization of VLSI Multiplier-I (Braun and booth multiplier) - Realization of VLSI Multiplier-II (Wallace Tree multiplier) - Implementation in HDL gate-level or behavioural modelling-synthesis report and analysis.	
Unit-4 - Design of Computing and Memory Unit	***12 Hour***
Realisation of 1K x 8 RAM & ROM- 4K x 16 RAM & ROM – Realisation of 4 bit and high order bit ALU – Implementation in HDL behavioural modelling – synthesis report with analysis.	
Unit-5 - Switch Level Modelling	***12 Hour***
Design and Analysis of inverter using CMOS and pseudo NMOS with HSPICE - Design and Analysis of AND/NAND gate in DCVSL and Pass transistor logic using LTSPICE- Design and analysis of 4- input Dynamic NAND gate using HSPICE	

Learning Resources	1. *Verilog HDL- A Guide to Digtial Design and Synthesis, Sameer Palnitkar, Pearson publication.*	2. *Xilinx vivado 2020 Version* 3. *Questasim - powered by Siemens*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	-	20%	-	20%	-	20%	-	-
Level 2	*Understand*	-	20%	-	20%	-	20%	-	-
Level 3	*Apply*	-	30%	-	30%	-	30%	-	-
Level 4	*Analyze*	-	30%	-	30%	-	30%	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100%		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishna Thota, Sr. Solution Engineer II, SRG, Synopsys India Pvt. Ltd	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1 Dr. J. Selvakumar, SRMIST
	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	21ECC322L	Course Name	COMMUNICATION LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*21MAB203T*	Co- requisite Courses	*Nil*	Progressive Courses	*21ECC302T, 21ECC304T*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*afford in depth awareness on various analog modulation and demodulation techniques*
CLR-2:	*familiarize effective methods of digital modulation and demodulation techniques*
CLR-3:	*examine detailed knowledge on microwave generation, transmission and measurement techniques*
CLR-4:	*provide ample evidence on light transmission through optical fiber and their mechanisms*
CLR-5:	*analyze the characteristics of specific Microwave and Optical devices and Components*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*recognize various analog modulation and demodulation techniques*	*2*	-	-	-	-	-	-	-	-	*3*	-	-	*3*	-	-
CO-2:	*identify systematic methods of digital modulation and demodulation techniques*	-	-	*2*	-	-	-	-	-	-	*3*	-	-	*3*	-	-
CO-3:	*discover microwave signal generation, transmission and different measurement techniques*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*realize different characteristics and mechanisms of light transmission through fiber*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*characterize and analyze Microwave and Optical devices and Components*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Analog Modulation and Demodulation Techniques	***12 Hour***
Amplitude modulation and demodulation, DSB-SC modulation and demodulation, frequency modulation and demodulation	
Unit-2 - Digital Modulation and Demodulation Techniques	***12 Hour***
Pulse Code Modulation and demodulation, DM and demodulation, PSK Modulation and demodulation, QPSK Modulation and Demodulation	
Unit-3 - Microwave Communication	***12 Hour***
Characteristics of Reflex Klystron, power distribution in Directional coupler, E plane, H plane and Magic Tee, Impedance measurement by slotted line method	
Unit-4 - Optical Communication	***12 Hour***
Characteristics of LED and Laser diode, Characteristics of PIN and APD, Measurement of Numerical Aperture, Propagation and Bending losses.	
Unit-5 - Microwave and Optical Communication	***12 Hour***
Gain and radiation pattern of Horn antenna, Characteristics of Filters, Strip line and Parallel line Coupler, Analysis of Analog and Digital Optical Link, Simulation of Optical Communication System using Optilux	

Learning Resources	*1. Singh. R. P & Sapre S. D, "Communication Systems: Analog & Digital," 3rd edition, McGrawHill Education, Seventh Reprint, 2016.* *2. Simon Haykin and Michael Moher, "Communication Systems," 5th edition, John Wiley & Sons, 2013.*	*3. Samuel Y. Liao, "Microwave Devices and Circuits", 3rd Edition, Pearson Education, 2013* *4. Keiser G, "Optical Fiber Communication Systems", 5th Edition, 6th Reprint, McGraw Hill Education, India, 2015.* *5. Laboratory Manual*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		CLA-1 Average of first cycle experiments (30%)		CLA-2 Average of second cycle experiments (30%)		Practical Examination (40% weightage			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	-	20%	-	20%	-	20%	-	-
Level 2	Understand	-	20%	-	20%	-	20%	-	-
Level 3	Apply	-	30%	-	30%	-	30%	-	-
Level 4	Analyze	-	30%	-	30%	-	30%	-	-
Level 5	Evaluate	-	-	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-	-	-
	Total	100 %		100 %		100%		-	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. M. Neelaveni Ammal, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	2. Dr. S. Vasanthadev Suryakala, SRMIST

Course Code	21ECC401T	**Course Name**	WIRELESS COMMUNICATION AND ANTENNA SYSTEMS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC205T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the elements of Wireless Communication and mobile communications*
CLR-2:	*understand the elements of Wireless Communication and mobile communications*
CLR-3:	*analyze how to apply Mobile Radio Wave Propagation - Small Scale Fading*
CLR-4:	*study the Capacity and Diversity concepts in wireless communications*
CLR-5:	*acquire the knowledge of Wireless System and Standards and Understand and design various wireless systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the knowledge of Wireless communication and basic cellular concepts*	*3*	-	-	-	-	-	-	-	-	-	-	2	-	-	-
CO-2:	*understand` the essential Radio wave propagation and mobile channel models*	-	*3*	-	-	-	-	-	-	-	-	-	2	-	-	*3*
CO-3:	*familiarize about Various performance analysis of mobile communication system*	*3*	2	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*attain the knowledge of Diversity and capacity concepts*	*3*	2	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*be familiar with the various standards of Mobile Communication Systems and Explore the various concepts of wireless communication, its design with respect to fading and link performance*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to Wireless Communications and Antennas ***9 Hour***

Introduction to wireless communication and mobile radio communication- Classification of wireless communications -simplex, half duplex, dull duplex- Paging and Cordless systems- Cellular telephone systems- Timing diagram - landline to mobile Two- Timing diagram - mobile to mobile- Basic antenna parameters, Far field and near field- Frequency reuse, sectored and omnidirectional Antennas- Channel assignment strategies- Handoff and its types- Interference and system capacity- -Cell splitting-Sectoring- Microcell Zone Concepts-Umbrella Cells- Solving Problem on antenna parameters

Unit-2 - Large Scale Fading ***9 Hour***

Introduction to Radio Wave Propagation-Large scale and small scale fading-Friss transmission equation-Free propagation model-pathloss model-Two ray model-Simplified pathloss model-Empirical model (Okumara)- Empirical model(Walfish and Bertoni model)-Piecewise linear model-log normal model-Shadowing-Combined pathless and shadowing-Outage Probability-Cell coverage area-Solving problems-VHF/UHF Antennas - Log periodic dipole array - Parabolic Reflector antennas

Unit-3 - Small Scale Fading ***9 Hour***

Introduction Small Scale multipath propagation-Impulse response model of multipath channel-Small Scale multipath measurements-Direct Pulse measurement-Slide -Small Scale multipath measurements-Sliding Correlator Measurements-Small Scale multipath measurements-Swept frequency measurement-Parameters of mobile multipath channel-Doppler spread and Coherent time-Type of fading: Flat and Frequency selective fading-Fast and slow fading-Ricean distribution-Rayleigh distribution-Solving problems(Doppler effect)- Design of Microstrip Patch Antenna

Unit-4 - Improvement of link Performance ***9 Hour***

Introduction to diversity, equalization, and capacity-Space Diversity-Scanning Diversity-Maximal ratio combiner-Equal gain diversity-Rake Receiver-Capacity in AWGN-Capacity of flat fading channels-Equalizer and its mode-Adaptive equalizer block diagram-Type of Equalizers-Introduction to MIMO antennas-Case Study: Recent Trends in Diversity and MIMO antennas

Unit-5 - Wireless Systems and Standards	***9 Hour***
AMPS Voice modulation Process- GSM system architecture and its interfaces-GSM frame structure-GSM speech operations input-output-Forward CDMA process- Reverse CDMA process-Multicarrier modulation-OFDM Transmitter Block diagram-OFDM Receiver Block Diagram-Importance of Cyclic Prefix-Case study (Modern Antennas)	

Learning Resources	1 *Rappaport.T.S." Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2011.* 2 *John D Kraus, Ronald J Marhefka, Ahmed S Khan "Antenna and Wave Propagation", 4th Edition, Tata McGraw Hill, 2010* 3 *Constantine Balanis. A, "Antenna Theory: Analysis and Design", 3rd Edition, John Wiley, 2012.*	4 *Andreas.F. Molisch., "Wireless Communications", Wiley, 2nd Edition- 2005, Reprint-2014* 5 *Andrea Goldsmith, "Wireless Communications", Cambridge University Press, Aug 2005* 6 *Schiller, "Mobile Communications", Pearson Education Asia Ltd., Reprint 2012* 7 *Lee W.C.Y.," Mobile Communications Engineering: Theory and Applications", McGraw Hill, New York,2nd Edition ,1998*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sandeep Kumar P, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. T. Ramarao, SRMIST*

Course Code	21ECC402P	**Course Name**	COMPUTER COMMUNICATION AND NETWORK SECURITY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic concepts in the field of computer networks*
CLR-2:	*provide the functional aspects of OSI model architecture*
CLR-3:	*acquire knowledge of the Network Layer protocols*
CLR-4:	*study the concepts in network security*
CLR-5:	*identify the effect of various malwares and counter measures*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*provide the basic services and concepts related to internetworking*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*explain the basic OSI model architecture and its lower layer functions*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*give an insight of the various Network Layer concepts, mechanisms and protocols*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*gain knowledge in the various forms of network security*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*analyse the effects of intrusion, viruses, firewalls and various levels of system security*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Data Communication and Networking ***9 Hour***

Introduction to Data Communication and Networking, Data transfer modes-Serial and Parallel transmission, Protocols & Standards, Layered Architecture, Principles of Layering & Description, Brief description of concepts in OSI & TCP/IP model, Network topologies, switching- Circuit and Packet

Case Studies on *Network topologies*

Unit-2 - Data Link Layer ***9 Hour***

Network models, OSI layer architecture, Data Link Layer-Introduction, Link Layer Addressing, Error Detection, Error correction, Data link Control-LLC, Data link control-MA, flow control and error control, HDLC

Case Studies on *Hamming code*

Unit-3 - Networking Layer ***9 Hour***

Introduction to Network Layer, Need for Internetworking, Addressing-Classful, Addressing-Classless, Routing protocols- Distance vector and link state, Internet protocol-IPV4 and IPV6, border gateway protocol

Case Studies on *Routing protocol-DVR*

Unit-4 - Network Security ***9 Hour***

Email security, Overview of PGP and S/MIME, IP Security, Web Security, Secure Socket Layer, Transport Layer Security, Secure Electronic Transaction

Case Studies on *Secure electronic Transaction*

Unit-5 - Security Attack ***9 Hour***

Intrusion Detection Techniques, Password Management, Malicious software, Viruses, Worms, and Zombies. Introduction to Firewall Types and Configurations, Trusted System, Port Scanning and Knocking.

Case Studies on *firewall*

Learning Resources	1. *Behrouz A. Forouzan, "Data communication & Networking", Mc-Graw Hill, 5th Edition Reprint, 2014.* 2. *Andrew S. Tanenbaum, "Computer Networks", Pearson Education India, 5th Edition, 2013*	*3. William Stallings, "Cryptography & Network Security", Pearson Education India, 6th edition 2014* *4. Bruce Schneier, "Applied Cryptography", Pearson Education India, 2nd edition., 2015* *5. Bernard Menezes, "Network Security and Cryptography", Cengage Learning, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*10%*	-	-	-	-
Level 2	*Understand*	*25%*	-	-	*20%*	-	-	-	-
Level 3	*Apply*	*30%*	-	-	*25%*	-	-	-	-
Level 4	*Analyze*	*25%*	-	-	*25%*	-	-	-	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr.E. Elamaran, SRMIST*
2. *Mr. Hariharasudhan, Johnson Controls,Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr.V. Nithya, SRMIST*

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Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21ECE201J	**Course Name**	PYTHON AND SCIENTIFIC PYTHON	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the python language construct and apply them to scientific computation*
CLR-2:	*interpret File reading and writing using Python*
CLR-3:	*discuss NumPy Features and Applications*
CLR-4:	*describe the Pandas constructs and Create insights into different equation-based system models and solve them with python*
CLR-5:	*generate Random numbers and construct simple games using Python*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply Python constructs to compute scientific formulas*	-	*2*	-	-	*3*	-	-	-	*3*	-	-	-	*3*	-	-
CO-2:	*read and write the files using Python*	-	*3*	-	-	*3*	-	-	-	*3*	-	-	-	-	-	*2*
CO-3:	*retrieve useful information from data using NumPy*	-	*3*	-	*2*	*3*	-	-	-	*3*	-	-	-	-	-	*3*
CO-4:	*examine the use of Pandas and Translate mathematical models and systems using difference equations*	-	-	-	*2*	*3*	-	-	-	*3*	-	-	-	-	-	*3*
CO-5:	*compute Probabilities and develop simple games*	-	-	*3*	-	*3*	-	-	-	*3*	-	-	-	*3*	-	-

Unit-1 - Python Basics ***12 Hour***

Python Basics- Python Components: Variables (integers, floats, strings, Booleans, complex), Data Types - Containers: lists, dictionaries, sets, tuples, Operators, Control flow: indentation, if, while, for, else- Programs on simple mathematical formulas.

Practice: *1. Programming on standard mathematical functions*
2. Programming on functions
3. Programming on lists and loops

Unit-2 - Modules and File I/O ***12 Hour***

Functions: Def, parameters, keywords, docstrings, return - programming with functions - Python classes and objects - Reading data from files – writing data to files – program on file reading and writing - Reading Data from Web Pages- About Web Pages - Access Web Pages in Programs: Reading Pure Text Files, Extracting Data from an HTML Page - Writing a Table to File, Reading and Writing Spreadsheet Files

Practice*: 4. Curve Plotting*
5. Programs on Animation
6. Sound generation of audio frequency

Unit-3 - Features and Applications of NumPy	***12 Hour***
Arrays: Indexing and Slicing, Reading, and writing an array to a file - Statistical methods in NumPy: Mean, Median, Variance, Standard Deviation, Percentile and Average - Matplotlib: plot, subplot, histograms, Bars, PieCharts – FFT and X-ray image processing ***Practice****: 7. Compute Student grades using Dictionary* *8. Reading a web page and calculating the average temperature* *9. Programming using class*	
Unit-4 - Pandas and Difference Equation Modeling	***12 Hour***
Pandas: Pandas Series, Data Frames, Read CSV, Read JSON, Analyzing Data Difference Equation Modeling : The Factorial as a Difference Equation, Fibonacci numbers, Growth of a Population, Payback of a Loan, Making a Living from a Fortune, Logistic Growth ***Practice:*** *10. Real card games using random number generation* *11. Simple Games: Guessing a Number and tic-toc-toe* *12. Programming using Pandas*	
Unit-5 - Random Process and Game Programming	***12 Hour***
Random: Drawing random numbers, Drawing integers, Computing probabilities, Binomial, Poisson and Normal Distribution, Random walk in 1D and 2D. Simple Games - Guessing a number and Rolling two dice, tic-toc-toe, snake and apple. ***Practice:*** *13. File Reading and Data Analysis using NumPy* *14. Random Walk in one Dimension Space* *15. NumPy signal processing: Blurring an image with a Gaussian filter*	

Learning Resources	*1. Hans Peter Langtangen,"A Primer on Scientific Programming with Python", Springer, 2014* *2. Christian Hill, "Learning Scientific Programming with Python", Cambridge University Press, 2nd Edition, 2020J*	*3. Juan Nunez-Iglesias, Stefan van der Walt, and Harriet Dashnow, "Artof Scientific Python", O'Reilly Media, 2017*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*-*	*15%*	*15%*	*-*
Level 2	*Understand*	*15%*	*-*	*-*	*15%*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*10%*	*-*	*-*
Level 6	*Create*	*10%*	*-*	*-*	*10%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Ms. Roshni Rajan, SDE II, Amazon, US.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University,*	*1. Dr. E. Chitra, SRMIST*
2. Mr. S. Ashish, Software Engineer, TCS – Digital, Chennai	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECE202T	**Course Name**	MICRO- AND NANO-FABRICATION TECHNOLOGIES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand thin film fabrication techniques including PVD and CVD and to apply the knowledge to film formation*
CLR-2:	*gain understanding of lithography, etching and ion implantation methods to fabricate, structure and modify the layer*
CLR-3:	*provide Nanofabrication techniques by Self-Assembly*
CLR-4:	*apply the knowledge of micro-fabrication technology to the fields of general microelectronics systems*
CLR-5:	*learn the significant advances in building micro/ nano structures applicable to their needs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the various layering Deposition Technologies*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*implement the pattern generation using Lithography Techniques*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*demonstrate the knowledge on fabrication processes by Self-Assembly*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the device and circuit fabrication Techniques*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*stamping techniques and printing importance of nanoscale devices*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-	*2*

Unit-1 - Deposition Technologies ***9 Hour***

The Origin of Thin-Film Technology, Thermal Physical Vapor Deposition (Thermal PVD), Molecular Beam Epitaxy (MBE), Pulsed Laser Deposition, Plasma and Arc Physical Vapor Deposition- Sputtering, Ion Beam Deposition, Chemical Vapor Deposition, Atomic Layer Deposition., Solgel Technology, Electrochemical and Chemical Reaction Deposition

Unit-2 - Etching Technologies and Lithography Techniques ***9 Hour***

Etching Technologies Basics, Wet-Chemical Etching-Process, Dry Etching-Physical Dry Etch, Chemical Dry Etch, Mechanical and Mechanical-Chemical Etching, Lithography-Optical Lithography, X-Ray Lithography, Direct write Lithography, Scanning Probe Based Lithography, Nano Imprint Lithography

Unit-3 – Nano-Fabrication by Self-Assembly ***9 Hour***

Top-Down and Bottom-Up Nanofabrication, Self-Assembly Process, Chemical, Physical, and Colloidal Self-Assembly, Static and Dynamic Self- Assembly Directed Self Assembly, Role of Defects in Self- Assembly, Nanosystem Building Blocks

Unit-4 - Device and Circuit Fabrication ***9 Hour***

History of complementary metal-oxide semiconductor (CMOS), Requirements of device isolation, Types of isolation, Local Oxidation of Silicon (LOCOS) and shallow trench isolation (STI) processes for local isolation, Concept of self-alignment, MOS fabrication with self-alignment, Requirement of planarization, Local and global planarization using chemical-mechanical polishing, Fabrication process of CMOS inverter, Usage of isolation and biasing of inverter, 'Latch up' concept for inverter, Design rules for CMOS Introduction to silicon-on-insulator (SOI), On chip fabrication processes of passive components.

Unit-5 - Stamping Techniques for Micro and Nano-Fabrication ***9 Hour***

Stamping Techniques, High Resolution Stamps, Printing Processes, fluids in printing processes, flexographic printing, gravure printing, Micro contact Printing and Nano transfer printing, screen printing, inkjet printing, Examples of printed devices, Comparison of printed devices with lithographically fabricated devices, Concept of hybrid printed electronics, Future of printed low-cost electronics.

Learning Resources	1. *Hans.H. atzen. Volker Saile. Jurg Leuthold, " Micro and Nano Fabrication Tools and Processes", Springer Berlin Heidelberg 2016* 2. *Bo Cui, "Recent advances in Nanofabrication Techniques and Applications", InTech Publisher, 2011* 3. *Sorab. K. Gandhi, "VLSI Fabrication and Principles", McGraw Hill,*	4. *Sami Franssila, "Introduction to Microfabrication", Wiley Publications, 2015.* 5. *Ampere A Tseng, " Nanofabrication Fundamentals and Applications", World Scientific Publishing 2008* 6. *A G Davies and J M T Thompson, "Advances in Nanoengineering Electronics, Materials and Assembly", Imperial College Press, 2007*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Ms. Roshni Rajan, SDE II, Amazon, US.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University,*	*1. Dr.J.K. Kasthuri Bha, SRMIST*
2. Mr. S. Ashish, Software Engineer, TCS – Digital, Chennai	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECE203J	**Course Name**	SMART SENSORS AND DEVICES FOR AGRICULTURE	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know sensors for agriculture and their basic design characteristics to build a network for collecting agricultural data*
CLR-2:	*provide fundamental knowledge of remote sensing sensors-based devices in agriculture*
CLR-3:	*expose the students to insight into nano sensors for agriculture applications*
CLR-4:	*impart the evolution of internet technology and the need for IoT devices in Agriculture*
CLR-5:	*design and develop AI, Edge, and IoT-based devices for sustainable development in agriculture*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*evaluate the characteristics of different types of sensors used in agriculture*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*realize the need for remote sensing sensors for smart agriculture*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	-	-	-
CO-3:	*apply nano sensors-based devices for precision agriculture based on the farmer's requirements*	*3*	-	-	-	-	-	*3*	-	-	-	-	-	2	-	-
CO-4:	*design and develop IoT-based sensor system for agriculture monitoring*	*3*	-	-	-	-	-	*3*	-	-	-	-	2	-	-	-
CO-5:	*develop AI, Edge, and Fog computing-based IoT networks for Agriculture applications*	*3*	-	2	-	2	-	-	-	-	-	-	-	-	-	2

Unit-1 - Sensor Fundamentals and Characteristics ***12 Hour***

Introduction to sensors, types of sensors, performance characteristics, and applications - Location sensors, Optical sensors, Electrochemical sensors, Mechanical sensors, Dielectric soil moisture sensors, Airflow sensors, pH sensors, Accelerometer sensors, Nano sensors, Nano biosensors, Application of sensors.

Practice on: *Application of sensors in agriculture -Soil moisture sensors for monitoring plants, electronic soil sensors to conserve water.*

Unit-2 - Remote Sensing Sensors for Precision Agriculture ***12 Hour***

Classification of remote sensors, Selection of sensor parameters, Spatial resolution, Spectral resolution, Radiometric resolution, Temporal resolution; Optical infrared sensors, GPS sensors, Agricultural temperature sensors, LiDAR

Practice on*: Application of GPS sensors, Agricultural temperature sensors for precision agriculture.*

Unit-3 – Nano Sensors in Agriculture ***12 Hour***

Nanoparticles, Nanoparticles based nano sensors for agriculture, Nano sensors in pesticide detection in soil, Nano biosensors – basic principle and characteristics. Nano biosensors for microbial detection in soil.

Practice on*: Application of sensors for detection of humidity of soil, pesticide residue, nutrient requirement and crop pest identification*

Unit-4 - IoT-based Devices in Agriculture ***12 Hour***

Agricultural Informatics -technological Components, IoT Basics and Characteristics of IoT and its Applications in Agriculture, IoT Requirements, Issues & Challenges, IoT Architectures towards urban greening, G-IoT, G-IoT Applications, G-IoT challenges, and opportunities, Need for a smart e-monitoring system for agriculture, Case study on IoT based monitoring systems, Research Challenges

Practice on*: IoT devices for monitoring applications and precision farming.*

Unit-5- AI, Edge, and IoT Frameworks for Agriculture	***12 Hour***
A fog computing-based IoT framework for prediction of crop disease using big data analytics Renewable energy and AI-powered IoT - Architecture and system design, User operability, Applications, Advantages, and Limitations ***Practice on****: Smart Precision farming application using AI, Edge and IoT.*	

Learning Resources		
	1. *Ajith Abraham, Sujata Dash, Joel J.P.C. Rodrigues, Biswaranjan Acharya, Subhendu Kumar Pani "AI, Edge and IoT-based Smart Agriculture", Elsevier Science,2021* 2. *D.D. Sahu , "Remote Sensing: Techniques in Agriculture" , Agrobios (India) 2008* 3. *Adil Denizli, Tuan Anh Nguyen, Susai Rajendran, Ghulam Yasin, Ashok Kumar, "Nanosensors for Agriculture, Elsevier Science,2021*	4. *Annamaria Castrignano, Gabriele Buttafuoco, Raj Khosla, Abdul Mouazen, Dimitrios Moshou, Olivier Naud, "Agricultural Internet of Things and Decision Support for Precision Smart Farming", Elsevier Science, 2020.* 5. *Rajesh Singh, "Internet of Things (IoT) Enabled Automation in Agriculture: Enabled Automation in Agriculture" New India Publishing Agency- Nipa , 2018*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*10%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*10%*	*20%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*20%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	*10%*	-	-	*20%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. S.A. Akbar, Chief Scientist, CEERI, Pilani*	1. *Dr.V. Mynavathi, Assistant Professor,TANUVAS*	1. *Dr. T. Deepa, SRMIST*

Course Code	21ECE204T	**Course Name**	OPTOELECTRONICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC201T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the working and nature of optical wave and optical semiconductors*
CLR-2:	*analyze the working principles of different photonic sources*
CLR-3:	*analyze the working principles of different photonic detectors*
CLR-4:	*create knowledge about various optoelectronic applications*
CLR-5:	*familiarize the concepts of optoelectronic integrated circuits*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the basic concepts of optics and semiconductor optics*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-2:	*demonstrate the working principle of various photonic sources and display devices*	*3*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*analyze the principle and operation of various detectors and noise associated with it*	*3*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*interpret the various optoelectronic modulators, switches, and interconnects*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*apply the concepts of integrated optoelectronic components and its application in various fields*	*3*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Wave Nature of Light and Solid-State Physics	***9 Hour***
Light Waves in a Homogeneous Medium - Refractive Index and Dispersion - Sellmeier equation and Cauchy equation - Snell's Law and Total Internal Reflection (TIR) - Superposition and Interference of Waves - Diffraction Principles - Fraunhofer Diffraction - Diffraction Grating - Energy bands in solids - Energy bands in solids - Conduction process in semiconductors - Optical process in semiconductors - Junction Theory.	
Unit-2 - Display Devices and Light Sources	***9 Hour***
Photo Luminescence, Cathode Luminescence, Electro Luminescence, Injection Luminescence - Plasma Display, Liquid Crystal Displays, Numeric Displays - LED Principles – Homojunction LED, Heterostructure LED – Choice of LED Materials and Structures – LED Efficiencies and Luminous Flux – Solving Problems - Laser: Operating principle, Emission and Absorption of Radiation, Population Inversion, Optical feedback, Threshold Condition, Semiconductor Lasers, Heterostructure Laser Diode	
Unit-3 - Optical Detection Devices	***9 Hour***
Principle of Photo Detection – Responsivity and Quantum Efficiency – Photoconductors – Photo diodes – The PIN Photodiode – Avalanche Photodiode – Principles and Structures – Heterojunction Photodiodes – Photoconductive detectors - Noise in photodetectors - Detector performance parameters - Detectors for long wavelength operation, wavelength selective detection - Charge Coupled Device (CCD).	
Unit-4 - Optoelectronic Modulators and Switching Devices	***9 Hour***
Introduction – Analog and Digital Modulation – Electro optic modulators – principles – electro optic effect – Magneto optic devices – Acousto optic modulators – principles – acousto optic effect – Raman Nath and Bragg type modulators - optical switching and logic devices – Faraday Rotation – Optical Isolators – Nonlinear Optics and Second Harmonic Generation.	
Unit-5 - Optoelectronic Integrated Circuits (OEIC) and Applications	***9 Hour***
Introduction – Need for Integration - Hybrid and Monolithic Integration – Slab and Strip waveguides – Basic IO structural elements – Guided wave devices and active couplers – Integrated Transmitters and Receivers– Application of Optoelectronic integrated circuits.	

Learning Resources	1. *S. O. Kasap, "Optoelectronics & Photonics: Principles & Practices", 2nd edition, Pearson Education, 2013.* 2. *Pallab Bhattacharya "Semiconductor Optoelectronic Devices", 2nd Edition, Prentice Hall of India Pvt. Ltd, New Delhi, 2009.*	3. *J. Wilson and J F B Hawkes "Optoelectronics- An Introduction", 3rd edition, Pearson Education Taiwan Ltd, 2010.* 4. *R. P. Khare, "Fiber Optics and Optoelectronics", Oxford University Press 2004.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*20%*	-	*15%*	-	*15%*	-
Level 3	*Apply*	*35%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*35%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*5%*	-	*5%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. S. Sathiyan, SRMIST*
2. *Mr. Hariharasudhan, Johnson Controls,Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECE205T	Course Name	FLEXIBLE ELECTRONICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the fundamentals of quantum physics to understand how atoms and molecules are formed*
CLR-2:	*illustrate the basics of charge transport and charge injection in an amorphous material*
CLR-3:	*introduce the concepts of organic light emitting diode*
CLR-4:	*explain the different methods of fabrication for organic devices and their characterization*
CLR-5:	*introduce the concepts of thin film transistor*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the principles of quantum physics to understand the behavior of atoms and molecules in a semiconductor*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze transport and Injection phenomenon for an organic semiconductor material*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*gain knowledge on organic light emitting diode*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*acquire knowledge on different aspects of fabrication and characterization*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-	-
CO-5:	*utilize the concepts of MOSFET to understand organic thin film transistor*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Quantum Mechanics, Atoms and Molecules	***9 Hour***
Brief history to Flexible Electronics, Quantum Mechanics: Basic Postulates, Infinite Potential Well, Finite Quantum Well, Coupled Quantum Well, Tunnelling, Atoms: Hydrogen Atom, Spin and Orbital Angular Momentum, Spin-Orbit Coupling, Multi-Electron Atoms, Molecules: Hydrogen Molecule, Molecular Orbitals, Common Organic Molecules, Polymers, Optical Process: Selection Rules, Radiative Lifetime, Absorption/Emission, Two Spin States	
Unit-2 - Transport and Injection	***9 Hour***
Transport, Free Electron, Electron in 1D Periodic Lattice, Effects of Disorder, Field Effect Mobility, Multiple Trap Release Model, Time of Flight, Grain- Boundary Potential Barrier Model, Variable Range Hopping Model, Mobility due to Hopping, Gaussian, Disorder Model, Mobility Empirical Model, Injection: Barrier Height, Interface Dipole, Barrier Height Lowering, Conventional Injection Models, Thermionic Emission, Tunnelling, Limitations, Microscopic Hopping Picture	
Unit-3- Organic Light Emitting Diode (OLED)	***9 Hour***
Performance Parameters, Power Conversion Efficiency, Quantifying Colour, OLED Basic Operation, Quantum Efficiency, Bilayer Device, Impact of SPIN on optical transitions, Phosphorescence, Forster Energy Transfer, Multi-layer OLED structure, Dexter Energy Transfer, Polymer LED, Degradation of OLED, OLED Displays.	
Unit-4 - Fabrication and Characterization	***9 Hour***
Materials: Polymers and small molecule, Fabrication Method, Characterization Methods, Introduction to B1500A (Semiconductor Parametric Analyser), Transfer and Output Characteristics of Metal Oxide Semiconductor FET and Extract Threshold Voltage, Mobility and Transconductance, Capacitance Voltage and Capacitance Frequency Characterization of MOSFET, Frequency Response	

Unit-5- Thin Film Transistor (TFT)	***9 Hour***
Brief History of TFT, Introduction to Hydrogenated Amorphous Silicon, Basic Organic FET Structure and Operation, OFET Fabrication, OFET Structures: Top vs. Bottom Contacts, Work Function Considerations, Characteristics of Gate Dielectrics, Encapsulation, Self-Aligned OFETs, Parameter Extraction, Characterization, Gate Sweep/Transfer Characteristic, Drain Sweep/Output Characteristic, Capacitance, Gate Leakage, OFET Applications, Organic Field-Effect Sensors, Design and Technology of Organic Field-Effect Sensors, Applications for Organic Field-Effect Sensors, Printing Technologies.	

Learning Resources	*1. Robert Eisberg and Robert Resnick, "Quantum Physics of Atoms, Molecules, Solids, Nuclei, and Particles",2nd ed., wiley,2006* *2. S. C. Tse, C. H. Cheung, S. K. So, "Organic Electronics", 1st ed., CRC Press, 2009* *3. Alastair Buckley, "Organic Light Emitting Diodes Material devices and Applications" , 1st ed., Woodhead Publishing, 2013*	*4. Joannis Kymissis, "Organic Field Effect Transistors: Theory, Fabrication and Characterization",1st ed., Springer, 2009* *5. Brajesh Kumar Kaushik, Brijesh Kumar, Sanjay Prajapati, Poornima Mittal, Organic Thin-Film Transistor Applications: Materials to Circuits, 1st ed., CRC Press, 2020.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	60%	-	40%	-	30%	-
Level 2	*Understand*	40%	-	40%	-	40%	-
Level 3	*Apply*	-	-	20%	-	30%	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Sandeep Patil EspinNanotech Solutions, IIT Kanpur	*1. Dr. KP Pradhan, IIIDM, Kanchipuram*	*1. Dr. Rajesh Agarwal, SRMIST*
2. Dr. Amrendra, Keysight Technologies, Bangalore	*2. Dr. Vivek, IIITDM, Kanchipuram*	*2. Dr. Soumya Ranjan, SRMIST*

Course Code	21ECE212T	**Course Name**	CONTROL SYSTEMS: THEORY AND APPLICATIONS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*know mathematical modeling techniques of mechanical and electrical systems, block diagram reduction and signal flow graphs*															
CLR-2:	*gain knowledge about the transient and steady state error and analysis*															
CLR-3:	*identify and analyze stability of a system using Routh array and root locus technique*															
CLR-4:	*know different frequency domain analytical techniques*															
CLR-5:	*acquire the knowledge of a controller for specific applications and tuning methods*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*determine Transfer function of a system by mathematical modeling, block diagram reduction and signal flow graphs*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the time domain response of a control system for standard test inputs, transient and steady state error*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*evaluate the system stability using Routh array and root locus techniques*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the frequency domain specifications from bode and polar plots*	-	*3*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*design a closed loop control system for specific application, controller parameters and tuning*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - System Component and it's Representation	***9 Hour***
Open and closed loop control system Transfer function of a system Need for mathematical modelling- Representation of mechanical translational and rotational systems using differential equation and determination of transfer function- Conversions of Mechanical system to Electrical system f-V and f-I electrical analogies- Block diagram reduction rules and methodology -Evaluation of transfer function using block diagram reduction - Signal flowgraphs and evaluation of transfer function- Block diagram to signal flow conversion..	
Unit-2 - Time Response Analysis	***9 Hour***
Standard test signals and their expression -Type number and order of a system- Transfer function of First order system for Step, ramp, Impulse and parabolic signal - General transfer function of second order system for different damping factor based on step response- Time domain specifications and their significance- Transient and Steady state error analysis -Static and dynamic Error coefficients. Analytical design for PD, PI and PID control systems	
Unit-3 - Stability Analysis	***9 Hour***
Poles and zeros of a system - Pole zero plot and concept of s plane - Concept of stability - Significance of Routh Hurwitz Technique with different cases -Root locus techniques-Root locus plot of typical systems-Design of Compensator using root locus-Lead Compensation	
Unit-4 - Frequency Domain Analysis	***9 Hour***
Frequency domain specifications- Bode plot approach and stability analysis- Rules for sketching Bode plot of typical systems - Design of Compensator using Bode Plot-Lag Compensation -Polar plot and significance-Sketching the Polar plot of typical systems- Nyquist stability criterion.	

Unit-5 - Control System Analysis using State Variable Methods and Applications	***9 Hour***
State variable representation-Conversion of state variable models to transfer function -Conversion of transfer functions to state variable models-Solution of state equations-Concepts of Controllability and Observability- Fuzzy logic-based control system-Adaptive Controller	

Learning Resources	*1. Nagrath. J and Gopal. M, "Control System Engineering", 5th Edition, New Age, 2007* *2. Benjamin C Kuo, "Automatic Control System", 9th edition, John Wiley & Sons, 2010.*	*3. Gopal. M, "Control System Principles and Design", 2nd Edition, TMH, 2002* *4. Sivanandam and Deepa, "Control system Engineering using MATLAB", 2nd edition, Vikas publishers, 2007", FexRay Consortium, 2010.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*20%*	-	*15%*	-	*25%*	-
Level 3	*Apply*	*25%*	-	*15%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	-	-
Level 6	*Create*	-	-	*15%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr. K. Vadivukkarasi, SRMIST*
2. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE301T	**Course Name**	NANOSCALE ELECTRONIC DEVICES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the need and effects of device miniaturization*
CLR-2:	*understand the principles of Carbon Nanotubes and their applications*
CLR-3:	*learn about gate and channel engineered nanoscale electronics devices*
CLR-4:	*create insights to the concepts of spin nanoscale devices*
CLR-5:	*analyze the design considerations of phase-change devices*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*realize the importance of scaling of devices*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*identify the physical properties and applications of Carbon nanotubes*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyze the performance measures of various devices through gate and channel engineering*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*choose appropriate application of the Spin Nanoscale Electronic Devices*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*understand the design considerations of phase-change devices*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Fundamentals of Nanoscale Electronic Devices ***9 Hour***

Free Electron Theory and Quantum Theory, Origin of Bandgap in Solids, Nearly Free Electron Model, Approximate Measure of Band Gap, Effective Mass Approximation, Tight Binding Approximation, Low-Dimensional Materials, Quantum Confinement in Low-Dimensional Material, Density of States in Bulk Materials, Semiconductor Nanostructures, Metallic Nanostructures, Carbon Nanostructures, Non-Equilibrium Green's Function (NEGF), Density function Theory.

Unit-2 - Carbon Nanotubes and Their Device Applications ***9 Hour***

Physical Properties of Carbon Nanotubes, Ballistic Transport and Quantum Conductance in CNTs, CNT Two-Probe Devices, Doping methods and techniques, Transport properties of two-probe CNT Devices, CNT Field-Effect Transistors (CNTFETs), CNT Logic gates, CNT sensors, CNT photodetectors and photoresistors, CNT Interconnects, CNT Memories

Unit-3 - Gate and Channel Engineered Nanoscale Electronic Devices ***9 Hour***

Introduction to Nanoscale Device, Electrostatic Effects, Threshold Voltage Roll-Off, Leakage Currents, Gate Leakage Current, Subthreshold Leakage Current, Junction Leakage Current, Silicon-On-Insulator, Multigate MOSFET, Double-Gate (DG) MOSFET, Trigate (TG) MOSFET, Gate-All-Around (GAA) MOSFET, Gate and Channel Engineering Techniques, Gate-Oxide Stack, Gate Metal Work Function Engineering, Channel Engineering, Strained Layer, Multigate Multi-Material MOSFET, Multigate Multi-Material Tunnel FET

Unit-4 - Spin Nanoscale Electronic Devices and Their Applications ***9 Hour***

Introduction to Spintronics, Giant Magnetoresistance (GMR) and Its Applications, Tunnel Magnetoresistance (TMR) and Its Applications, Spin Injection Efficiency, Spin Devices, Magnetic Tunnel Junction (MTJ), Switching Mechanism in MTJ, Logic-In Memory Architecture, Spin Field-Effect Transistor, Multi-Gate Spin Field-Effect Transistor, Spin-FET-Based Logic Design

Unit-5 - Phase-Change Devices and Their Applications ***9 Hour***

Phase-Change Memory (PCM), Overview of Phase-Change Material Properties, Scaling of Phase-Change Memory Devices, PCM Device Architecture, PCM-Based Logic Gate Design, OR Gate Design Using PCM Logic, NOR Gate Design Using PCM Logic, Memristor, Silicon Nanowire-Based Memresistive Devices, Memristor-Based Logic Design, Resistive Random-Access Memory (RRAM), Physical Structure of RRAM.

Learning Resources	1. Khurshed Ahmad Shah, Farooq Ahmad Khanday "Nanoscale Electronic Devices and Their Applications", CRC Press, 2021. 2. Rainer Waser (Ed.), "Nanoelectronics and Information Technology", Wiley- VCH, Third, Completely Revised and Enlarged Edition, 2012. 3. Jan M. Rabaey, Anantha Chandrakasan, and Borivoje Nikolic," Digital Integrated Circuits 2nd edition", Pearson, 2000	4. Ban P. Wong, Anurag Mittal, YuCao, Gren Starr, "Nano- CMOS Circuit and Physical Design", John Willey and sons Publication, 2005 5. George W. Hanson, "Fundamentals of Nanoelectronics", Prentice Hall, 2007 6. Karl Goser, Peter GlÖsekötter, Jan Dienstuhl, "Nanoelectronics and Nanosystems", Springer, 2004 7. Vladimir V. Mitin, Viatcheslav A. Kochelap, Michael A. Stroscio, "Introduction to Nanoelectronics: Science, Nanotechnology, Engineering, and Applications", Cambridge University Press, 2012

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University	1. Dr. J. K. Kasthuri Bha, SRMIST
2. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai	2. Dr. Arijit Bardhan Roy, SRMIST

Course Code	21ECE302J	**Course Name**	REAL TIME OPERATING SYSTEMS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21CSS101J*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce Real Time Operating Systems (RTOS) and the Process management*
CLR-2:	*acquire knowledge of threading and process synchronization*
CLR-3:	*outline different scheduling algorithms and deadlock*
CLR-4:	*infer various memory management concepts for RTOS*
CLR-5:	*develop sample projects based on RTOS applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop knowledge about RTOS and the Process Management*	*3*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply the concepts of threading and synchronization for embedded applications*	*3*	*3*	-	-	*2*	-	-	-	-	-	-	-	2	-	-
CO-3:	*illustrate the concepts and requirements of Scheduling*	*3*	-	*3*	-	*2*	-	-	-	-	-	-	-	2	-	-
CO-4:	*analyze the memory management for RTOS*	*3*	-	*3*	-	*2*	-	-	-	-	-	-	-	2	-	-
CO-5:	*implement the knowledge in related sample use cases*	*3*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Real Time Operating Systems and Process ***12 Hour***

Operating system concepts, Fundamental and Functions, Evolution of Operating Systems, Operation, Structure and Architecture of Computer Systems, OS Structure and Operations, Kernel Data Structures, Computing Environments, RTOS, Process State and Control block, Process Scheduling Queues and Schedulers, Process Creation and Termination, Inter Process Communication IPC, Client - Server System Communication.

Practice on *Linux OS and C Programming,*

Unit-2 - Threading and Process Synchronization ***12 Hour***

Threads Overview, Multiprocessor Programming and Multithread models, Thread Libraries and Implicit Threading, Issues in Threading, Synchronization Concepts, The Critical Section Problem, Hardware Synchronization, Mutex Locks, Semaphores, Monitors - Implementation Using Semaphores

Practice on *Threading and Synchronization*

Unit-3 - Scheduling and Deadlocks ***12 Hour***

Scheduling Concepts and Criteria, Algorithms for Scheduling, Thread and Multiprocessor Scheduling, Real Time scheduling, Deadlocks- Characterization, Handling Deadlocks, Deadlock Prevention, Deadlock Avoidance, Deadlock Detection and Recovery from Deadlock

Practice on *Scheduling algorithms.*

Unit-4 - Memory Management ***12 Hour***

Memory Hardware Organization, Memory Allocation, Swapping, Contiguous Memory Allocation, Segmentation, Paging, Structure of the Page Table, Overview of Virtual Memory, Demand Paging, Page Replacement Algorithms, and Allocation of Page Frames, Thrashing, Kernel Memory Allocation

Practice on *Memory Management*

Unit-5 - RTOS Applications	***12 Hour***
Real time systems: Data acquisition system, Real time systems: Data acquisition system, Performance metrics, Audio Input/Output, Priority Scheduler, Multi-level Feedback Queue, Starvation and aging, Priority inversion and inheritance, Overview of available RTOS, RTOS for Digital Signal Processing - Examples and Discussion, RTOS for Control Systems - Examples and Discussion ***Practice on*** *Application programs using RTOS*	

Learning Resources	*1. Abraham Silberschatz, Peter Baer Galvin, Greg Gagne, Operating System Concepts, Tenth edition, Wiley, 2018* *2. Jonathan Valvano, "Real time operating systems for ARM Cortex-M Microcontrollers, Embedded systems - Volume 3", ARM Educational Media, 2017.*	*3. Andrew Sloss ET all, "ARM system developer's guide", Elsevier, 2004.* *4. Quing Li, "Real time techniques for embedded systems", CMP Books, 2003.* *5. K. C. Wang, "Embedded and Real time operating systems", Springer, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*20%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr. Sudhanya P, SRMIST*
2. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	*2. Dr. K. Vadivukarasi, SRMIST*

Course Code	21ECE303T	Course Name	MEMS TECHNOLOGIES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*familiarize with MEMS materials and their properties*
CLR-2:	*study the various micro machining techniques*
CLR-3:	*explore the micro device manufacturing process*
CLR-4:	*impart knowledge of the principle and concepts of micro sensor and actuators*
CLR-5:	*examine the design methodologies used in MEMS devices use cases*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*select appropriate MEMS materials according to the application*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*determine suitable micro machining techniques*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*demonstrate the micro device manufacturing and assembly process*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*analyze and adopt appropriate micro sensor and actuators principle for optimum design*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*validate the MEMS devices design and fabrication methodologies used in use cases*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Properties of MEMS Materials ***9 Hour***

Crystal structure – Orientation effects – crystal defects – Impurities in Silicon – Properties of Silicon and Gallium Arsenide - Polymer – Polyimide, PMMA, PDNS, LCP, SU8, Parylene, Nano structure materials - Titanium dioxide. Silver. Synthetic amorphous silica. Iron oxide. Pigments. Carbon Fullerenes and Nanotubes

Unit-2 - Fabrication Technology ***9 Hour***

Bulk Micromachining: wet etching of silicon-Isotropic etching-anisotropic etching-alkali hydroxide etchants-ammonium hydroxide-tetra methyl ammonium hydroxide (TMAH)-Ethylene Diamine Pyrochatechol (EDP)-ultrasonic agitation in wet etching- stop layers for dopant elective etchants. Porous-silicon formation –anisotropic wet etching of porous aluminum-anisotropic wet etching - quartz-vapour phase etches. RLE-laser driven bulk processing. Surface Micromachining: Thin film processes-nonmetallic thin film for micromachining –silicon dioxide – silicon nitride - silicon carbide - polycrystalline diamond - polysilicon and other semiconductors and thin film transition – wet etching of non-metallic thin film-metallic thin film for micromachining - Resistive evaporation – E - beam evaporation-sputter deposition-comparison of evaporation and sputtering - CVD of metals - adhesion layer for metals -Electro deposition (E plating) - Electrodeposition mechanism: - DC electroplating-pulsed electroplating-Agitation for electroplating-black metal film-electro less plating.

Unit-3 - Fabrication Technology – II ***9 Hour***

Bonding Processes: Anodic Bonding-Anodic bonding using deposited glass-silicon fusion bonding-other bonding and techniques-compound processes using bonding. Sacrificial Processes and Other Techniques: Sticking problem during wet releasing-prevention of sticking-phase change release methods-geometry-examples of sacrificial processes - Sacrificial LIGA process:

Unit-4 - MEMS Sensing and Actuation Mechanics ***9 Hour***

Electromechanical effects: Piezo resistance - Piezoelectricity - Shape memory alloy-Thermal effects: Temperature coefficient of resistance - Thermo-electricity – Thermocouples – Micro fluidics: - Squeeze film damping - Surface tension and bubbles -Devices: pumps, valves, mixers -Integrated fluidic systems: BioMEMS.

Unit-5 - Application – Use Case Study	***9 Hour***
Design and analysis of piezoresistive Pressure Sensors, Design and analysis of Capacitive Accelerometer, pressure sensor, Actuator Design of Piezoelectric Accelerometer, sensor, Actuator Design of microfluidic devices, Design and analysis of thermal sensing and actuation, Analysis of MEMS packaging	

Learning Resources	*1. Madou, Marc J. "Fundamentals of microfabrication and nanotechnology, three-volume set". CRC Press, 2018.* *2. Hsu, Tai-Ran." MEMS and microsystems: design, manufacture, and nanoscale engineering". John Wiley & Sons, 2008.* *3. Liu, Chang. "Foundations of MEMS". Pearson Education India, 2012.* *4. Senturia, Stephen D. "Microsystem design. Springer Science & Business Media", 2007* *5. Charles P.Poojlejr Fran K J.Owners, "Introduction to Nano Technology ", Willey student Edition 2008.*	*6. G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K.N. Bhat, V.K. Aatre, "Micro and Smart Systems", Wiley India, First Edition, 2010.* *7. Julian W.Gardner, Vijay K.Varadan, Osama O.Awadel Karim, "Microsensors MEMS and Smart Devices", John Wiley & sons Ltd., 2001.* *8. Mohamed Gad – el- Hak,"The MEMS HAND book", CRC press 2005* *9. Vikas Choudhary, Krzysztof Iniewski , "MEMS Fundamental Technology and Applications", 1st Edition Published by CRC Press, April 21, 2017.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1 Dr. P. Eswaran, SRMIST*
2. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE304T	Course Name	CYBER PHYSICAL SYSTEM FRAMEWORK	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain cyber-physical systems fundamentals and principles knowledge as building blocks to promote further design and implementation of more complex real time systems*
CLR-2:	*understand cyber physical systems design for synchronous model with specific case study for arm processor*
CLR-3:	*in what way cyber physical systems are crucial for the optimal performance of asynchronous model*
CLR-4:	*comprehend the cyber physical systems design and implementation in dynamical models*
CLR-5:	*hybridization of cyber physical systems which will help the students to anticipate upcoming technologies*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basics of cyber physical systems*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*design synchronous models for Real Time applications*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*design Asynchronous models for Real Time applications*	-	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	-	-
CO-4:	*develop Deep Understanding on selection of hardware and software's for designing dynamical systems*	-	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	-	-
CO-5:	*come up with cost effective, reliable, robust and feasible designs for real world problems*	-	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Cyber Physical Systems ***9 Hour***

Introduction To Cyber-Physical Systems, Cyber-Physical System Requirements, Interoperability, Survivability, Real Time System, Internet of Things (IOT), Radio Frequency Identification Technology and its use in CPS, Wireless Sensor Networks Technology and its application in CPS, Powerline Communication, Smart Cities And Internet Of Everything, Ubiquitous Computing Fundamentals, Autonomous Systems In Ubiquitous Computing, Cyber Physical Vehicle Tracking System (A case study).

Unit-2 - Synchronous Model ***9 Hour***

Synchronous model overview, Reactive Components, Variables, Valuations, Expression and Execution, Extended-State Machines, Properties of Components, Various Types of components, Task Graphs and Await Dependencies, Composing Components, Output Hiding, Synchronous Designs (Synchronous Circuits, Cruise Control Systems, Synchronous Networks).

Unit-3 - Asynchronous Model ***9 Hour***

Asynchronous Process overview, States, Internal Actions, Executions, Extended State Machines, Operations On Process, Blocking Vs Non-Blocking Synchronization, Deadlocks, Shared Memory, Fairness Assumptions, Asynchronous Coordination Protocols, Leader Election, Reliable Transmission, Wait Fee Consensus, Safety Specifications, Invariants Of Transition Systems, Safety Monitors

Unit-4 - Dynamical System ***9 Hour***

Overview of dynamic systems, Continuous Time Model, Continuously Evolving Inputs and Outputs, Models with Disturbance, Composing Components Stability, Linear Systems Linearity, Solutions of Linear Differential Equations and stability, Designing Controllers, Open Loop Vs Feedback Controller, PID Controllers, Analysis Techniques, Barrier Certificates.

Unit-5 - Hybrid Systems ***9 Hour***

Hybrid Dynamical Model, Zeno Behavior, Designing Hybrid Systems, Automated Guided Vehicle, Obstacle Avoidance with Multi Robot Coordination, Multi Hop Control Networks, Linear Hybrid Automata, Pursuit Game problem, Timed Automata, Model of Timed Automata.

Learning Resources	1. Rajeev Alur, "Principles of Cyber Physical Systems", 1st Edition, MIT Press 2015. 2. Raj Rajkumar , "Cyber Physical Systems," 2nd Edition, Elsevier 2015	3. Edward D Lamie, "Computing Fundamentals of Cyber Physical Systems", 2nd Edition, Newnes Elsevier Publication.

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*10%*	-	*10%*	-	*10%*	-
Level 2	*Understand*	*15%*	-	*15%*	-	*15%*	-
Level 3	*Apply*	*25%*	-	*25%*	-	*20%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*20%*	-
Level 5	*Evaluate*	*15%*	-	*15%*	-	*20%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*15%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. Md Jawaid Alam, SRMIST*
2. *Dr. Madan Kumar Lakshmanan, Senior Scientist, CEERI, lmadank@gmail.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

								L	T	P	C
Course Code	21ECE305J	**Course Name**	MACHINE LEARNING ALGORITHMS	**Course Category**	E	PROFESSIONAL ELECTIVE		2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide a basis for understanding machine learning*
CLR-2:	*learn various regression and classification algorithms in supervised learning*
CLR-3:	*gain knowledge about classification using decision trees and ensemble learning*
CLR-4:	*acquire knowledge about clustering algorithms and reinforcement learning*
CLR-5:	*explore the concepts behind Bayesian learning*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basic terminologies in machine learning*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*analyze data classification using supervised learning*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*articulate the working of decision tree classifier and ensemble learning*	-	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-4:	*gain the knowledge of various unsupervised and reinforcement learning algorithms*	-	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*demonstrate the Bayesian learning technique*	-	*2*	-	*3*	*1*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Machine Learning ***12 Hour***

Machine learning process - AI vs ML vs DL - Types: supervised, unsupervised, reinforcement learning - Types of supervised learning - Curse of dimensionality - Overfitting versus underfitting – Bias Variance tradeoff – General principles in machine learning - Feature extraction - Training, testing and validation set - k-fold cross validation - confusion matrix - Performance metrics - ROC curve

Practice: *Demonstrate k-fold cross validation and evaluation of performance metrics.*

Unit-2 - Supervised Learning ***12 Hour***

Regression: Linear regression, Logistic regression - Stochastic gradient descent - Classification: K-nearest neighbor algorithm -Support Vector Machine: Linear SVM, Soft SVM, Nonlinear SVM, Multiclass SVM - Naïve Bayes.

Practice*: Implement linear regression, logistic regression, k-nearest neighbor, SVM, Naïve Bayes.*

Unit-3 - Decision Trees & Ensemble Learning ***12 Hour***

Binary decision trees: Impurity measures - Gini impurity index, Cross-entropy impurity index, misclassification impurity index – Ensemble learning: Random Forest, Adaboost, Gradient tree boosting, voting classifier.

Practice*: Implement decision tree learning, bagging using random forest, Adaboost, voting classifier.*

Unit-4 - Unsupervised Learning & Reinforcement Learning ***12 Hour***

Clustering: K-means clustering, Hierarchical clustering - Gaussian Mixture Model - Reinforcement learning - Dimensionality reduction: LDA, PCA, ICA, Random projections.

Practice*: Implement k-means clustering, hierarchical clustering.*

Unit-5 - Bayesian Learning ***12 Hour***

Formulation of Bayesian learning: Bayesian inference, maximum a posterior estimation, sequential Bayesian learning – Conjugate priors –Approximate inference: Laplace's method, Variational Bayesian methods – Gaussian processes – nonparametric priors, regression and classification.

Practice*: Demonstrate Bayesian inference*

Learning Resources	1. *Ethem Alpaydin, "Introduction to machine learning", Fourth Edition, MIT press, 2020.* 2. *Hui Jiang, "Machine Learning Fundamentals: A Concise Introduction", First Edition, Cambridge University Press, 2021.* 3. *Giuseppe Bonaccorso, "Machine learning algorithms: Popular algorithms for data science and machine learning", Second Edition, Packt Publishing Ltd, 2018.*	4. *Shai Shalev-Shwartz, and Shai Ben-David, "Understanding machine learning: From theory to algorithms", Third Edition, Cambridge university press, 2015.* 5. *Marsland, Stephen. "Machine learning: an algorithmic perspective". Second Edition, CRC press, 2014.* 6. *Kevin P. Murphy, "Machine learning: a probabilistic perspective", First Edition, MIT press, 2012.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*25%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. R. Jansi, SRMIST*

Course Code	21ECE401T	**Course Name**	ADVANCED DIGITAL SYSTEM DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC203T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore the advanced Boolean theorems for logic simplification and implementation*
CLR-2:	*analyze the formal procedures for the analysis and design of synchronous and asynchronous sequential circuits*
CLR-3:	*understand concept of Programmable Devices (PROM, PLA, PAL, CPLD and FPGA) and implement combinational and sequential logic circuits using them*
CLR-4:	*adopt systematic approach with the use of ASM chart ASMD chart, RTL representation for the design of digital circuits and systems*
CLR-5:	*apply VHDL as a design-entry language for FPGA in electronic design automation of digital circuits*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply advanced theorems to simplify the design aspects of various practical circuits*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze synchronous sequential circuits and write VHDL Code*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*analyze Asynchronous sequential circuits and construct circuit using VHDL*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*implement various digital circuits using Programmable Logic Devices*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*demonstrate FPGAs and Construct digital circuits using VHDL*	*3*	*2*	*3*	-	*3*	-	-	-	-	-	-	-		-	*1*

Unit-1 - Expansion Theorems and State Tables	***9 Hour***
Shannon's Expansion theorem and its applications, Consensus theorem, R Reed-Muller Expansion technique, Multiplexer logic as function generators, Implementation of Multiple output logic functions, Mealy and Moore machines, State diagrams, State table, State reduction and state assignment techniques.	
Unit-2 - VHDL Modeling	***9 Hour***
Introduction to VHDL, Entity and Architecture description, VHDL Data types and Operators, Concurrent, Sequential Assignment Statements, Types of Modelling in VHDL, Behavioral, dataflow and structural modelling,	
Unit-3 - Synchronous and Asynchronous Sequential Design	***9 Hour***
Synchronous Sequential Design system, Models of Synchronous Sequential Design system, Algorithmic state machine, Synthesis from ASM Chart, analysis of Asynchronous sequential circuit, Design of Asynchronous sequential circuit, Asynchronous state machines, setup and hold times and metastability.	
Unit-4 - Programable Logical Devices and Hazards in VHDL	***9 Hour***
Static hazards, Dynamic hazards, Essential hazards, Programming logic device families, designing synchronous sequential circuit using PROM, Programmable Array Logic (PAL), Programmable Array Logic (PAL),	
Unit-5 - FPGA Logic Family	***9 Hour***
FPGA-Xilinx FPGA, Xilinx 3000 series FPGA, Xilinx 4000 series FPGA, Design of sequential circuits (using VHDL), Introduction to CAD, Basic CAD operation.	

Learning Resources	1. *Charles H. Roth, Jr. University of Texas at Austin. Larry L. Kinney," Fundamentals of Logic Design", 7th ed., Cengage Learning, 2012* 2. *Richard S. Sandige, Michal L. Sandige, "Fundamentals of digital and computer design with VHDL", McGrawHill, 2014* 3. *Mark Zwolinski, "Digital system Design with VHDL", 2nd edition, Prentice Hall, 2004.* 4. *Jayaram Bhasker, "A VHDL Primer", 3rd ed., Prentice Hall, 2011*	5. *Charles. H. Roth, Jr, "Digital Systems Design using VHDL, CENGAGE Learning, 2010* 6. *Morris Mano M, Michael D. Ciletti, "Digital Design with an Introduction to the Verilog HDL", Pearson, 2014.* 7. *Xilinx Vivado TCAD Tool. https://www.xilinx.com/support/documentation- navigation/design-hubs/dh0010-vivado-simulation-hub.html*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Vikas Verma, Physical design Engineer, Mediatek, vikas.verma@mediatek.com*	1. *Dr. G. P. S. C Mishra, Associate Professor, NIT Raipur, Chhattisgarh*	1. *Dr. Manish Verma, SRMIST*
2. *Mr. Mahesh Malewale Tanaji, Physical Design Engineer, mahesh.tanaji.malewale@intel.com*	2. *DR. Shivendra Yadav, Assistant Professor, SVNIT, Surat, Gujrat*	2. *Dr. Damodar Panigrahy, SRMIST*

							L	T	P	C
Course Code	21ECE402T	**Course Name**	SEMICONDUCTOR DEVICE MODELING	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*determine the characteristics of semiconductor when deviations from equilibrium occur*
CLR-2:	*derive the mathematical relations formed from the excess carriers in unit volume of semiconductor due to generation, recombination, and drift and diffusion process*
CLR-3:	*develop ambipolar transport equations which describes the behavior of excess electrons and holes*
CLR-4:	*analyze the structure, characteristics, qualitative and quantitative understanding of the operation of a MOSFET*
CLR-5:	*model MOS transistor by including various short-channel effects*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the density of quantum states for determining the position of Fermi energy level as a function of doping concentrations and temperature*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*understand the basic transport mechanisms for determining the current-voltage characteristics of semiconductor crystal*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*analyze the behavior of nonequilibrium electron and hole concentration as function of time and space coordinates*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*develop the mathematical relation between the drain current, the gate-to-source voltage, and the drain-to-source voltage of MOS transistor*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*examine the effects of second order effects in short channel MOS transistor*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - The Semiconductor in Equilibrium	***9 Hour***
Statistical Mechanics - Statistical Laws, Fermi-Dirac Probability Function, Distribution Function and the Fermi Energy, Charge Carriers in Semiconductors- Equilibrium Distribution of Electrons and Holes, The n0 and p0 Equations, The Intrinsic Carrier Concentration, Intrinsic Fermi-Level Positions; The Extrinsic Semiconductor - Equilibrium Distribution of Electrons and Holes, The n0p0 Product, The Fermi-Dirac Integral, Degenerate and Nondegenerate Semiconductors; Statistics of Donors and Acceptors - Probability Function, Complete Ionization and Freeze-Out; Charge Neutrality, Position of Fermi Energy Level - Mathematical Derivation, Variation of EF with Doping Concentration and Temperature.	
Unit-2 - Carrier Transport Phenomena	***9 Hour***
Carrier Drift - Drift Current Density, Mobility Effects, Conductivity, Velocity Saturation, V-I Characteristics; Carrier Diffusion - Diffusion Current Density, Total Current Density; Graded Impurity Distribution - Induced Electric Field, The Einstein Relation, The Hall Effect	
Unit-3 - Nonequilibrium Excess Carriers in Semiconductors	***9 Hour***
Carrier Generation and Recombination, Characteristics of Excess Carriers - Continuity Equations, Time-Dependent Diffusion Equations; Ambipolar Transport - Derivation of the Ambipolar Transport Equation, Limits of Extrinsic Doping and Low Injection, Applications of the Ambipolar Transport Equation, Dielectric Relaxation Time Constant; Shockley-Read-Hall Theory of Recombination, Surface Effects - Surface States, Surface Recombination Velocity.	

Unit-4 - MOS Transistor	***9 Hour***
The Two-terminal MOS structure, Energy-Band Diagrams, Depletion Layer Thickness, Work Function Differences, Flat-Band Voltage, Threshold Voltage, Charge Distribution, Capacitance - Voltage Characteristics - Fixed Oxide and Interface Charge Effects, MOSFET Operations - Current Voltage Relationship Concepts and Mathematical Derivation, Velocity Saturation, Ballistic Transport.	
Unit-5 - Advanced Topics in MOSFET's	***9 Hour***
Effect of Gate and Drain Voltages on Carrier Mobility in the Inversion Layer, Channel Length Modulation, MOSFET Breakdown and Punch-through, Subthreshold Current, MOSFET Scaling, Nonuniform Doping in the Channel, Threshold Voltage of Short-channel MOSFETs, Small Signal Analysis - Meyers Model, Small Signal Equivalent Circuit of MOSFET Amplifier.	

Learning Resources	*1. Donald Neamen, Dhrubesh Biswas, “Semiconductor Physics and Devices”, McGraw Hill, 4th Ed, 2012.* *2. Nandita Dasgupta and Amitav Dasgupta, “Semiconductor Devices: Modelling and Technology” Prentice-Hall of India Pvt.Ltd; 1st Ed, 2004.* *3. G. Streetman, and S. K. Banerjee, “Solid State Electronic Devices,” 7th edition, Pearson, 2014.*	*4. S. M. Sze and K. N. Kwok, “Physics of Semiconductor Devices,” 3rd edition, John Wiley&Sons, 2006.* *5. Y. Tsividis and C. McAndrew, “MOSFET modeling for Circuit Simulation”, Oxford University Press, 2011.*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*40%*	-	*40%*	-	*40%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Vikas Verma, Physical design Engineer, Mediatek, vikas.verma@mediatek.com	*1. Dr. G. P. S. C Mishra, Associate Professor, NIT Raipur, Chhattisgarh*	*1. Dr. Maria Jossy A, SRMIST*
2. Mr. Mahesh Malewale Tanaji, Physical Design Engineer, mahesh.tanaji.malewale@intel.com	*2. DR. Shivendra Yadav, Assistant Professor, SVNIT, Surat, Gujrat*	

Course Code	21ECE403T	Course Name	MICROWAVE INTEGRATED CIRCUITS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basic concepts of transmission lines and matching circuits*
CLR-2:	*design of microwave passive devices*
CLR-3:	*gain knowledge on diodes, BJT and FET*
CLR-4:	*explain the construction and working of oscillators and mixers*
CLR-5:	*summarize the concepts of MIC fabrication and packaging*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the fundamentals of transmission line theory, Smith chart and its interpretation in the analysis and design of matching circuits*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*analyze microwave passive devices, analysis and design of filters*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*apply the knowledge of microwave active components and familiarize the methodologies on the design of Amplifiers*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*analyze various oscillators and mixers*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*illustrate the fabrication of MIC devices and packaging techniques*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Fundamental Concepts of Transmission Lines and Matching Circuits	***9 Hour***
Conventional Frequency Bands, Lumped and Distributed Circuits, Lumped Element Circuit Model for a Transmission Line, Field Analysis of Transmission Lines, Lossless Terminated Lines, Two Port Network and S-parameters, Striplines, Microstrip Lines, Smith Chart, Matching with Lumped Elements, Single-Stub Tuning	
Unit-2 - Power Dividers, Couplers and Filters	***9 Hour***
Basic Properties of Dividers and Couplers, The T-Junction Power Divider, The Wilkinson Power Divider, The Quadrature (90◦) Hybrid Coupler, The 180◦ Hybrid Coupler, Filter Design by the Image Parameter Method, Filter Design by the Insertion Loss Method, Filter Transformations, Filter Implementation.	
Unit-3 - Active Devices and Amplifier Design	***9 Hour***
PIN Diode, Varactor Diode, Tunnel Diode, IMPATT Diode, TRAPATT Diode, Gunn Diode, BJT, FET, Two Port Power Gains, Stability Circles, Transistor Amplifier Design, Power Amplifiers	
Unit-4 - Oscillators and Mixers	***9 Hour***
Basic Oscillator Models, Fixed Frequency Oscillators, Dielectric Resonator Oscillators, YIG Tuned Oscillator, Voltage Controlled Oscillator, Gunn Element Oscillator, Basic Concepts of Mixers, Frequency Domain Considerations, Single-Ended Mixer Design, Single-Balanced Mixer, Double-Balanced Mixer	
Unit-5 - MIC Fabrication and Packaging	***9 Hour***
Substrate Materials, Etching Technology Laminated Plastic Plates, Thin Film Hybrid Circuits, Thick Film Hybrid Circuits, Semiconductor Sapphire Technology, Monolithic Microwave Integrated Circuits, Packaging and Electrical Connections	

Learning Resources	1. *David M. Pozar, "Microwave Engineering", Fourth Edition, John Wiley & Sons, Inc, 2011.* 2. *Reinhold Ludwig, and Pave1 Bretchko "RF Circuit Design: Theory and Application", II Edition, Pearson Education, 2011* 3. *Thomas H Lee, "Planar Microwave Engineering", Cambridge University Press, 2004*	4. *Hoffman R.K. "Handbook of Microwave Integrated Circuits", Artech House, Boston, 1987.* 5. *Matthew M. Radmanesh, "Radio Frequency and Microwave Electronics", Pearson Education, II Edition 2002* 6. *Samuel. Y. Liao, "Microwave Circuit Analysis and Amplifier Design", Prentice Hall. Inc., 1987.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	25%	-	25%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1 Dr. K. V. Phani Kumar, SRMIST*

Course Code	21ECE404T	**Course Name**	TERAHERTZ DEVICES AND APPLICATIONS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECE211T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the background of terahertz technology*
CLR-2:	*study terahertz sources and detectors based on electronics and photonics*
CLR-3:	*analyze the operation of terahertz components such as antennas and filters*
CLR-4:	*interpret the terahertz spectroscopy and imaging*
CLR-5:	*identify the applications of terahertz technology in wireless communication, sensing and analysis*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the concepts of terahertz technology*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*analyze the working principle of different types of terahertz signal sources*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*examine the working mechanism of different types of terahertz detectors*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*illustrate the practical implementation of fabrication of components and circuits for terahertz systems*	-	*3*	-	-	-	-	*2*	-	-	-	-	-	-	-	*3*
CO-5:	*summarize different applications of terahertz technology for imaging, sensing and communications*	-	-	*2*	*2*	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Terahertz Technology	***9 Hour***
Electromagnetic radiation and propagation fundamentals, Introduction to THz, Terahertz Band, Terahertz Terminology, Properties of THz Waves, Key technological issues for Terahertz technology, Advantages, and limitations of terahertz waves, Material properties at mm and sub-mm frequencies	
Unit-2- Terahertz Sources	***9 Hour***
Terahertz sources based on electronics: Diodes, transistors, resonant tunneling diodes, vacuum electronics; Terahertz sources based on photonics: Non-linear crystals, quantum cascade lasers, plasma-based source; Terahertz sources based on optoelectronics: Photomixer, photoconductive antenna and its types; Noises at terahertz frequencies in different sources	
Unit-3- Terahertz Detectors	***9 Hour***
Terahertz detectors based on electronics: HOT electron bolometer, Heterodyne SIS receivers: Theory and design, Superconducting tuning circuitries, HEB heterodyne receivers: Theory and design, Terahertz MMICs: Theory and design, Terahertz detectors based on photonics	
Unit-4 - Fabrication Technologies and Terahertz Components	***9 Hour***
Introduction to terahertz fabrication technologies, Terahertz components: Metamaterials and plastic fibers, HEMT cryogenic amplifiers: Theory and design, Antennas, Filters, Waveguides, Beam Splitter, Beam Combiner, Polarizer, Mirrors, Isolator, Circulator, Cameras	
Unit-5- Terahertz Applications	***9 Hour***
Terahertz applications: THz Spectroscopy-Time-Domain and Frequency-Domain, Terahertz Imaging-Active and passive, Real-Time Imaging, Tomographic Imaging, THz Communication-Modulation Schemes, OOK Modulation Systems, THz Radars-Pulse Radars, CW Radar, Industrial applications, Space communication, Cutting-edge terahertz technologies	

Learning Resources	1. J.S. Rieh, "Introduction to Terahertz Electronics". Springer Nature, 2020. 2 A.Rostami, H. Rasooli, H. Baghban, "Terahertz Technology: Fundamentals and Applications", Germany, Springer, 2011. 3 R. E. Miles, P. Harrison, D. Lippens, "Terahertz Sources and Systems “, Dordrecht: Kluwer, Springer, 2000.	4 K. Sakai, "Terahertz Optoelectronics", Springer, 2004. 5 H.-J. Song, T. Nagatsuma, "Handbook of Terahertz Technologies, Devices and applications", Pan Stanford Publishing Pte. Ltd., 2015. 6 D. Saeedkia, "Handbook of Terahertz Technology for Imaging, Sensing and Communications", Woodhead Publishing, 2013.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	35%	-	35%	-	35%	-
Level 4	Analyze	25%	-	30%	-	25%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Mr. Harish Chandra Kumawat, SRMIST

Course Code	21ECE220T	Course Name	WIRELESS AND OPTICAL SENSORS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*comprehend the basic knowledge on Electromagnetic wave propagation and properties for design of wireless sensors for indoor applications*
CLR-2:	*gain awareness on various RF components and wireless devices used in wireless Networks*
CLR-3:	*realize the working principle of optical waveguides and adaptive optics for optical properties measurement purposes*
CLR-4:	*understand the optical fiber based various sensor configurations for physical and chemical sensing applications*
CLR-5:	*upsurge the knowledge on various optical sensors ranging from simple switches to Holography*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*calculate the wireless networks parameters and optimize the free space wireless communications in indoor networks*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*design wireless transceivers using RF, Bluetooth, IEEE802 Sensors for indoor communications*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*explain various optical waveguide concepts along with adaptive optics*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*realize Optical fiber based sensing mechanisms for physical and chemical applications*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*comprehend various optical sensors ranging from switches to holography*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Wireless Sensors Basic Concepts	***9 Hour***
Electromagnetic wave propagation, Power aspects of Free-space propagating and link analysis, Antenna Characteristics, Reflection, Atmospheric, refraction, Diffraction of electromagnetic waves, Indore propagation of EM Waves, Frequency allocation.	
Unit-2 - RF Components	***9 Hour***
Amplifiers, Attenuators, Filters, Frequency Multiplexers, Modulators and detectors, Antennas, Phase detectors, Power dividers and combiners, Transceivers, Wireless Modems. Wireless instruments and sensors Networks. Bluetooth, IEEEE802 Sensors.	
Unit-3 - Optical Sensing and Measurement	***9 Hour***
Overview of optical sensing, Principle of optical metrology, Optical waveguide sensors, Intensity measurement, Interferometric measurements, Fluorescence measurement, surface Plasmon measurement, Adaptive optics and wavefronts sensing, Multiphoton microscopy	
Unit-4 - Fiber Optic Sensors	***9 Hour***
Historic overview, Optical Fiber introduction, Point sensors for intensity, Point sensors for interferometry, Fiber optic sensors multiplexing, Distributed fiber optic sensors, Fiber Bragg grating sensors, optical fiber chemical sensor, Industrial fiber strain gauge sensor	
Unit-5 - Various Optical Sensors and its Applications	***9 Hour***
Switches, Displacement, Velocity, Temperature, Strain, Spectrometry, Refractometry, Speckle pattern interferometry, Holography.	

Learning Resources	1. *Eren, H., "Wireless Sensors and Instruments: Networks, Design, and Applications". CRC Press, 2018.*	2. *Haus, J., "Optical Sensors: Basics and Applications". Wiley, 2010.* 3. *Faramarz Farahi, Jose Luis Santos, "Handbook of Optical Sensors", CRC Press, 2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*20%*	-
Level 4	*Analyze*	*10%*	-	*10%*	-	*10%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. Bandaru Ramakrishna, SRMIST*

Course Code	21ECE221T	**Course Name**	RADAR AND NAVIGATIONAL AIDS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain Knowledge on the basics of Radar System*
CLR-2:	*explore the knowledge of different types of Radar*
CLR-3:	*interpret the various detection schemes*
CLR-4:	*understand the functions of Radar transmitters and Receivers*
CLR-5:	*introduce the fundamentals of navigation system and remote sensing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the principle operation of Radar with the help of range equation and parameters*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*apply Doppler principle to radars and hence comprehend the features of different types of radar*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*analyze the reception of Radar signals under noise and different propagation modes*	2	-	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*illustrate the functions of various parts of Radar transmitters and Receivers*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*examine the principle of navigation with aids of various navigation systems and basics of remote sensing*	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Introduction to Radar Equation	***9 Hour***
Introduction-Basic Radar- Radar Frequencies -Applications of Radar- The Simple form of Radar Equation- Radar Block Diagram- Receiver Noise- Signal- to-Noise Ratio- Integration of Radar Pulses- Radar Cross Section of Targets-Simple Targets- Radar Cross Section of Targets-Complex Targets Transmitter Power- Radar cross Section Fluctuations- Swerling Target Model- Transmitter Power- Pulse Repetition Frequency-Antenna Parameters- System losses-Microwave plumbing loss, Antenna loss, Signal Processing loss- System losses-Doppler processing, Collapsing, Operator loss, propagation Effects	
Unit-2 - MTI and Pulse Doppler Radar	***9 Hour***
Introduction to Doppler Radar- Introduction to MTI Radar- Delay –Line Cancellers- Doppler Filter Banks- Digital MTI Processing- Moving Target Detector - Limitations to MTI Performance- Pulse Doppler Radar-High, Medium, and Low PRF Doppler- Other Doppler Radar Topics- Tracking with Radar- Mono pulse Tracking- Two Coordinate amplitude comparison monopulse tracking- Conical Scan and Sequential Lobing-Limitations to Tracking. Accuracy- Case study on weather radars- Case study on weather radars	
Unit-3 - Detection of Signals in Noise	***9 Hour***
Detection of Signals in Noise -Detection Criteria- Probabilities of Detection and False Alarm- Matched Filter Receiver- Derivation of Matched filter frequency response- Automatic Detector- Constant-False-Alarm Rate Receivers- Signal Management- Propagation Radar Waves- Atmospheric Refraction- Standard propagation- Nonstandard Propagation- Ambiguity Diagram- Pulse compression- Linear FM pulse compression-Binary Phase Coded pulse compression-Introduction to clutter- Surface Clutter Radar equation	
Unit-4 - Radar Transmitter and Receiver	***9 Hour***
Radar Transmitters and Receivers- Linear Beam Power Tubes-Reflex Klystron- Linear Beam Power Tubes-TWT- Solid State RF Power Sources- Magnetron -Crossed Field Amplifiers- Other RF Power Sources-Other aspects of Radar Transmitter- The Radar Receiver - Receiver noise Figure- Super heterodyne Receiver- Link budget analysis- LNA and Mixers- Duplexers- Receiver Protectors- Radar Displays	

Unit-5 - Radio Navigation and Introduction to Remote Sensing	***9 Hour***
Introduction - Four methods of Navigation .- Positioning- Errors in Direction Finding- - Automatic Direction Finders- Hyperbolic Systems of Navigation-Loran-C - The Decca Navigation System -Decca Receivers - Range and Accuracy of Decca – TACAN - TACAN Equipment - Case study on Airborne Tactial networks- Instrument Landing System (ILS) – Case study on mismatch of ILS – Foundations of Remote Sensing – Energy interactions with Earth Surface Features – The Global Positioning System (GPS) - Characteristics of Remote sensing – Geographic Information Systems – Case Study in application of remote sensing and GIS in precision agriculture.	

Learning Resources	1. *Merrill I. Skolnik," Introduction to Radar Systems", 3rd Edition Tata Mc Graw-Hill 2008* 2. *R.B. Underdown and David Cockburn, "Ground Studies for Pilots: Radio Aids",6th Edition, Blackwell Publishing, 2011* 3. *Myron Kayton, Walter R.Fried, "Avionics Navigation Systems", Second Edition, Wiley-India Edition, 2010.* 4. *N.S.Nagaraja, "Elements of Electronic Navigation Systems", 2nd Edition, TMH, 2000.*	5. *Mark, Richards.A, "Fundamentals of radar signal processing", Mc-Graw Hill, Electronic Engineering, 1st Edition, 2005.* 6. *Jenny L. Reed, Aaron D. Lanterman, John M. Trostel," Tutorial: Weather Radar: Operation and Phenomenology", IEEE Aerospace and Electronic Systems Magazine, Vol: 32, 7, 2017.* 7. *Lillesand, Thomas, Ralph W. Kiefer, and Jonathan Chipman. "Remote sensing and image interpretation", John Wiley & Sons, 2015.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*15%*	-
Level 2	*Understand*	*30%*	-	*30%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad,kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. S. Vasanthadev Suryakala, SRMIST*
2. *Mr. Hariharasudhan - Johnson Controls,Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *C. T. Manimegalai, SRMIST*

Course Code	21ECE222T	**Course Name**	ADHOC AND SENSOR NETWORKS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know about the Ad hoc Networks*
CLR-2:	*learn the various aspects in MAC Layer and the concept of Quality of Service*
CLR-3:	*understand energy management in Ad hoc Networks*
CLR-4:	*predict insights of Sensor network*
CLR-5:	*analyze various aspects Hybrid networks and routing configuration*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe about Ad hoc Networks and various routing protocols used in Ad hoc networks*	-	-	-	-	-	-	3	-	-	-	-	2	2	-	-
CO-2:	*know the various functional areas such as MAC Layer and QOS*	3	-	2	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	*interpret the energy management protocols in Ad hoc Networks*	-	-	-	3	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*summarize about the Sensor network and its associated protocols*	3	-	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*analyze various hybrid networks and its routing protocols*	-	-	2	3	-	-	-	-	-	-	-	-	1	-	-

Unit-1 - Ad Hoc Wireless Networks ***9 Hour***

Cellular and Ad hoc Wireless Networks, Applications of Ad hoc Wireless Networks, Issues in Ad hoc Wireless Networks .MAC Protocol for Ad hoc Networks - Issues in Designing a MAC protocol for Ad hoc Wireless networks, Design goals of a MAC protocol for ad hoc wireless networks. Classifications of MAC protocols, Contention based protocols, Contention based protocols with reservation mechanisms and Contention based protocols with scheduling mechanisms.

Unit-2 - Quality of Service in Ad Hoc Wireless Networks ***9 Hour***

Real-Time Traffic support, Issues, and challenges in providing QoS, Classifications of QoS solutions. MAC Layer solution - cluster TDMA, IEEE 802.11e, DBASE. Network Layer solution -QOS routing protocols, Ticket Based QOS Routing protocols, Predictive location-based QOS routing. QOS framework, QOS models, QOS Resource Reservation Signaling, INSIGNIA- Operation of INSIGNIA framework, INORA-Coarse feedback scheme, Class based fine feedback scheme, SWAN-Model, Proactive RTMAC.

Unit-3 - Energy Management ***9 Hour***

Need for energy management, Classifications of Energy Management Schemes, Battery Management Schemes, Data link layer solution-Lazy packet scheduling scheme, Battery Aware MAC protocol. Transmission Power Management Schemes-Data link layer solution, Dynamic power adjustments policies, distribute topology control Algorithm Construct distributed power control loop, Centralized Topology control Algorithm Network layer solution–common power protocol, Minimum power consumption routing, Minimum battery cost Routing. Higher Layer solution, System power management scheme – Processor power management schemes, Power saving Modes, Power Aware Multi-Access Signaling. Device power Management Scheme-Low Power Design of Hardware, Hard Disk Drive (HDD) power consumption.

Unit-4 – Wireless Sensor Networks	***9 Hour***
Introduction – Applications of sensor networks, Comparison with Ad hoc wireless network, Issues, and challenges in designing sensor network. Sensor Network Architecture – Layered Architecture, Clustered Architecture, Data Dissemination, Flooding, Gossiping, Rumour Routing, Sequential Assignment Routing, Cost field approach, Data Gathering, Direct Transmission, Binary scheme, Chain Based Three level scheme .MAC protocols for sensor Networks-Self organizing MAC, CSMA Based MAC Location Discovery-Indoor and sensor network localization. Quality of Sensor Networks-coverage, Exposure. Recent Trends in Sensor Networks-Energy Efficient Design, synchronization, Transport Layer Issue, Security-Localized Encryption and Authentication protocols (LEAP), Intrusion Tolerant Routing in Wireless Sensor Network (INSENS). Real-Time communication – SPEED Protocol and RAP protocols.	
Unit-5 – Next Generation Hybrid Wireless Architectures	***9 Hour***
Classification of Hybrid architectures, multi-hop cellular network (MCN) Architecture, Mobile assisted data forwarding (MADF) Architecture, iCAR architecture, Hybrid wireless Network (HWN) Architecture, The SOPRANO architecture, and the A-GSM architecture. Routing in Hybrid wireless network- Base assisted ad hoc routing (BAAR), Operation of BAAR protocol. Base driven multi-hop bridging protocol (BMBP), Message used BMBP procedure. Pricing in Multi-Hop wireless networks. Power control scheme in Hybrid Wireless Networks – Issues in using variable power in IEEE 802.11, Power optimization scheme, Load Balancing in Hybrid Wireless Networks- Preferred Ring Based Routing Scheme, preferred inner Routing Scheme (PIRS), Preferred outer Ring Routing Scheme (PORS), Preferred Destination/Source Ring Based Routing Schemes.	

Learning Resources	1. *Siva Ram Murthy C., Manoj B.S, "Ad hoc Wireless Networks – Architectures and Protocols", 2nd ed., Pearson, 2006* 2. *Feng Zhao, Leonidas Guibas," Wireless Sensor Networks", 1st ed., Morgan Kaufman Publishers, 2004*	3. *C.K. Toh, "Ad hoc Mobile Wireless Networks", 7th ed., Pearson, 2007* 4. *Thomas Brag, Sebastin Buettrich, "Wireless Mesh Networking", 3rd ed., O'Reilly Publishers, 2007*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1 *Dr. K. Vijayan, SRMIST*

Course Code	21ECE223T	**Course Name**	SATELLITE COMMUNICATION AND BROADCASTING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study the background and orbital mechanics of satellite communication systems*
CLR-2:	*investigate satellite links and identify areas to improve link performance*
CLR-3:	*identify the various propagation effects and access techniques for satellite communication links*
CLR-4:	*interpret the applications of satellite communication in VSAT systems, satellite TV, and radios*
CLR-5:	*explore the concepts of satellite navigation and packet communication*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the concept and operation of satellite communication systems*	*2*	*2*	*-*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*analyze satellite launching, link design, link availability, and interference*	*-*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*examine the mechanism of multiple access techniques, propagation effects, and their impact on satellite communication*	*2*	*-*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*illustrate the practical implementation of VSAT and DBS systems*	*3*	*2*	*-*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*review the satellite communication navigation and global positioning system applications*	*3*	*2*	*-*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 – Overview of Satellite Communication ***9 Hour***

Principle, historical developments, frequency allocations for satellite services. Orbital mechanics: Kepler's laws, orbital parameters, look angle determination, orbital perturbations, orbit control system, geostationary orbit, telemetry, tracking, command and monitoring, power systems, communication subsystems, transponders, satellite antennas, equipment reliability and space qualification

Unit-2 – Satellite Link Design ***9 Hour***

Basic transmission theory, system noise temperature and G/T ratio, design of downlinks, satellite systems using small earth stations uplink design, carrier to noise (C/N) ratio, design of satellite links for specified C/N (with and without frequency re-use), link budget, system design examples

Unit-3 – Propagation Effects and their Impact on Satellite-Earth Links ***9 Hour***

Quantifying attenuation and depolarization, rain and ice effects, cloud attenuation, tropospheric and ionospheric scintillation, prediction of XPD, propagation impairment countermeasures Multiple access techniques for satellite links: Multiple access, frequency division multiple access, time division multiple access, demand access multiple access, random access, code division multiple access

Unit-4 – VSAT Systems ***9 Hour***

Network architectures, access control protocol, basic techniques, sat earth station engineering, calculation of link margins for VSAT star network, system design procedures. Direct broadcast satellite (DBS) TV and radio: C-band and Ku-band home satellite TV, DBS modulation, digital DBS-TV, DBS-TV system design, DBS-TV link budget, error control in digital DBS-TV, master control station and uplink, establishment of DBS–TV antennas, satellite radio broadcasting

Unit-5 – Satellite Navigation and Global Positioning System (GPS) ***9 Hour***

Radio and satellite navigation, GPS position location principles, GPS receivers and codes, satellite signal acquisition, GPS navigation message, GPS signal levels, timing accuracy, GPS receiver operation, case study – IRNSS/NAVIC, case study – GAGAN (GPS Aided GEO Augmented Navigation) Satellite packet communication: Message transmission by FDMA, message transmission by TDMA, pure Aloha-satellite packet switching, slotted Aloha, packet reservation

Learning Resources	1. *D.Roddy, "Satellite Communications", McGraw Hill Education, 4th Edition, 2017.* 2. *T.Pratt, C.Bostian and J.Allnutt, "Satellite Communications", Wiley, 2nd Edition, 2013.* 3. *W. L. Pritchart, H. G. Suyderhoud and R. A. Nelson, "Satellite Communication Systems Engineering", Pearson Education, 2nd Edition, 2012.*	4. *G. D. Gordon and W. L. Morgan, "Communications Satellite Handbook", Wiley, 2010.* 5. *L. J. Ippolito Jr, "Satellite Communications Systems Engineering: Atmospheric Effects, Satellite Link Design and System Performance", John Wiley & Sons, 2nd Edition, 2017.* 6. *M.Richharia,"Satellite Communication Systems: Design Principles", Macmillan, 2nd Edition, 2003.*

Learning Assessment

		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Formative CLA-1 Average of unit test (50%)*		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*35%*	-	*35%*	-	*35%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
.1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	*1 Dr. Sachin Kumar, SRMIST*
	2. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	

							L	T	P	C
Course Code	21ECE224T	**Course Name**	CRYPTOGRAPHY AND NETWORK SECURITY	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*recognize classical and modern symmetric encryption standards*
CLR-2:	*analyze different public key cryptography algorithms*
CLR-3:	*interpret the various techniques in authentication schemes*
CLR-4:	*study the concepts in network security*
CLR-5:	*identify the effect of various malwares and counter measures*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*examine the methods of classical and modern Encryption*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply the concepts of Number theory in key generation and encryption standards*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*discuss about the authentication and digital signature schemes*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*gain knowledge in the various forms of network security*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyse the effects of intrusion, viruses, firewalls and various levels of system security*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Conventional and Modern Encryption & Block Ciphers	***9 Hour***
Security Services, Mechanisms, Attacks. Network Security Model, Cryptography and Cryptanalysis, Conventional Encryption Techniques, DES and its Security Strength, Block Cipher Modes of Operation, Key Distribution Centre, Overview of AES, IDEA, Blowfish, RC5, and CAST-128, Characteristics of Advanced Symmetric Block Ciphers, Steganography	
Unit-2 - Public Key Encryption	***9 Hour***
Number Theory, Public Key Cryptosystems, RSA Algorithm, Public Key Management, Public Key Certificate Generation and Verification, X. 509 Certificates, Diffie-Hellman Key Exchange, Elliptic Curve cryptography.	
Unit-3- Authentication Protocols, Hash & MAC Algorithms	***9 Hour***
Message Authentication, DAC, CMAC, Hash Functions, MD5, SHA-1 and SHA-512, HMAC, Digital Signature Standard and Algorithm, One way and Mutual User Authentication Techniques, Kerberos	
Unit-4 - Email Security, IP Security and Web Security	***9 Hour***
Email security, Overview of PGP and S/MIME, IP Security, Web Security, Secure Socket Layer, Transport Layer Security, Secure Electronic Transaction	
Unit-5- System Security	***9 Hour***
Intrusion Detection Techniques, Password Management, Malicious software, Viruses, Worms, and Zombies. Introduction to Firewall Types and Configurations, Trusted System, Port Scanning and Knocking.	

Learning Resources	*1. William Stallings, "Cryptography & Network Security",6th ed., Pearson, 2014* *2. Behrouz A. Forouzan, Debdeep Mukhopadhyay, "Cryptography and Network Security", 2nd ed., Tata McGraw Hill, 2010*	*3. Bruce Schneier, "Applied Cryptography", 2nd ed., 2015* *4. Bernard Menezes, "Network Security and Cryptography", Cengage Learning, 2010*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Mrs.A. Vinnarasi, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. B. Ramachandran, SRMIST.*

Course Code	21ECE225T	Course Name	OPTICAL SYSTEMS AND NETWORKS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	ECE	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study the elements of Optical fiber Communications systems and networks*
CLR-2:	*identify the different Modulation, Detection, and Link design for Optical systems*
CLR-3:	*investigate the Recent Optical Communication Technology*
CLR-4:	*explore the concept of Optical Networks*
CLR-5:	*interpret and correlate the Switching and Routing Networks*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the concepts of Optical fiber Communications and its characteristics*	3	-	-	3	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*explore the significance of system design for Analog and Digital Optical systems*	3	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*describe and Analyze the Recent Optical Communication Technologies*	-	-	2	-	-	-	-	-	-	-	-	-	-	-	3
CO-4:	*illustrate the concept of Optical Networks*	-	2	-	-	-	-	-	-	3	-	-	-	-	-	-
CO-5:	*categorize and conclude the Photonic Packet Switching and Wavelength Routing Networks with its applications*	-	-	-	2	-	-	-	-	3	-	-	-	-	-	-

Unit-1 – Optical Fiber Communications	***9 Hour***
Historical development, The general system, Advantages of optical fiber communication, Optical fiber wave guides: Ray theory transmission, Modes in planar guide, Phase and group velocity, cylindrical fiber: Modes, Step index fibers, Graded index fibers, Single mode fibers, Cutoff wavelength, Mode field diameter, effective refractive index. Fiber Materials, Photonic crystal fibers, Optical Sources and Detectors Characteristics	
Unit-2 - System Design	***9 Hour***
Intensity modulation/ direct detection: Source limitations, equalization, design considerations, digital systems, regenerative repeater, digital optical receiver, bit error rate (BER), eye diagram, link design-power budget, rise time budget, analog systems, direct intensity modulation, subcarrier intensity modulation, distribution systems. Case study-Video Transmission oven fiber optic links	
Unit-3 - Recent Optical Communication Technologies	***9 Hour***
Free space optical communication system: Transmission parameters, Sources, and detectors for FSO, effect of atmospheric attenuation and turbulence on FSO, terrestrial system. Optical Code Division Multiple Accesses (OCDMA): performance of synchronous OCDMA, optical encoders and decoders, Sub carrier multiplexing systems. Case study-Simulation of Modeling Techniques for Optical Communication Systems.	
Unit-4 - Introduction to Optical Networks	***9 Hour***
First generation optical networks, multiplexing techniques, second generation optical networks, virtual circuit services and datagrams, transparency of regenerators, Broadcast and Select Networks: Topologies for broadcast networks, bus, star, ring and mesh topology, MAC protocols, throughput calculation, synchronization, aloha and slotted aloha, testbeds, lambda net, rainbow and star net.	
Unit-5 - Photonic Packet Switching and Wavelength Routing Networks	***9 Hour***
Optical time domain multiplexing (OTDM), methods of multiplexing and demultiplexing, broadcast OTDM networks. Classification of light paths, The Optical layer, Wavelength Cross Connects (WXC) wavelength reuse, Static and reconfigurable network and its applications. Case Study: NBM - Empowering Digital India with Fiber Network.	

Learning Resources	1. *J.M. Senior, "Optical fibre communications, Principles & Practice", (PHI), 3/e, 2009* 2. *G. P. Agrawal, "Fiber-optic communication systems", John Wiley & sons, Inc. 5/e, 2010.* 3. *Gerd keiser "optical fiber communication" 5th edition, mcgraw-hill,2017* 4. *J.E. Midwinter, "Photonics in Switching" Academic Press, 1993.*	5. *R. Ramaswami and K. N. Sivarajan, "Optical Networks", Morgan Kaufmann Publishers, 3/e, 2010* 6. *C. S. R. Murthy and M. Gurusamy, "WDM Optical Networks", Prentice Hall, 2002.* 7. *Le Nguyen Binh, "Optical Fiber Communication Systems with MATLAB and Simulink Models", Second Edition CRC Press, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	30%	-	20%	-	30%	-
Level 2	*Understand*	40%	-	25%	-	40%	-
Level 3	*Apply*	30%	-	35%	-	30%	-
Level 4	*Analyze*	-	-	20%	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	1. *Dr T. Rama Rao, SRMIST*
	2. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	2. *Dr.C.T. Manimegalai, SRMIST*

Course Code	21ECE320T	Course Name	SOFTWARE DEFINED NETWORKS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	ECE	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understanding the evolution of SDN*
CLR-2:	*familiarize with the SDN Devices and Controllers*
CLR-3:	*analyze the basics of open flow and NFV*
CLR-4:	*create insights to various use case of SDN*
CLR-5:	*understand the concepts of SDN open source and Software Defined Mobile Networks*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the SDN architecture and its benefits*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*analyze SDN controllers and Devices functionality*	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*interpret the open flow technology and Network Virtualization*	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*discuss about SDN Application and Use Case*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*gain knowledge towards SDN Implementation in 5G Mobile Networks*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - Basics of SDN ***9 Hour***

Introduction to SDN- Evolution of Switches and Control Planes, Cost, SDN Implications for Research and Innovation, Need of SDN- Data Center Innovation, Data Center Needs, The Control Plane, Data Plane, Moving Information Between Planes, Separation Importance, Technical Landscape, Hybrid Approaches Ships in the Night, Dual Function Switches

Unit-2 - SDN Devices and Controller ***9 Hour***

How SDN Works- Fundamental Characteristics of SDN, SDN Operation, SDN Devices, SDN Controller, SDN Applications, Alternate SDN Methods, VMware/Nicira, OpenFlow-Related, Mininet, NOX/POX ,Trema, Ryu,

Unit-3 – Open Flow and Network Virtualization ***9 Hour***

OpenFlow Overview- The OpenFlow Switch, The OpenFlow Controller, The OpenFlow Protocol, OpenFlow 1.0 and OpenFlow Basics- Ports and Port Queues, Flow Table, Packet Matching, Actions and Packet Forwarding, Messaging Between Controller and Switch, OpenFlow 1.3 Additions and OpenFlow Limitations, OpenFlow Programming, Network virtualization - Challenges, Architecture, Building Blocks, Example system, Micro segmentation

Unit-4 - SDN Application and Use Case ***9 Hour***

SDN in the Data Center - Data Center Definition, Data Center Demands, Tunneling Technologies for the Data Center, Path Technologies in the Data Center Switching Fabrics, Traffic Engineering for WAN, Software Defined WAN, Access Networks - SD - PON, SD- RAN

Unit-5 - SDN Implementation in 5G Mobile Networks ***9 Hour***

SDN Open Source-Chapter-Specific Terminology , Open Source Licensing Issues, Profiles of SDN Open Source Users ,OpenFlow Source Code, Switch Implementations , Controller Implementations , SDN Applications, Simulation, Testing, and Tools, OpenStack, SDN Futures-Current State of Affairs, Potential Novel Applications of Open SDN, LTE Architecture Integration with SDN - Restructuring mobile networks to SDN, SDN and LTE integration Benefits, Controller Placement - Performance objectives, Controller Placement problem

Learning Resources	1. *Paul Goransson and Chuck Black, "Software Defined Networks: A Comprehensive Approach," Morgan Kaufmann Publications, 2014.* 2. *Thomas D.Nadeau & Ken Gray,"SDN - Software Defined Networks,"O'Reilly, 2013.* 3. *Larry. L. Peterson, Carmelo Cascone, et.al, " Software-Defined Networks: A Systems Approach, Systems Approach LLC, 2021.*	4. *Madhusanka. Liyanage et.al, "Software Defined Mobile Networks, Beyond LTE Network Architecture," Wiley, 2015.* 5. *Arsany Basta; Andreas Blenk; Klaus Hoffmann; Hans Jochen Morper; Marco Hoffmann; Wolfgang Kellerer, "Towards a Cost Optimal Design for a 5G Mobile Core Network Based on SDN and NFV",,IEEE Transactions on Network and Service Management, 2017, Volume: 14, Issue: 4 Pages: 1061 - 1075*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*25%*	-	*15%*	-	*25%*	-
Level 2	*Understand*	*30%*	-	*20%*	-	*30%*	-
Level 3	*Apply*	*30%*	-	*40%*	-	*30%*	-
Level 4	*Analyze*	*15%*	-	*25%*	-	*15%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. V. Nithya, SRMIST*
		2. *Dr. P. Vijayakumar, SRMIST*

Course Code	21ECE321T	**Course Name**	RF AND MICROWAVE SEMICONDUCTOR DEVICES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC201T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on microwave semiconductor materials and to understand the fundamental of electronic components under microwave signal*
CLR-2:	*attain knowledge of microwave components and devices that are used in modern microwave radar and communication systems*
CLR-3:	*analyze the characteristics and operation of microwave transistors*
CLR-4:	*familiarize the fundamentals of RF power transistors and challenges*
CLR-5:	*acquire deep understanding of development of RF and modern semiconductor devices*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the properties of Semiconductor Junction Diodes under microwave signals*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*analyze the development of negative resistance characteristics in tunnel diode and transit time devices*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*characterize the microwave components and circuits in terms of their performance parameters*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*express the characteristics of RF power transistors*	*3*	*2*	*1*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*evaluate the concepts of RF and semiconductor devices and apply in the design of electronic systems*	*3*	*1*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	*1*

Unit-1 - Semiconductor P-N Junction	***9 Hour***
Review of properties of semiconductors, Transient and ac behavior of p-n junctions, Effect of doping profile on the capacitance of p-n junctions, Noise in p-n junctions, Varactor diode, Construction and Operation of Varactor Diode, Schottky effect, Schottky barrier diode, Hetero junctions, Construction and operation of microwave PIN diode, Applications.	
Unit-2 - Negative Resistance and Transit Time Devices	***9 Hour***
Negative Resistance Devices, Tunnel Diode, tunneling process in p-n junction, MIS tunnel diodes, Backward Diode, Transferred Electron Devices, IMPATT, Small-signal analysis of IMPATT diodes, TRAPATT-Power output and efficiency, BARITT Diodes, Two-valley model of compound semiconductors, vd-E characteristics, Gunn Effect, modes of operation, small-signal analysis of Gunn diode, Power-frequency limit	
Unit-3 - Microwave BJT Transistors	***9 Hour***
Microwave Transistor, High frequency limitations of BJT, Microwave bipolar transistors – operation, Hetero junction bipolar transistors- operation, Kirk effect, High frequency response, MESFET- Principle of operation, Properties of semiconductor materials used in MESFET, MESFET Technology, MESFET Modeling, I-V Characteristics, High frequency performance, MISFET-Introduction, Operating characteristics of MISFET	
Unit-4 - HEMT Transistors and RF Power Transistor	***9 Hour***
Introduction to HEMT, Short channel effects, Device operation, Device design, Scaling issues, Material Systems for HEMT Devices, GaAs HEMT, InP HEMT, Technology comparisons, Introduction of RF power transistor, Figure of Merit for RF Power Transistor, Common RF power devices, Material properties, State-of-the-art-wide bandgap microwave transistor data, Challenges to production	
Unit-5 - RF Package Design and Development	***9 Hour***
Introduction to RF Package, Thermal Management, Mechanical Design, Package electrical and electromagnetic Modeling, Design verification, Materials testing, Reliability testing, computer integrated Manufacturing, Thermal modeling, Thermal analysis of resistance networks, Introduction to computer aided design, Benefits, limitations and applications of CAD	

Learning Resources	1. Golio, M.,“RF and Microwave Semiconductor Devices Handbook”, CRC Press,(2002) 2. Simon M. Sze, Yiming Li, Kwok K. Ng, “Physics of Semiconductor 3. Devices”, 4th Ed., Wiley (2021).	4. Glover, I.A., Pennoek, S.R. and Shepherd P.R., “Microwave Devices, Circuits and Sub-Systems”, 4th Ed., John Wiley & Sons (2005) 5. Liao, S.Y., “Microwave Devices and Circuits”, 4th Ed., Pearson Education (2002).

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Saivineeth, ML Accelerator Architect @ Google	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr.S. Bashyam, SRMIST
		2. Dr.J. Manjula, SRMIST,

Course Code	21ECE322T	**Course Name**	DATA ANALYTICS USING R	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify usage of R programming for various data types an data structures*
CLR-2:	*understand control statements, functions and exception handling in R*
CLR-3:	*interpret the R language basic statistical and probability concepts*
CLR-4:	*explore R programming tool for statistical testing*
CLR-5:	*select different graphical representations to recognize patterns and trends in data*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*enumerate data Structures in R such as Vector, List, Matrix, Array & Data Frame*	-	3	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-2:	*write R programming codes using control statements, functions and exception handling*	-	-	3	-	2	-	-	-	-	-	-	-	3	-	-
CO-3:	*demonstrate statistical analysis and technologies on data to find trends and solve problems using R*	-	3	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-4:	*apply the different distributions and statistical testing using R*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	3
CO-5:	*construct data visualization using various types of graphs and plots in R*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	3

Unit-1 - Data Types and Structures in R Language ***9 Hour***

Numerics, Arithmetic, Assignment, and Vectors-R for Basic Math, Assigning Objects, Creating a Vector, Sequences , Repetition, Sorting, and Lengths, Subsetting and Element Extraction, Matrices and Arrays, Defining a Matrix, Row and Column Bindings, Matrix Dimensions, Subsetting, Matrix Operations and Algebra, Multidimensional Arrays, Non-numeric values, Logical Values, Characters, Lists and Data Frames, Lists of Objects, Data Frames, Basic Plotting, Using plot with Coordinate Vectors, Graphical Parameters, The ggplot2 Package, Reading and Writing Files, R-Ready Data Sets, Reading in External Data Files, Writing Out Data Files and Plots

Unit-2 - Control Statements, Functions and Exception Handling in R ***9 Hour***

Calling Functions- Scoping, Argument Matching, Conditions and Loops- if Statements, Coding Loops, for Loops, while Loops, Other Control Flow Mechanisms-The repeat Statement, Writing Functions, the function Command, Arguments, Specialized Functions, Recursive Functions, Exceptions, Timings, and Visibility -Exception Handling, Progress and Timing, Measuring Completion Time, Masking,

Unit-3 - Statistics and Probability ***9 Hour***

Elementary Statistics- Describing Raw Data, Numeric Variables, Numeric Variables, Univariate and Multivariate Data, Summary Statistics- Mean, Median, Mode, Counts, Percentages, and Proportions, Quantiles, Percentiles, Variance, Standard Deviation, and the Interquartile Range, Covariance and Correlation, Outliers, Probability-Events and Probability , Random Variables and Probability Distributions , Common Probability Distribution-Bernoulli Distribution ,Binomial Distribution , Poisson Distribution , Common Probability Density Functions - Uniform, Normal, Student's t-distribution, Exponential.

Unit-4 - Statistical Testing and Modeling ***9 Hour***

Sampling Distributions and Confidence - Distribution for a Sample Mean, Distribution for a Sample Proportion, Confidence Intervals, Hypothesis Testing- Hypotheses, p-value, Significance Level, Testing Means, Testing Proportions, Testing Categorical Variables, Hypothesis Test Errors, Type I Errors, Type II Errors, Analysis of Variance - One-Way ANOVA, One-Way ANOVA Table Construction, Simple Linear Regression-Definition of the Model, Estimating the Intercept and Slope Parameters, Fitting Linear Models with lm, Illustrating Residuals, Prediction, Plotting Intervals, Interpolation vs. Extrapolation, Linear Model Selection and Diagnostics

Unit-5 - Data Visualization	***9 Hour***
Exploring Data - Creating a Scatter Plot, Line Graph, Bar Graph, Histogram, Box Plot, Plotting a Function Curve, Bar Graphs- Basic Bar Graph ,Grouping Bars Together, Bar Graph of Counts, Using Colors in a Bar Graph, Stacked Bar Graph, Basic Line Graph - Adding Points to a Line Graph, a Line Graph with Multiple Lines, Changing the Appearance of Lines and points, Graph with a Shaded Area, Stacked Area Graph, Adding a Confidence Region, Scatter Plots- Basic Scatter Plot, Grouping Data Points by a Variable Using Shape or Color, Using Different Point Shapes, Mapping a Continuous Variable to Color or Size, Summarized Data Distributions- Basic Histogram, Multiple Histograms from Grouped Data, Density Curve, Violin Plot, Density Plot of Two-Dimensional Data, Annotations, Axes, Legends,	

Learning Resources	*1. Tilman M. Davies," The Book of R, A First Course in Programming and Statistics", No Starch Press, Inc. 2016* *2. Winston Chang, "R Graphics Cookbook", O'Reilly Media, Inc.,2013*	*3. James G, Witten D, Hastie T, Tibshirani R "Introduction to Statistical Learning", Springer, 2013.* *4. Norman Matloff, "The Art of R Programming, A Tour of Statistical Software Design", No Starch Press, Inc.,2011*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr.J. Subhashini, SRMIST*
		2. Dr.P. Vijayakumar, SRMIST

Course Code	21ECE323T	**Course Name**	CYBER SECURITY	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the security concepts, standards and protocols of cyber security*
CLR-2:	*familiarize various types of cyber-attacks and cyber-crimes*
CLR-3:	*analyze security and privacy threats in computer networks*
CLR-4:	*develop deep understanding on cyber-crime issues and forensics*
CLR-5:	*discuss the improvement in cyber security on hardware and software*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the design secure systems using digital security standards*	-	*3*	-	-	*1*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*design different practical digital encrypted systems with minimal supervision*	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*implementation of the hardware and software's for designing cyber physical system*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*discussing the cyber-crime issues and investigations*	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyze the improvement in cyber security*	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Digital Security — *9 Hour*

Digital Privacy- Privacy Laws- Types of Cyber Attacks- Computer Security Risks-Online Tracking-Malware -Hacking - Pharming - Phishing - Ransomware-virus- Wi-Fi Eavesdropping - Social Engineering attack type-Security Solutions-Antivirus-Firewalls-Password-Secure Online Browsing- Secure WIFI Settings-Cloud Storage security - IOT Security-case study: Protect children online

Unit-2 - Online Anonymity — *9 Hour*

Anonymity-Anonymous Networks-TOR Networks -I2P Network- Freenet - Darknet-Anonymous OS–Secure File Sharing- VPN-Proxy Servers- Connection Leak Testing-Check for DNS Leak-Fix DNS Leak-Secure Search Engine-Web Browser Privacy Configuration-Anonymous Payment- case study: Payment Security Measures

Unit-3 - Secure Communication — *9 Hour*

Introduction to Encryption & Cryptography- Cryptographic Functions-Types-Cryptographic Trust Models-Cryptographic Key Pair-Disk encryption using windows bitlocker - Disk Encryption Using Open-Source Tools-Multitask Encryption Tools- Securing Data In Transit -Cloud Storage Encryption-Encrypt DNS Traffic-Email Communication-Attacking Cryptographic Systems- Types of attacking cryptographic systems-case study: Countermeasures Against Cryptography Attacks

Unit-4 - Cyber Crime Issues & Challenges — *9 Hour*

Cyber Crime-Classifications-Kinds of Cyber Crime-cyber forensic-computer forensics-Digital Forensics-Password manager- Windows Firewall with Advanced Security- Connection Security Rules-safe internet browsing-Buying Online-Wireless Security-Email-social media marketing security-smart phone security-Challenges in smart devices

Unit-5 - Advances in Cyber Security — *9 Hour*

Introduction to cyber security today-DDOs-Strategies for improving cyber security-Bastion hardware-software security architecture-Trusted platform module-Mitigating Hardware information leaks-Defending software systems against cyber-attacks

Learning Resources	1. Nihad Hassan, Rami Hijazi, "Digital Privacy and Security Using Windows: A Practical Guide"1st Edition, Apress Publications, 2017	2. D.Frank Hsu, Dorothy Marinucci, "Advances in Cyber Security; Technology, Operations and Experiences"1st Edition, Fordham University Press, New York 2013 3. Nina Godbole & Sunit Belapure “Cyber Security”, Wiley India, 2012

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	10%	-	10%	-	10%	-
Level 6	Create	10%	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr.R. Dayana, SRMIST
2. Dr. Madan Kumar Lakshmanan, Senior Scientist, CEERI, lmadank@gmail.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	21ECE324T	Course Name	ADVANCED MOBILE COMMUNICATION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*introducing recent advancements and growing trends in mobile telecommunications*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*figure out the methods to improve the Data Rates in mobile communication*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*inferring technical requirements for 5G, network architecture*															
CLR-4:	*acquire the knowledge of Network Planning and Deployment techniques*															
CLR-5:	*analyzing security techniques and Applications of Advanced Mobile communication system*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*examine the development, challenges and requirements of mobile communications*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*interpret the methods to improve the data rate*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*connect the layers of communication systems*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*analyze the techniques of Planning and deployment of communication network*	-	-	-	*2*	-	-	-	-	*3*	-	-	-	-	-	-
CO-5:	*summarize the security, services and applications of Next generation communication techniques*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-	-

Unit-1 - Introduction ***9 Hour***

Overview -What Is 5G? -Background -Research and Challenges for Electronics -Expected 5G in Practice - 5G and Security -Motivations -5G Standardization and Regulation -Global Standardization in 5G Era. 5G Requirements Based on ITU- The Technical Specifications of 3GPP-The 5 G Security.

Case Study*: Mobile Network Operators and Mobile Device Manufacturers in India*

Unit-2 - Data Rates in Mobile Communication ***9 Hour***

Fundamental Constraints in achieving High Data Rates Noise-limited scenarios Interference-limited scenarios Higher-order Modulation, Multi carrier modulation Wider bandwidth, Spectrum Composition Low frequency spectrum, capacity and coverage, spectrum for 5GNR, unlicensed mm waves bands, Terahertz spectrum, spectrum requirements for 6G: SUB-6.

Unit-3 - Radio Network ***9 Hour***

Radio access technology-Orthogonal Frequency Division Multiplexing- Channel estimation and equalization- Multiple-Input Multiple-Output Techniques-Advanced MIMO-Radio network architecture and Interfaces.

Case Study*: The Role of 5G and beyond in the Cyber-World*

Unit-4 - Network Planning and Deployment ***9 Hour***

Core and Transmission Network Dimensioning- Radio Network Planning- Core and Radio Network Deployment Scenarios- Standalone and Non-Standalone Deployment Scenarios- Network Interfaces and Elements-core deployment-Measurements.

Case Study *: Security Opportunities for Stakeholders*

Unit-5 - Security Services and Applications ***9 Hour***

Security Threats and Challenges- Security Implications in 5G Environments and Use Cases - Security Layers- Device Security- Security between Network Entities, Vehicle Communications- Machine Learning and Artificial Intelligence.

Case Study*: The concept and vision of 6G Massive IoT*

Learning Resources	1. *5G explained: security and deployment of advanced mobile communications by Jyrki T.J. Penttinen. Hoboken, NJ, USA: John Wiley & Sons, Inc., 2019.* 2. *6G wireless communications and mobile networking by xianzhong Xie, Bo Rong, Michel Kadoch-Bentham books*	3. *Rappaport.T.S.," Wireless Communications: Principles and Practice", 2nd Edition, Pearson, 2011* 4. *Chiller, "Mobile Communications", Pearson Education Asia Ltd., Reprint 2012*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*20%*	-	*30%*	-
Level 2	*Understand*	*30%*	-	*25%*	-	*40%*	-
Level 3	*Apply*	*40%*	-	*35%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*20%*	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)*	1 *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1 *Dr.C.T. Manimegalai, SRMIST*

Course Code	21ECE420T	**Course Name**	INFORMATION THEORY AND CODING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the significance of the quantitative measure of information in the communications systems*
CLR-2:	*impart the fundamentals of error control coding techniques and their applications*
CLR-3:	*analyze the fixed and variable length codes*
CLR-4:	*assess the performance of convolutional coding schemes in different practical*
CLR-5:	*estimate the channel capacity and its types*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the basics of information and coding methodology*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-2:	*develop various codes and error checksum*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*apply variable length codes for source coding, Comprehend various source coding schemes*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*implementation of convolution codes for error detection and correction*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*analyze any type of channel and select coding techniques to improve channel performance*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Source Coding	***9 Hour***
Model of signaling system - Mathematical models for information sources – Encoding a source alphabet– Code Formation for an information -Radix r code – source coding with different radix- Miscellaneous codes- Simple parity checks – CRC codes – Single / Double parity checks - Lempel–Ziv Coding-case study: Relationship of information theory to other fields	
Unit-2 - Error Detection / Correction & Codes	***9 Hour***
Hamming weight – Hamming distance – Minimum distance decoding- Hamming codes – Linear block codes – Cyclic codes – Syndrome calculation –Block encoders and Decoders	
Unit-3 - Variable-Length Codes – Huffman Codes	***9 Hour***
Unique decoding – Instantaneous codes and its construction – The Kraft's inequality – Shortened block codes – The McMillan's Inequality – Huffman codes and its special cases – Extensions of a code –Radix-r Huffman codes	
Unit-4 - Convolutional Codes	***9 Hour***
Encoding of Convolutional Codes-Properties- Maximum likelihood decoding -Viterbi decoding-sequential decoding-Trellis-Turbo codes	
Unit-5 - Entropy & Channel Capacity	***9 Hour***
Entropy: marginal, conditional, joint, and relative entropies- Mutual information-information rate- channel capacity-redundancy and efficiency of channels- Discrete channels –Types- Shannon theorem-Shannon-Fano coding	

Learning Resources	*1. Thomas M. Cover and Joy A. Thomas, "Elements of Information Theory", second edition, Wiley, 2012* *2. Shu Lin and Daniel J Costello, "Error Control coding fundamentals and applications", 2nd edition, Pearson Education, Inc, Prentice Hall,2011*	*3. Hamming, Richard W, "Coding and Information Theory", Prentice Hall Inc., NJ, 1986.* *4. Proakis J. G., "Digital Communications", McGraw Hill Inc., 4th Edition, NY, 2001.* *5. R. Togneri, C.J.S deSilva, Fundamentals of Information Theory and Coding Design, Taylor and Francis, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	10%	-	10%	-	10%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	20%	-	20%	-	20%	-
Level 5	*Evaluate*	15%	-	15%	-	15%	-
Level 6	*Create*	5%	-	5%	-	5%	-
	Total	100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr.R. Dayana, SRMIST
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	21ECE421T	**Course Name**	WIRELESS COMMUNICATION NETWORKS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the different types of wireless communication networks*
CLR-2:	*define large scale fading in mobile radio wave propagation*
CLR-3:	*demonstrate small scale fading in mobile radio wave propagation*
CLR-4:	*investigate the concepts of capacity and diversity to improve wireless network link performance*
CLR-5:	*evaluate different types of wireless communication networks and standards*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the concepts of wireless communication and networks*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*analyze different radio wave propagation models for wireless communications*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*apply different multipath propagation channel models*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*illustrate the link performance improvement techniques*	-	*3*	-	-	-	-	*2*	-	-	-	-	-	-	-	*3*
CO-5:	*summarize different wireless communication standards to construct wireless networks*	-	-	*2*	*2*	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Wireless Communications and Networks	***9 Hour***
Introduction to wireless communication and mobile radio communication, classification of wireless communications/networks - simplex, half duplex, full duplex, paging and cordless systems, cellular telephone systems, timing diagram - landline to mobile, timing diagram - mobile to mobile, frequency reuse, sectored and omni-directional antennas, channel assignment strategies, handoff and its types, interference and system capacity, cell splitting and sectoring, microcell zone concepts, umbrella cells, introduction to telecommunication networking: trunking and grade of service	
Unit-2 - Large Scale Fading	***9 Hour***
Introduction to radio wave propagation, large scale, and small-scale fading, Friis transmission equation - free space propagation model - pathloss model, two ray model, simplified pathloss model, empirical model – Okumura, empirical model –Okumura model problem, empirical model - Walfish and Bertoni model, piecewise linear model - log normal model, shadowing, combined pathloss and shadowing, outage probability, cell coverage area	
Unit-3 - Small Scale Fading	***9 Hour***
Introduction Small scale multipath propagation, impulse response model of multipath channel, impulse response model of multipath channel, small scale multipath measurements - direct pulse measurement, small scale multipath measurements - sliding correlator measurement, small scale multipath measurements - swept frequency measurement, parameters of mobile multipath channels - time dispersion and coherent bandwidth, parameters of mobile multipath channels - doppler spread and coherent time, types of fading: flat and frequency selective fading, types of fading: fast and slow fading, Ricean distribution, Rayleigh distribution	
Unit-4 - Improvement in Link Performance	***9 Hour***
Improvement in link performance/ communication networks - introduction to diversity, equalization and capacity, space diversity, scanning diversity, maximal ratio combiner, equal gain diversity, rake receiver, MIMO/diversity, massive MIMO (elementary level), equalizer and its mode, adaptive equalizer block diagram, types of equalizers - elementary level only, Shannon capacity equation and throughput	

Unit-5 - Wireless Networks and Standards	***9 Hour***
Evolution of various wireless standards, GSM system architecture and its interfaces, GSM frame structure, CDMA transmitter network architecture, CDMA receiver network architecture, OFDM block diagram, importance of cyclic prefix, introduction to 4G and 5G communications (frequency allocations and data rates), case study – 4G LTE architecture, case study – 5G architecture	

Learning Resources		
	1. Rappaport.T. S, "Wireless Communications: Principles and Practice", Second Edition, Pearson Education, Reprint 2011. *2. Andreas. F. Molisch., "Wireless Communications", Wiley Publications, Second Edition-2005, Reprint-2014.* *3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, Aug 2005.*	*4. John D Kraus, Ronald J Marhefka, Ahmed S Khan "Antenna and wave propagation" 4th Edition 2010.* *5. Jochen Schiller, "Mobile Communications", Pearson Education Asia Ltd., Reprint 2012.* *6. Lee W.C.Y., " Mobile Communications Engineering: Theory and Applications", McGraw Hill, New York, 2nd Edition, 1998.*

Learning Assessment

		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Formative CLA-1 Average of unit test (50%)*		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*35%*	-	*35%*	-	*35%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Sachin Kumar, SRMIST*

Course Code	21ECE240T	**Course Name**	WAVELETS AND SIGNAL PROCESSING	**Course Category**	E	PROFESSIONAL ELECTIVE		L	T	P	C
								3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*summarize multi resolution analysis and wavelet signal processing*
CLR-2:	*identify the families of wavelets required to apply the transformation to various real time applications*
CLR-3:	*discuss about discrete systems that employs wavelet transformation*
CLR-4:	*analyze various real time applications using filter banks*
CLR-5:	*acquire knowledge on wavelet transforms, types and applications of multiresolution analysis*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*compare the multi resolution analysis for discrete signals*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*summarize the families of wavelets for compression*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*apply Discrete wavelet transform to signals*	*1*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*design filter bank and its structure*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-5:	*apply wavelet transformations for varied applications*	-	-	*2*	*1*	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Multiresolution Analysis	***9 Hour***
Introduction to multi resolution/ multi scale analysis- Time-frequency analysis and wavelets- Piecewise constant approximation- Haar wavelet- Building up the concept of dyadic Multiresolution Analysis (MRA)-Relating dyadic MRA to filter banks-A review of discrete signal processing-Elements of multi rate systems - Two-band filter bank design for dyadic wavelets	
Unit-2 - Families of Wavelets	***9 Hour***
Orthogonal -Biorthogonal wavelets-Daubechies' family of wavelets-Conjugate Quadrature Filter Banks - and their design-Data Compression-Fingerprint compression standards-JPEG-2000 standards-Solving problems	
Unit-3 - Discrete Wavelet Transform	***9 Hour***
Discretization in steps-Discretization of scale -Generalized filter bank-Discretization of translation -Generalized output sampling-Discretization of time/ space (independent variable)-Going from piecewise linear to piecewise polynomial-The class of spline wavelets-A case for infinite impulse response (IIR) filter banks	
Unit-4 - Filter Banks	***9 Hour***
Introduction to Variants of the wavelet transform-Implementational structures-The wave packet transform-Computational efficiency in realizing filter banks -Polyphase components-The lattice structure-Solving Problems-The lifting scheme	
Unit-5 - Signal Processing Applications	***9 Hour***
Transient analysis-Singularity Detection-Biomedical signal processing applications-Efficient signal design and realization-Wavelet based modulation and demodulation-Applications in mathematical approximation-Applications to the solution of some differential equations-Solving Problems -case study image compression using Scilab	

Learning Resources	1. M. Vetterli, J. Kovacevic, "Wavelets and Subband Coding", Prentice Hall, 2007 2. S. Mallat, "A Wavelet Tour of Signal Processing", Academic Press, 2nd ed., 1999	3. Gilbert Strang, Truong Nguyen, "Wavelets and Filter BanksWellesley"Cambridge Press,2nd ed1998. 4. C.S. Burrus, Ramesh A. Gopinath, and Haitao Guo, "Introduction to Wavelets and Wavelet Transforms: A Primer", Prentice Hall, 1997

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr.C. Vimala, SRMIST*
2. *Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr.S. Dhanalakshmi, SRMIST*

Course Code	21ECE241J	**Course Name**	AUDIO AND SPEECH PROCESSING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21ECC204T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*knowledge on audio processing and characteristics of speech signal*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-2:	*know the speech signal analysis in time domain*															
CLR-3:	*identify frequency characteristics of speech signal and know the linear predictive analysis of speech signal*															
CLR-4:	*acquire the fundamental knowledge on acoustic theory of speech production and construct the digital model of speech signal*															
CLR-5:	*identify the ethical issues of elements of music and know about the sound vibrations –pure tones and perception of pitch*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*acquire the basics of audio processing and characteristics of speech*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze the function of feature extraction in speech and audio signal processing using time domain characteristics*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*demonstrate the frequency characteristics of speech signal and the linear predictive analysis of speech*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*apply appropriate digital models for speech signal*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*interpret the time elements of music*	-	-	*2*	-	-	*1*	-	-	-	-	-	-	-	-	-

Unit-1 - Fundamentals in Audio Processing ***12 Hour***

Introduction to Digital audio, Capturing and converting sound, Sampling of sound wave, Audio handling, Normalization, Audio processing, Segmentation, Analysis of window sizing, Visualization, Sound generation, Speech production mechanism-Characteristics of Speech, Speech Understanding

Practice*: Basic operations on speech signals, Fourier transform and magnitude spectrum of speech signal, Cepstrum smoothed magnitude spectrum*

Unit-2 - Speech Signal Analysis in Time Domain ***12 Hour***

Speech signal analysis, Time domain parameters of speech signal, Methods for extracting the parameters- Short time Energy, Short -time Average Magnitude, Short Time Zero crossing Rate (ZCR), The short Time Autocorrelation Function, Silence Discrimination using ZCR and energy, Pitch Period Estimation using Autocorrelation Function

Practice: *Short-term energy of a speech signal, Speech analysis using zero crossing detector, Speech analysis using autocorrelation and Short-time Fourier transform spectrum.*

Unit-3 - Speech Signal analysis in Frequency Domain ***12 Hour***

Short Time Fourier analysis, Filter bank analysis, Homomorphic speech analysis -Homomorphic Systems for Convolution, The Complex Spectrum of Speech, The Homomorphic Vocoder, Formant and Pitch Estimation, Linear Predictive analysis of speech -Introduction, Basic Principles of Linear Predictive analysis of speech, Autocorrelation method, Covariance method, Solution of LPC equations Durbin's Recursive Solution for the Autocorrelation Equations.

Practice: *Linear prediction magnitude spectrum, Estimation of formant frequencies using linear prediction, Estimation of pitch period using Simplified Inverse Filter Tracking Algorithm (SIFT) and harmonic product spectrum*

Unit-4 - Digital Models for Speech Signal	***12 Hour***
Introduction to Acoustic Phonetics, Acoustic theory of speech production-Sound propagation - uniform lossless tube, Effect of losses in the vocal tract, Effect of radiation at the lips, Vocal tract transfer function of vowels, Effect of nasal coupling, Excitation of sound in vocal tract, Digital models for speech Signals ***Practice:*** *Phoneme-level segmentation of speech, Estimation of sound in vocal tract, Sound vibrations*	
Unit-5 - Time Elements in Music	***12 Hour***
Sound vibrations – Pure tones and perception of pitch, Auditory coding in the nervous system, Subjective pitch and role of nervous system, Sound Waves, Acoustic Energy, and the Perception of Loudness- The Loudness Perception Mechanism and Related Processes, Perception of Pitch and Timbre of Musical Tones ***Practice:*** *Feature extraction of speech signal, Speech production mechanism, Study of feature extraction and SVM classifier*	

Learning Resources	1. *Ian McLaughlin, Applied Speech, and audio processing, with MATLAB examples, 1st edition Cambridge University Press, 2009.* 2. *Ben Gold, Nelson Morgan, Dan Ellis, Wiley, Speech, and Audio Signal Processing: Processing and Perception of Speech and Music, 2nd edition. John Wiley & Sons 2011.* 3. *Ken Pohlmann, Principles of Digital Audio, 6th edition., McGraw-Hill, 2007*	4. *Lawrence Rabiner, B.H. Juang, Fundamentals of Speech Recognition, 2nd edition. Prentice-hall, 1993* 5. *A.R. Jayan, Speech and Audio Signal Processing, PHI Learning Pvt. Ltd, 2016.* 6. *Juan G. Roederer, The Physics and Psychophysics of music, An Introduction 4th edition, Springer, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*25%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Mrs.Suganthi Brindha G, SRMIST*
2. *Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr.S. Dhanalakshmi, SRMIST*

Course Code	21ECE242J	**Course Name**	PATTERN RECOGNITION AND NEURAL NETWORKS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*have an insight on pattern recognition*
CLR-2:	*analyze few parameter estimation methods for pattern recognition*
CLR-3:	*acquire knowledge on the fundamental neural networks*
CLR-4:	*apply the neural network recurrence for pattern recognition studies*
CLR-5:	*know the practical applications of neural networks in pattern recognition*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*outline the fundamentals of recognition of patterns, regularities in data and classifiers*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*understand the basic issues in classification of error estimation, such as definitions, test-set error estimation and training-set error estimation*	*2*	*1*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*acquire knowledge on the basics of neuron model and fundamentals on learning algorithms*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*realize the error model and calculate the deviation with back propagation networks*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*identifying the applications of neural networks in the area of pattern recognition*	-	-	*2*	*3*	*3*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Introduction to Pattern Recognition ***12 Hour***

Introduction to Pattern Recognition- Overview of Pattern Classifiers- Bayesian decision making - Bayes Classifier - Bayes Classifier for minimizing Risk-Estimating Bayes Error; Minimax and Neymann-Pearson Classifiers

Practice on *Digitization of analog signals, extract information from image, analysis of a data set with classifiers.*

Unit-2 - Linear Basis Function Models ***12 Hour***

Maximum likelihood and least squares- Sequential learning -The Bias-Variance Decomposition. - Bayesian Linear Regression -Parameter distribution - Predictive distribution - Bayesian Model Comparison -Evaluation of the evidence function - Maximizing the evidence functions- Limitations of Fixed Basis Functions.

Practice on *Bayesian regression, selection of predictive features and clustering methods*

Unit-3 - Introduction to Neural Networks ***12 Hour***

Neuron model- Learning methods- Basic learning rules - Supervised, Unsupervised, and reinforced -Basic learning rules of ANN-Feed-forward Network Functions - Weight-space symmetries -Network Training – Perceptron theory- Parameter optimization -Local quadratic approximation - Use of gradient information -Gradient descent optimization

Practice on *function description with Mc Culloh Pitt, Hebb and Perceptron.*

Unit-4 - ANN for Classification and Regression ***12 Hour***

Hop-field networks, Recurrent and bi-directional associative memories, Boltzmann machine - Back propagation networks – Error Backpropagation- Evaluation of error-function derivatives - Efficiency of backpropagation - Annealing –Travelling salesman problem.

Practice on *Back propagation networks, Hopfield networks and memory associations*

Unit-5 - ANN for Organization and Recognition	***12 Hour***
Self-organizing map - learning algorithm – feature selection -feature map classifier – applications - Architecture of Adaptive Resonance Theory – Pattern matching in ART network - Handwritten digit recognition-character recognition networks ***Practice on*** *orthogonality, character recognition and a mini project*	

Learning Resources	1. *Laurene Fausett, "Fundamentals of Neural Networks: Architecture, Algorithms and Applications", Pearson Education, (reprint) 2006.* 2. *Martin T.Hagan, "Neural network design", Cengage publications, 2010.* 3. *C.M.Bishop, "Neural Networks and Pattern Recognition", Oxford University Press (Indian Edition), 2003.*	4. *R.O.Duda, P.E.Hart and D.G.Stork, "Pattern Classification", John Wiley, 2002* 5. *Freeman J.A. and Skapura B.M., "Neural Networks, Algorithms Applications and Programming Techniques", Addison-Wesely, 1991.* 6. *Kosko B, "Neural Networks and Fuzzy Systems: A dynamical system approach to machine intelligence", Prentice Hall of India, 2009*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*15%*	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr.A. Ruhan Bevi, SRMIST*

Course Code	21ECE340J	Course Name	DIGITAL IMAGE AND VIDEO PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart knowledge on the basic image processing techniques*
CLR-2:	*identify image frequency level filtering and reconstruction techniques*
CLR-3:	*gain knowledge on Image Segmentation and descriptors*
CLR-4:	*educate the basics of video processing*
CLR-5:	*describe video sampling, storage and communication procedures*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire the fundamentals of Image Processing*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*describe the image frequency domain filtering, restoration, and reconstruction*	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	*1*
CO-3:	*construct image segmentation models and know about descriptors extraction*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*interpret the video compression and sampling standards*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*evaluate video sampling and storage techniques*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	*1*

Unit-1 - Fundamentals of Image Processing ***12 Hour***

Elements of visual perception, Image sensing and acquisition, Image sampling and quantization, Relationship between pixels, Image Transforms, Transformation functions, Histogram Processing, Spatial- Smoothing, Sharpening filters

Practice*: Image sampling and quantization, Count black and white pixels in image, Histogram equalization*

Unit-2 - Image Filtering and Reconstruction ***12 Hour***

Filtering in frequency domain - Sampling, Fourier transform of sampled functions, Discrete Fourier Transform, Properties, Image Restoration and Reconstruction - Noise model, Spatial Filtering, noise reduction by frequency domain filtering, Inverse, Wiener, Least Square, Geometric Filtering

Practice*: Frequency domain filtering, Image Reconstruction, Matching Filters*

Unit-3 - Image Segmentation ***12 Hour***

Point, Line, Edge Detection, Thresholding, Region based segmentation, Morphological Watersheds, Motion in image segmentation, Boundary, Region descriptors, Use of principal components

Practice*: Image Segmentation, Region descriptors detection, Extraction of Principal Components*

Unit-4 - Basics of Video Processing ***12 Hour***

Video basics, Time-varying Image formation Models, Spatio Temporal Sampling, Optical flow, General methodologies, Overview of coding systems, Video Compression Standards, Object based video coding

Practice: *Split video into frames, Sampling video signal, Video Compression*

Unit-5 - Video Sampling and Storage ***12 Hour***

Video Sampling and Interpolation, Video Rendering and Assessment, Perceptual criteria for Image Quality Evaluation, Video Storage, Retrieval and Communication

Practice*: Content based image retrieval, Video quality evaluation, video communication networks*

Learning Resources	1. *Gonzalez.R.C & Woods, "Digital Image Processing",. R.E., 3/e, Pearson Education, 2008.* 2. *Bovik, "Handbook of Image & Video Processing", Academic Press, 2000.* 3. *Yao Wang, Jorn Ostermann and Ya Qin Zhang, "Video Processing and Communications", Prentice Hall Publishers, 2002.*	4. *Thanki, Rohit M., Kothari, Ashish M, "Digital Image Processing using SCILAB", Springer* 5. *Mohammad Atique, Amol Bhagat, "Introduction to Digital Signal Processing - Using Matlab and Scilab", Vikas Publishing*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*-*	*15%*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*-*	*20%*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*25%*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*-*	*25%*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*10%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*5%*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Athif Shah, CTO, Abe Technologies, Chennai*	1. *Dr.V. Masilamani, Associate Professor, Computational Engineering, IIIT D&M, Kancheepuram*	1. *Dr.S. Dhanalakshmi, SRM IST*
2. *Mr.A. Vishwanath, Research and Innovation Scientist, Genet.IO.Hyderabad*	2. *Dr.V. Sathiesh Kumar, Assistant Professor, Electronics Department, MIT, Chennai*	2. *Dr.S.Latha,Assistant, SRM IST*

Course Code	21ECE341J	**Course Name**	DSP SYSTEM DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21ECC204T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*summarize the concept of analog to digital conversion*
CLR-2:	*analyze multirate signal processing*
CLR-3:	*explain the architecture of TMS320C54X*
CLR-4:	*gain knowledge on DSP architecture and instruction sets of TMS320C6X*
CLR-5:	*design DSP system for real time applications*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the effect of finite word length and structure realization*	*1*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*apply concepts of multirate signal processing*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-3:	*summarize TMS320C54x architecture*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*acquire in-depth knowledge on DSP architecture and instruction sets of TMS320C6X*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*infer Knowledge on DSP system based design and application*	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - Finite Word Length Effect and Structure Realization ***12 Hour***

Basic Elements of DSP, Advantages and applications of DSP, Sampling of analog signals Sampling theorem, Aliasing and Quantization of continuous amplitude signal, Quantization noise, Errors due to truncation and rounding off, Realization of digital filters - Direct form I realization, Canonical structure Realization

***Practice**: Generation of sequences (functional & random), Correlation, Linear convolution, circular convolution*

Unit-2 - Multirate Signal Processing ***12 Hour***

Introduction to Multirate signal processing, decimation, interpolation, anti-aliasing filter, anti-imaging filter, Sampling rate conversion by a rational factor I/D, Polyphase structure of decimator, Polyphase decimation using z transform, Polyphase structure of interpolator, Polyphase interpolation using z transform, Advantage and applications of multirate DSP, interfacing of digital systems with different sampling rates, Practical Applications of multirate DSP, Sub band coding of speech signals, filter bank

***Practice**: Interpolation, effect of interpolation in frequency domain, decimation, effect of decimation in frequency domain, , design of anti-aliasing filter, design of anti-imaging filter*

Unit-3 - TMS320C54x Architecture ***12 Hour***

Harvard Architecture and Von- Neuman Architecture, Texas Instruments TMS320 Family, TMS320C54x DSP Functional Block Diagram and Explanation, MAC Unit, Pipeline and Parallel Processing, Instruction Set of TMS320C54x, Addressing Modes of TMS320C, Introduction to code composer studio and Procedure to work on ccs using target

***Practice: :** Design of digital FIR Low, High, Band Pass filters using different windows, Design of digital filters using Impulse invariance method, Design of digital filters Bilinear transformation*

Unit-4 - TMS320C6X Architecture ***12 Hour***

Architecture of TMS320C6X , Pipeline CPU, Functional Units, Addressing modes, TMS320C6X Instruction Sets, TMS320C6X Assembly Language Operations, Individual Instruction Descriptions, Arithmetic and logical operations, Memory data operations, Conditional Operations

***Practice:** study of architectural digital signal processor, Arithmetic operations using processor (Addition, Subtraction, Multiplication) - Assembly and C language*

Unit-5 - DSP Applications	***12 Hour***
Dual tone Multi-Frequency (DTMF) Signaling, Software Defined Radio (SDR), QAM Transmitter and QAM Receiver, u-Law for Speech Companding, Acoustic Direction Tracker, Multirate Filter, Neural Network for Signal Recognition, PID Controller, Four-Channel Multiplexer for Fast Data Acquisition, Video Line Rate Analysis, MP3 Player, DSP Automotive application. ***Practice**: Linear and circular convolution using DSP processor, waveform generation using DSP processor.*	

Learning Resources	*1. B Venkataramani, M Bhaskar, "Digital Signal Processors: Architecture, Programming and Applications", TMH Publishers, 2nd edition, 2017* *2. Paulo S. R. DinizEduardo A. B. da Silva and Sergio L. Netto, "Digital Signal Processing System Analysis and Design", Cambridge University Press, 2nd Edition.2010* *3. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", Pearson Education, 4th edition, 2007*	*4. RulphChassaing - "DSP Applications Using C and the TMS320C6x DSK" John Wiley & Sons, Inc. 2002.* *5. Nasser Kehtarnavaz, "Real-Time Digital Signal Processing Based on the TMS320C6000", Newnes, 2005.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	-	15%	15%	-
Level 2	*Understand*	25%	-	-	20%	25%	-
Level 3	*Apply*	30%	-	-	25%	30%	-
Level 4	*Analyze*	30%	-	-	25%	30%	-
Level 5	*Evaluate*	-	-	-	15%	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Bombardier Transportation, Ahmedabad, kumaranuj.anii@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. Damodar Panigrahy, SRMIST*
2. Mr. Hariharasudhan - Johnson Controls, Pune, hariharasudhan.v@jci.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. S. Dhanalakshmi, SRMIST*

Course Code	21ECE366T	**Course Name**	DIGITAL INTEGRATED CIRCUITS AND SYNTHESIS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the fundamentals of combinational logic design*
CLR-2:	*illustrate the basics of sequential logic design*
CLR-3:	*introduce complex design and understand the finite state machines*
CLR-4:	*understand the concept of PLD based designs*
CLR-5:	*introduce the concepts of ASICs and SOC*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the various modelling of combinational logic design*	*3*	2	-	-	2	-	-	-	-	-	-	-	2	-	-
CO-2:	*explain the concepts of sequential logic design*	-	2	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*interpret on complex designs and improve the design performance of FSM*	*3*	-	*3*	*1*	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*illustrate the various FGPA based designs*	*3*	-	*3*	*1*	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*develop the concepts of RTL synthesis and optimization techniques*	-	2	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Combinational Logic Design ***9 Hour***

Evolution of Logic Design, Integrated Circuit Design and Methodologies, Verilog HDL, Verilog Design Description. Verilog Arithmetic Operators, Verilog Logical Operators, Verilog Equality and Inequality Operators. Multiplexers, Decoders, Encoders.

Unit-2 - Sequential Logic Design ***9 Hour***

Sequential Logic Design -Sequential Logic, Flip-Flop, Synchronous and Asynchronous Reset. Design of JK Flip-flop, D Flip-flop and T Flip-flop, Synchronous Counters, Shift Register. Timing and Performance Evaluation, Asynchronous Counter Design, Memory Modules and Design, Sequential Design Guidelines -Use of Blocking Assignments, Nonblocking Assignments, Use of If-Else Versus Case Statements, Internally Generated Clocks, Use of Pipelining in Design.

Unit-3 - Complex Designs Using Verilog RTL ***9 Hour***

ALU Design, Functions and Tasks, Parity Generators and Detectors. Design of parity generators, Barrel Shifters, Finite State Machines, Moore versus Mealy Machines. Design of FSM, Encoding Styles, Sequence Detectors Using FSMs, Improving the Design Performance for FSMs.

Unit-4 - Simulation Concepts and PLD-Based Designs ***9 Hour***

Simulation for Blocking and Non-blocking Assignments, Blocking Assignments with Inter-assignment Delays, Blocking Assignments with Intra-assignment Delays, Nonblocking Assignments with Inter-assignment Delays, Nonblocking Assignments with Intra-assignment Delays. Introduction to PLD, FPGA as Programmable ASIC. FPGA Design Flow.

Unit-5 - ASIC RTL Synthesis ***9 Hour***

Full-Custom ASIC, Standard Cell ASIC, Gate Array ASIC. Case study: Types of ASICs, ASIC Design Flow, ASIC Synthesis, Synthesis Optimization Techniques. System on Chip (SOC) Design, SOC Architecture, SOC Design Flow, SOC Design Challenges, SOC Design Blocks.

Learning Resources	1. *Jan M.Rabaey, Digital Integrated Circuits: A design perspective, Pearson education, 2016* 2. *Vaibbhav Taraate, Digital Logic Design Using Verilog Coding and RTL Synthesis, Springer , 2016*	3. *Samir Palnitkar , Verilog HDL : A guide to digital design and synthesis, Prentice Hall PTR, Second edition,2003* 4. *Sunggu lee, Advanced Digital Logic Design Using VHDL, State Machines, and Synthesis for FPGA's, CL- Engineering, 2005*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *KVN Savan kumar savan.k.k.v.n@intel.com*	1. *Dr. J. Ramesh, Professor, PSG College of Tech , jr.ece@psgtech.ac.in*	1. *Dr.K. Vijayan, SRMIST*

Course Code	21ECE440T	Course Name	ADAPTIVE SIGNAL PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC204T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Program Outcomes (PO)												Program Specific Outcomes		
CLR-1:	*acquire knowledge about the random processes*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*describe the various applications of adaptive filters*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*analyze the variants of Least Mean Square algorithm*															
CLR-4:	*gain knowledge on data selective adaptive filtering and its types*															
CLR-5:	*compile the types of periodogram for spectral analysis*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*identify the different random processes*	3	2	-	-	-	-	-	-	-	-	-	-	-	1	-
CO-2:	*construct adaptive filters for various applications*	-	3	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*analyze the variants of Least Mean Square algorithm*	-	2	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*describe the data selective adaptive filtering and its types*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	1
CO-5:	*illustrate Spectral analysis using periodogram*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	1

Unit-1 - Introduction to Random Process **9 Hour**

Distribution and density functions, moments, Independent, Uncorrelated and orthogonal random variables, Vector-space representation of random variables, Schwarz Inequality, Orthogonality principle in estimation, Central Limit theorem, Random processes, Wide-Sense Stationary processes, Autocorrelation and autocovariance functions, Spectral representation of random signals, Wiener Khinchin theorem, Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance, Innovation process and whitening filter, Random signal modelling: MA(q), AR(p) , ARMA(p,q) models

Unit-2 - Adaptive Filters **9 Hour**

Principle and application, Steepest descent algorithm, Convergence characteristics, LMS algorithm, Convergence, Excess Mean Square Error, Leaky LMS algorithm, Application of adaptive filters, RLS algorithm, Matrix inversion Lemma, Initialization, Tracking of nonstationarity,

***Case Study**- Applications of adaptive signal processing: Noise Cancellation*

Unit-3 - Least Mean Square Algorithm and its Variants **9 Hour**

LMS algorithm in real-time applications, sign-LMS: Sign Regressor, Sign Error and Sign LMS, Normalized LMS algorithm, Block LMS - FFT based implementation of the block LMS Algorithm, Variable Step Size (VSS) LMS and NLMS algorithm, Self-correcting LMS algorithm, Affine Projection algorithm vs LMS algorithm,

***Case study**-application using VSS algorithm*

Unit-4 - Data Selective Adaptive Filtering **9 Hour**

Set membership LMS, Set membership NLMS, Set membership binormalised LMS, Computational complexity, Partial update adaptive filters,

***Case Study**: Application of data selective filters for system identification, echo cancellation.*

Unit-5 - Spectral Analysis	***9 Hour***
Estimated autocorrelation function, Periodogram, Averaging the periodogram (Bartlett Method), Welch modification, Blackman, and Tukey method of smoothing periodogram, Parametric method, AR(p) spectral estimation and detection of Harmonic signals. ***Case Study:*** *Applications of adaptive signal processing: System identification, channel equalization*	

Learning Resources	1. *S. Haykin, "Adaptive Filter Theory", Prentice-Hall, 4-th edition, 2001.* 2. *Ali H. Sayed, "Fundamentals of Adaptive Filtering", Jo10hn Wiley, 2003.* 3. *D. Manolakis, V. Ingle, S. Kogan, "Statistical and Adaptive Signal Processing: Spectral Estimation, Signal Modeling, Adaptive Filtering and Array Processing", McGraw Hill, 1999.*	4. *B. Widrow, S. Stearns, "Adaptive Signal Processing", Prentice-Hall, 1985* 5. *Monson H. Hayes, "Statistical Digital Signal Processing and Modeling", Edition: 1st, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	30%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	20%	-	25%	-
Level 4	*Analyze*	20%	-	20%	-	25%	-
Level 5	*Evaluate*	-	-	20%	-	10%	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Athif Shah, CTO, Abe Technologies, Chennai*	1. *Dr.V.Masilamani, Associate Professor, Computational Engineering, IIIT D&M, Kancheepuram*	1. *Dr.S. Dhanalakshmi, SRMIST*
2. *Mr.A.Vishwanath, Research and Innovation Scientist, Genet.IO.Hyderabad*	2. *Dr.V.Sathiesh Kumar, Assistant Professor, Electronics Department, MIT, Chennai*	2. *Mrs. S. Hannah Pauline, SRMIST*

Course Code	21ECE441T	**Course Name**	MACHINE PERCEPTION WITH COGNITION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*understand the concepts of image processing and color fundamentals*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*gain Knowledge on the various machine perception concepts*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*acquire knowledge on filter texture analysis of an image*															
CLR-4:	*learn the relation between the templates to match the image requirements*															
CLR-5:	*describe the practical applications of computer vision in images understanding*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*demonstrate the fundamentals of image and color models*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*acquire the basic machine perception concepts*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*analyze the various textures for image synthesis*	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	3	-
CO-4:	*explain the objects based on template relations*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*apply the concept of image recognition*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Image Formation and Image Models **9 Hour**

The human Eye - Introduction to image formation- Image models- Cameras- Pinhole camera, Camera with lenses- Camera models- Sample programs for reading images, understanding pixel- Shadows and shading-Color -Human color perception, Representing color

Unit-2 - Machine Perception **9 Hour**

Machine Perception- Line drawing, Object recognition and Scene analysis, Concept formation- Machine perception- Sensory object, Visual machine perception- Machine Understanding-Case study on completion and transparency problem- Shape classes- Perceptual operators- The Basic 3D object classes

Unit-3 - Filtering and Texture Analysis Techniques **9 Hour**

Linear filters and convolution-Sampling and Aliasing-Filters as Templates- Normalized correlation and finding patterns-Gaussian pyramid- Detecting edges- Using Laplacian to detect edges, Gradient based edge detection- Representing texture-Analysis using Laplacian pyramid- Synthesizing textures for rendering-Shape from Texture

Unit-4 - Recognition by Relations Between Templates **9 Hour**

Finding templates Using classifiers- Methods for building classifiers-Building classifiers from class Histogram-Feature selection- Finding objects by Voting on relations between templates- Relational reasoning using probabilistic models and search- Using classifiers to prune search- Hidden Markov Models- case study on finding people with Hidden Markov Model

Unit-5 - Recognition **9 Hour**

Object Detection- Face Recognition- Instance recognition- Category recognition- 3D shape models of face surveillance Foreground separation- Background separation- Particle filter- Champer matching, tracking and occlusions

Learning Resources	1. *E. R. Davies, "Computer & Machine Vision", Fourth Edition, Academic Press, 2012* 2. *Zbigniew Les, Magdalena Les, "Machine Understanding:Machine Perception and Machine Perception MU", Springer, 2020* 3. *Szeliski, Richard, "Computer vision: algorithms and applications", Springer Nature, 2022.* 4. *Solem, Jan Erik, "Programming Computer Vision with Python: Tools and algorithms for analyzing images", O'Reilly Media, Inc., 2012.*	5. *Mark Nixon and Alberto S. Aquado, "Feature Extraction & Image Processing for Computer Vision", Third Edition, Academic Press, 2012* 6. *D. L. Baggio et al., "Mastering OpenCV with Practical Computer Vision Projects", Packt Publishing, 2012*

Learning Assessment							
		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Formative CLA-1 Average of unit test (50%)*		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr.S. Vasanthadev Suryakala, SRMIST*
2. *Mr. Hariharasudhan, Johnson Controls, Pune, hariharasudhan.v@jci.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr. S. Dhanalakshmi, SRMIST*

Course Code	21ECE442T	**Course Name**	MULTIMEDIA COMPRESSION TECHNIQUES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*summarize on probability models and introducing the elements of coding*
CLR-2:	*implement lossless compression*
CLR-3:	*discover various types of lossy data compression*
CLR-4:	*apply the vector quantization techniques*
CLR-5:	*carry out the transform coding and incorporate it in various standards*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the principles of compression lucidly*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*evaluate the different types of lossless compression*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the various techniques towards lossy image compression*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*analyze the methods available in vector quantization*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*1*	-
CO-5:	*examine transform coding for data compression and applications*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Principles of Compression ***9 Hour***

Discrete memoryless information source, Kraft inequality, Optimal codes, Source coding theorem-Entropy joint entropy and conditional entropy, Relative entropy, Mutual information, Chain rules, Data-processing inequality, Fano's inequality symmetric channels, Properties of channel capacity, jointly typical sequences, Channel coding theorem, Fano's inequality.

Unit-2 - Lossless Compression ***9 Hour***

Mathematical preliminaries for lossless compression, Huffman coding, Optimality of Huffman codes, Extended Huffman coding, Adaptive Huffman coding, Arithmetic coding, Adaptive arithmetic coding, Run length coding, Dictionary techniques, Applications Lempel- Ziv coding, Predictive coding, Burrows Wheeler transform,

Unit-3 - Lossy Compression ***9 Hour***

Rate Distortion (RD) function, Properties of RD, Calculation of RD for the binary source and the Gaussian source, RD theorem, Converse of the RD theorem, Quantization problem, Scalar quantization- Uniform quantizer, Trellis coded quantization transforms, Adaptive Quantization, Non-uniform quantization, Dynamic Markov compression, Entropy coded quantization

Unit-4 - Vector Quantization ***9 Hour***

Vector Quantization (VQ), LBG algorithm, Tree structured VQ, Structured VQ, Variations of VQ, Gain shape VQ, Mean removed VQ, Classified VQ, Multistage VQ, Adaptive VQ, Basic algorithm, Prediction in DPCM, Adaptive DPCM, Delta Modulation

Unit-5 -Transform Coding and Standards ***9 Hour***

Transform coding introduction, Karhunen-Loeve transform, Discrete cosine transform, discrete Walsh Hadamard transform, Quantization and coding of transform coefficients, Image compression, JPEG, SPIHT-Analysis/Synthesis Schemes, JPEG 2000- Analysis/Synthesis Schemes, Audio coding:- MPEG audio coding

Learning Resources	1. *Khalid Sayood, "Introduction to Data Compression", Fifth edition,Morgan Kaufmann Publishers, 2017* 2. *N. Jayant and P. Noll, "Digital Coding of Waveforms: Principles and Applications to Speech and Video", Prentice Hall, USA, 1984.* 3. *Ze. Nian Li and M. S. Drew, "Fundamentals of Multimedia", Second edition, Pearson Education (Asia) Pvt. Ltd., 2004.*	4. *Yun-Qing Shi, Huifang Sun, "Image and Video Compression for Multimedia Engineering Fundamentals, Algorithms, and Standards", Third edition, CRC Press, 2021.* 5. *D. Salomon, "Handbook of Data Compression", Fifth Edition, Springer-Verlag London Limited 2010* 6. *M. Rabbani: "Digital image compression techniques", First Edition, SPIE Press Book, 1991*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. Diwakar R. Marur, SRMIST*

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(Syllabi for Electronic and Communication Engineering w/s in Cyber Physical System Programme Courses)

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(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

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Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21ECE250J	**Course Name**	SENSORS AND ACTUATORS FOR CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn sensor basic working*
CLR-2:	*understand sensor design for embedded applications*
CLR-3:	*design optimal real time models and learn the uncertainties*
CLR-4:	*understand the Interface of Sensor System Design and Implementation*
CLR-5:	*understand the functions of actuators*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the overall sensor characteristics required to make energy conversions*	*3*	-	-	-	-	-	2	-	-	-	-	2	*3*	-	-
CO-2:	*summarize the functionalities of various Optical Sensors*	*3*	-	-	-	-	-	-	-	-	-	-	2	-	*3*	-
CO-3:	*implement security, surveillance, energy management systems with minimal supervision*	-	*2*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*explore the various chemical sensors and sensing systems for miniaturized systems for mobile applications*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	*2*
CO-5:	*explain the functionalities of various types of actuators*	*3*	-	-	-	-	-	2	-	-	-	-	2	*3*	-	-

Unit-1 - Sensor Basic Blocks	***12 Hour***
Data Acquisition, Sensors, Signals, and Systems - Sensor Classification - Units of Measurements - Transfer Functions – Mathematical Models – Functional Approximations - Linear Regression, Polynomial Approximations - Piecewise Linear Approximations - Spline Interpolation, Multidimensional Transfer Functions - Calibration, Computation of Parameters – Iterative Computation of Stimulus	
Unit-2 - Optical Sensing	***12 Hour***
Optical Units - Effects of Optical Radiations - Photo Conducting Sensors, Photoelectric Sensors - Optical Position Sensor - Charge Coupled Device (CCD) Sensors and Detectors - Thermopile PIR - Pyro electric sensors - Active Far Infrared (AFIR) Sensors	
Unit-3 - Human Detectors	***12 Hour***
Ultrasonic Detectors - Microwave Motion Detectors - Capacitive Occupancy Detectors - Triboelectric Detectors - Pressure-Gradient Sensors – Gesture sensing – Tactile sensors	
Unit-4 - Chemical and Biological Sensors	***12 Hour***
Chemical Sensor and its characteristics – Biochemical Sensors – Electrochemical Sensors – Potentiometric Sensors – Metal Oxide Semiconductor (MOS)Chemical Sensors – Color Change sensors – Electronic Nose and Tongue	
Unit-5 - Actuators	***12 Hour***
Basic elements of Sensor- Actuator system – Classification of Actuators and other classification methods - Capacitive Actuators – Ultrasonic Sensors and Actuators - Magneto strictive Sensors and Actuators - Radiation Sensors and Actuators: Antenna as an Actuators	

Learning Resources	1. *Phillip A. Laplante, "Handbook of Modern Sensors – Physics Design and Applications", 5th Edition, Springer Publication, 2015.*	2. *Nathan Ida, "Sensors, Actuators, and their Interfaces - A Multidisciplinary Introduction," 1st Edition, SciTech Publishing, Edison, NJ*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	25%	-	-	15%	15%	-
Level 2	*Understand*	25%	-	-	20%	25%	-
Level 3	*Apply*	30%	-	-	25%	30%	-
Level 4	*Analyze*	20%	-	-	25%	30%	-
Level 5	*Evaluate*	-	-	-	10%	-	-
Level 6	*Create*	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah Chairman, Abe, Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. M. Sangeetha, SRMIST*
2. *Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr. P. Vijayakumar, SRMIST*

Course Code	21ECE251T	**Course Name**	EMBEDDED AND IMPLANTED DEVICES FOR CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*understand the various embedded processors and memory architecture*															
CLR-2:	*identify suitable hardware and software available to develop a CPS*															
CLR-3:	*study the multitasking and threading techniques for embedded processors*															
CLR-4:	*analyze the implementation scheme of implantable CPS for health care application*															
CLR-5:	*use CPS for energy management and design a CPS framework for real time application*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*identify suitable embedded processor and memory for cyber physical system applications*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*select optimal hardware and software for cyber physical system model*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*efficiently use the embedded processor resources*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*develop implantable CPS model for health care application*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*develop implantable CPS model for various real-world problems*	*1*	*2*	*3*	-	*2*	-	-	*1*	*2*	-	-	*2*	-	-	*3*

Unit-1 - Embedded Processors	***9 Hour***
Types of Processors - Microcontrollers, DSP Processors, Graphics Processors, Parallelism- Parallelism vs Concurrency, Pipelining, Instruction-Level Parallelism, Multicore Architectures, Memory Architectures - Memory Technologies, Memory Hierarchy, Memory Models.	
Unit-2 - Input and Output Hardware and Software	***9 Hour***
I/O Hardware - Pulse Width Modulation, General-Purpose Digital I/O, Serial Interfaces, Parallel Interfaces, and Buses, Sequential Software in a Concurrent World- Interrupts and Exceptions, Timers, Atomicity, Interrupt Controllers, Modelling Interrupts.	
Unit-3 - Multitasking and Scheduling	***9 Hour***
Multitasking -Threads, Creating Threads, Implementing Threads, Mutual Exclusion, Deadlock, Memory Consistency Models, The Problem with Threads, Processes and Message Passing, Scheduling - Basics Of Scheduling, Scheduling Decisions, Task Models, Comparing Schedulers, Implementation of A Scheduler, Rate Monotonic Scheduling, Earliest Deadline First, Scheduling and Mutual Exclusion, Multiprocessor Scheduling	
Unit-4 - Implanted Cyber-Physical Systems	***9 Hour***
Medical Cyber-Physical Systems - System Description and Operational Scenarios, Key Design Drivers and Quality Attributes- Trends, Quality Attributes and Challenges of The MCPS Domain, On-Demand Medical Devices and Assured Safety, Smart Alarms and Clinical Decision Support Systems, Closed-Loop System, Energy Cyber-Physical Systems - System Description and Operational Scenarios, Key Design Drivers and Quality Attributes , Cyber Paradigm for Sustainable SEES, Practitioners' Implications.	
Unit-5 - Human-in-the-Loop Cyber Physical Systems	***9 Hour***
Theory of HiTLCPSS - Data Acquisition, Humans as Sets of Sensors, Humans as Communication Nodes, State Inference- Human nature, Humans as Processing Nodes, Actuation, Technologies for Supporting HiTLCPS, HiTL In Healthcare, Social Networking.	

Learning Resources	*1. E. A. Lee And S. A. Seshia, Introduction to Embedded Systems - A Cyber-Physical Systems Approach, Second Edition, Mit Press, 2017.* *2. Houbing Song Danda Rawat Sabina Jeschke Christian Brecher, Cyber-Physical Systems Foundations, Principles And Applications, , 1st Edition, Academic Press, 2016* *3. Raj Rajkumar, Dionisio De Niz, Mark Klein, Cyber-Physical Systems, Pearson Education, Inc.2017,* *4. David Nunes, Jorge Sá Silva, Fernando Boavida, A Practical Introduction to Human-In-The-Loop Cyber-Physical Systems, Johnwiley & Sons Ltd, 2018.*	*5. Raj Kamal, Internet of Things, Mcgraw Hill Education; First Edition, 2017.* *6. Edward Ashford Lee, Sanjit Arunkumar Seshia, Introduction to Embedded Systems - A Cyber Physical Systems Approach - Second Edition, Lulu Enterprises Incorporated, 2014* *7. Hamid R. Arabnia, Leonidas Deligiannidis, Fernando G. Tinetti, Embedded Systems, Cyber-Physical Systems, And Applications, The 2017 Worldcomp International Conference Proceedings, Csrea, 2018*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*20%*	*-*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Athif Shah Chairman, Abe, Semiconductor, abechennai@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr.M. Sangeetha, SRMIST*
2. Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Mr. T. Saminathan, SRMIST*

Course Code	21ECE252J	**Course Name**	CYBER PHYSICAL CONTROL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the basics and advanced concepts of control systems*
CLR-2:	*impart knowledge about the industrial controllers process and their instrumentation*
CLR-3:	*comprehend basic symbology and process control elements and techniques*
CLR-4:	*know about Industrial standards and methods for calibration and controller tuning*
CLR-5:	*acquire knowledge on Control systems networking*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret mathematical equations of control systems and their stability*	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze instrumentation process control instrumentation and various control flow*	3	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*illustrate optimal process control methods*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*evaluate Industrial standards and methods for calibration of industrial instrumentation*	-	3	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*explore Industrial networking HART protocols*	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Control System ***12 Hour***

Elements of Open- and Closed-Loop Systems -Feedback Control-Feedforward control, Transfer function for SISO, MISO, SIMO system, poles and zeros of a transfer function, Impulse response and step response, Controller operation: control modes, ON-OFF control, Proportional control of heating system, Proportional integral control, Time proportioning control, Time proportioning circuit, Thermal systems: Heat Transfer system, Thermometer, Pneumatic system.

Case Study *- An arbitrary input time response of Control system, Pole, and Zeros Map of a system*

Unit-2 - Industrial Process Techniques and Instrumentation ***12 Hour***

Batch Processes-Batch Processes Control Requirements- -Continuous Processes Control Requirements-Measurement Devices (Sensors): Dynamic, Static- Feedback Loop Interface Instruments -Block diagram of a closed-loop automated system-Transmitters, Transducers-Monitoring Instruments: Indicators, Alarms, Recorders-Manipulation Devices (The Final Control Element): The Solenoid Valve, DC and AC Motors, The Control Valve-Instrumentation Symbology-General Instrument Symbols-Tag Numbers Line Symbols-Valve and Actuator Symbols-Reading a Single Loop-Information Block.

Case Study- *Closed loop control system, Delay time, Rise time, Peak time and Peak overshoot of Control system*

Unit-3 - Process-Control Methods ***12 Hour***

Need of Controllers-Open-Loop Control-Closed-Loop Control-Process Behavior-Selecting a Controller-On-Off Control-Continuous Control, Proportional Mode-Integral Mode, Derivative Mode-Advanced Control Techniques-Cascade Control--Feed-Forward Control-Ratio Control- Adaptive Control-Pneumatic Controllers- Panel-Mounted Controllers-Personal Computers-Programmable Logic Controllers-Distributed Control Systems (DCS).

Case Study- *SISO system model, MIMO Control system*

Unit-4 - Industrial Standards and Methods for Calibration and Controller Tuning	***12 Hour***
Instrument Calibration and Controller Tuning-Reasons for Performing Calibrations-Calibration Preparation-Standard Calibration Procedure-Five-Point Calibration Procedure-Process Calibrators-Sensor Calibration-Transmitter Calibration-Tuning the Controller-Trial-and-Error Tuning Method-Ziegler-Nichols Tuning Methods- Ziegler-Nichols Continuous-Cycling Method-Ziegler-Nichols Reaction-Curve Tuning Method-Controller Autotuning. ***Case Study****- DC motor control using PID controller, tuning a PID Controller Using the Ziegler-Nichols Method*	
Unit-5 - Industrial Networking	***12 Hour***
Hierarchy of Industrial Networks, Network Topologies, Network Backbones: Hubs, Switches, Bridges, Gateways. Network Communication Standards- Fieldbus Networks: Modbus, HART. ***Case Study-*** *Tuning system controller using Simulink*	

Learning Resources	1. *Industrial Automated Systems: Instrumentation and Motion Control, Terry Bartelt, SBN-13: 978-1-4354-8888-5* 2. *Nagrath I.J and Gopal M, "Control Systems Engineering", New Age Publishers, 5th ed 2009* 3. *S. Hasan Saeed, "Automatic Control Systems", S K Kataria and sons, 2013 edition*	4. *Frank Petruzella. D, "Programmable Logic Controllers", Tata McGraw Hill Third Edition, 2010* 5. *Bolton. W, "Programmable Logic Controllers" Fifth Edition, Elsevier Newnes, 2009.* 6. *Michael Lucas, "Distributed Control Systems", Van Nostrand Reinhold Co., 1986.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	25%	-	-	20%	15%	-
Level 2	Understand	20%	-	-	15%	20%	-
Level 3	Apply	15%	-	-	25%	25%	-
Level 4	Analyze	20%	-	-	25%	20%	-
Level 5	Evaluate	10%	-	-	10%	10%	-
Level 6	Create	10%	-	-	5%	10%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com*	1. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	1. *Dr. K. Vadivukkarasi, SRMIST*

								L	T	P	C
Course Code	21ECE350T	**Course Name**	REAL TIME CYBER PHYSICAL SYSTEM			**Course Category**	E	PROFESSIONAL ELECTIVE			
								3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the process, model and compositions of real time cyber physical systems*
CLR-2:	*identify the software architectures and design components of real time cyber physical systems*
CLR-3:	*create insights to the sensor networking technologies with real time cyber physical systems*
CLR-4:	*analyze the concepts of Ubiquitous Computing in cyber physical systems*
CLR-5:	*use Cyber physical systems for further new application and developments*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement real time cyber physical system for engineering applications*	-	-	-	-	-	-	3	-	-	-	-	2	-	3	-
CO-2:	*design software architectures and schedulers for real time cyber physical model*	-	-	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-3:	*analyze sensor networking technologies for real time cyber physical systems*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*apply the CPS model to replace older existing technology models*	-	-	-	-	-	-	3	-	-	-	-	-	-	-	-
CO-5:	*incorporate the concepts of cyber physical systems in real time applications*	-	-	3	-	-	-	-	-	-	-	-	-	-	3	-

Unit-1 - Introduction to Real Time Systems	***9 Hour***
Overview Of Embedded Systems, Examples Of Embedded Systems, Soft Real-Time Systems, Hard Real-Time Systems, Spectrum Of Real-Time Systems, Examples Of Real Time Systems, Case Study: Real Time Systems, Introduction To Cross-Platform Development, Hardware Architecture, Software Development: Software Design, System Programming Language C/C++, Build Target Images, Build Target Images, ***Case Study:*** *Building A QNX Image, Transfer Executable File Object to Target, Integrated Testing On Target, System Production*	
Unit-2 - Software Architectures for Real Time Systems, Real Time Scheduling and Sharing	***9 Hour***
Real-Time Tasks, Round-Robin Architecture, Round Robin with Interrupts, Queue-Based Architecture, Real-Time Scheduling: Clock-Driven Approach, Real-Time Scheduling: Rate-Monotonic Approach, Real-Time Scheduling: Sporadic Server, Resource Sharing: Shared Variables, Shared Memory, Semaphore, Mutex, Condition Variable	
Unit-3 - CPS Architectural Design, Data Management and Routing with WSN Technologies	***9 Hour***
Wireless Sensor Networks, Distinguishing WSN, MANET, M2M, and CPS, Cyber-Physical System Design challenges, Cyber-Physical Systems architecture, The role of WSN technologies in CPSs, Towards a new CPS Architecture, Data management: WSN Vs. WSN-CPS, Data management Activities, Cyber-Physical Cloud Computing: Opportunities and Challenges, Design challenges and issues for routing in WSN within the context Of CPS, Routing protocols in WSNs for CPSs, Future directions of routing protocols in WSN for CPS, ***Case Study****: WSN-CPS Applications*	
Unit-4 - Computing Fundamentals in Cyber Physical Systems	***9 Hour***
Ubiquitous Computing History to Date, Ubiquitous Computing Fundamentals, Smart Devices: Components and Services, Tagging, Sensing, And Controlling, Autonomous Systems in Ubiquitous Computing, ***Case Study****: Robot Manipulator, Introduction to Systems Engineering, Introduction to Software Engineering, V-Model, Agile Software Development Methodology, Comparison Of The V-Model And The Agile Software Development Methodology, Requirements in Software Design in Cyber-Physical Systems, Maritime Area Case Studies*	

Unit-5 - Real Time CPS Applications and Case Studies	***9 Hour***
Cyber-Physical Systems Applications: Communication, Consumer Interaction, Energy, Infrastructure, Health Care, Manufacturing, Military, Robotics, Transportation, Smart Cities and the Internet of Everything, Medical Cyber-Physical Systems: Introduction, Background and Related Works, Technical Components, Towards Cognitive Prostheses, Challenges and Opportunities, Mobile WSN-CPS Applications, Smart Space Systems, Emergency Response Systems, Human Activity Inference, Smart Factory, ***Case Study:*** *Cyber-Physical Vehicle Tracking System*	

Learning Resources	1. *Kuodi Jain-Real Time Systems , 1st edition, Intech Open Publishing, 2015* 2. *Xiaocong Fan- Real-Time Embedded Systems Design Principles and Engineering Practices, 1 st Edition, Newnes Publications, 2016*	3. *Sherali Zeadally and Nafaaˆ Jabeur- Cyber-Physical System Design with Sensor Networking Technologies, 1st Edition, IEEE Design & Test, 2017* 4. *Dietmar P.F. Moller- Guide to Computing Fundamentals in Cyber-Physical Systems, 2nd edition, Springer Publications, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*25%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*20%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Athif Shah,Chairman,Abe Semiconductor, abechennai@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. M. Sangeetha, SRMIST*
2. Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com	*2 Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. V. Padmajothi, SRMIST*

Course Code	21ECE351T	**Course Name**	UNSUPERVISED INTELLIGENCE IN CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learning of unsupervised intelligence algorithms in cyber physical system*
CLR-2:	*understand the working of model based reinforcement learning*
CLR-3:	*learn with case study about reinforcement learning*
CLR-4:	*use of python programming for reinforcement learning*
CLR-5:	*unsupervised learning using SCIKIT learner, tensor flow and KERAS, Gain overall understand of the cyber intelligent systems for real world applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*ability to understand reinforcement learning and its use for intelligence*	-	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-
CO-2:	*able to design intelligent systems using cyber security standards*	-	-	*2*	-	-	*3*	-	-	-	-	-	-		-	-
CO-3:	*implement different practical self learning systems with minimal supervision*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*develop deep reinforcement learning for designing cyber physical system*	-	-	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-
CO-5:	*come up with cost effective, reliable, robust and feasible designs for real world problems, Design and implement real time systems and address the problems and limitations*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Reinforcement Learning and CPS ***9 Hour***

overview of reinforcement learning, comparison of different reinforcement learning methods, examples of different reinforcement learning methods, applications of different reinforcement learning methods, history of reinforcement learning, history of reinforcement learning, simulation tool kits for reinforcement learning, simulation tool kit for reinforcement learning, overview of cyber physical system, examples of cyber physical systems, cyber security-introduction, cyber security examples, cyber security standards, reinforcement learning problems, multi armed bandit problem, contextual bandit problem, reinforce learning problem

Unit-2 - Model Based Reinforcement Learning ***9 Hour***

Model based reinforcement learning introduction, model free reinforcement learning, model based reinforcement learning principles, working and applications, dynamic programming, dynamic programming principles & applications, partially observable Markov decision process, partially observable Markov decision process – architecture, partially observable Markov decision process – working & applications, continuous observable Markov decision process – working & applications, reinforcement learning predication analysis, reinforcement learning control methods, reinforcement learning advanced algorithm, reinforcement learning advanced algorithm examples, reinforcement learning advanced algorithm applications

Unit-3 - Deep Reinforcement Learning & Case Study ***9 Hour***

Deep reinforcement learning introduction, deep reinforcement learning examples, deep reinforcement learning working principles, deep reinforcement learning mathematical modelling, deep reinforcement learning value function, deep reinforcement learning value function tools, deep reinforcement learning value policy tools, reinforcement learning for cyber security, reinforcement learning for cyber security – examples, reinforcement learning for cyber security – architectures, reinforcement learning for cyber security – architectures, reinforcement learning for cyber security – system function, case study: online cyber attack detection in smart grid –introduction and application, case study: online cyber attack detection in smart grid –system design, case study: online cyber attack detection in smart grid –working principle, case study: online cyber attack detection in smart grid –system model, case study: online cyber attack detection in smart grid –state estimation

Unit-4 - Python Programming for Reinforcement Learning	***9 Hour***
introduction to reinforcement learning using python, introduction to reinforcement learning libraries used, introduction to reinforcement learning set up of tools, elements of reinforcement learning, agent environment interface, types of reinforcement environment, reinforcement environment platforms, reinforcement environment platform call function, getting started with OpenAI and TensorFlow, setting up your machine for open ai and tensor flow, OpenAI gym, OpenAI universe, TensorFlow, the Markov chain and Markov process, Markov decision process, the bellman equation, optimality, solving the bellman equation.	
Unit-5 - Unsupervised Learning Using Scikit-Learner, Tensorflow and Keras	***9 Hour***
Unsupervised learning using scikit-learn, dimensionality reduction, the motivation for dimensionality reduction, dimensionality reduction algorithms, principal component analysis, singular value decomposition, dictionary learning, independent component analysis, unsupervised learning using tensor flow, Keras- auto encoders, auto encoder: the encoder and the decoder, under complete auto encoder, over complete auto encoders, dense vs. sparse autoencoders, denoising autoencoder, variational autoencoder, hands-on with autoencoder, hands-on with autoencoder	

Learning Resources	*1. Chong Li, Meikang Qiu, Reinforcement Learning for Cyber-Physical Systems and Cybersecurity Case Studies, 1st Edition, CRC Press.*	*2. Sudharsan Ravichandiran, Hands-On Reinforcement Learning with Python, 2nd Edition, Packet Publishing, 2018.* *3. Ankur A. Patel, Hands-On Unsupervised Learning Using Python, 1st Edition, O'Reilly Media, Inc., March 2019*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	10%	-	20%	-
Level 2	*Understand*	30%	-	10%	-	30%	-
Level 3	*Apply*	30%	-	40%	-	30%	-
Level 4	*Analyze*	20%	-	40%	-	20%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com	*1 Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*1. Dr.P. Vijayakumar, SRMIST*

Course Code	21ECE352T	**Course Name**	HIGH PERFORMANCE COMPUTING FOR CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understanding the role of supercomputers*
CLR-2:	*implementing the HPC Applications on Grid and cloud Infrastructures*
CLR-3:	*jgrim Simplifies the process of porting applications*
CLR-4:	*learning on Scheduled Algorithm*
CLR-5:	*real –world Infrastructures-Research area, Big Data challenge and Applications in cloud environment customization design*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*improve products reduce the time taken for develop new products-HPC*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*reduce the production cost*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*high performance computing systems can be highly useful to analyze the data*	-	-	*2*	*3*	-	*2*	-	-	-	-	-	-	-	-	-
CO-4:	*big data as our ability to gather the information*	-	-	*2*	*3*	-	*2*	-	-	-	-	-	-	-	-	-
CO-5:	*ability to learn the Algorithm, HPC main advantage learning here (Processing speed supercomputer)*	-	-	*2*	*3*	-	*1*	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Super Computers ***9 Hour***

Introduction of super computers and grids, grids and supercomputers, grids do support supercomputing, grids cannot replace supercomputers, the role of supercomputers in grids, a public-private supercomputing grid partnership prerequisites and problems, mode of operation, the public-private grid, discussion of results, conclusion, introduction to porting HPC applications to grids and clouds -applications and the grid infrastructure, applications and resource management, applications

Unit-2 - Scheduling Architectures ***9 Hour***

Introduction to scheduling- mouldable job allocation for handling resource fragmentation in computational grid, computational grid model and experimental setting, mouldable job allocation on homogeneous parallel computer, moldable job allocation in heterogeneous grid, comparison with multi-site co-allocation and conclusion, introduction to speculative scheduling of parameter sweep application using job behaviour descriptions, architecture overview, job behaviour description, simple, complex description, generating simple job descriptions, generating complex job descriptions, complex descriptions with mutation, scheduling strategies, static data feeder strategy, dynamic data feeder strategy, implementation, scheduler, description generator, description repository service, simulation results, summary and conclusion

Unit-3 - Privacy and Security Framework ***9 Hour***

Introduction to security, a policy based security framework for privacy-enhancing data access and usage control in grids, privacy management in large scale distributed systems, managing initial data access, controlling data usage, grids and their requirements for privacy management, architecture of a policy based security framework for privacy-enhancing data access and usage control in grids, application of the security framework to a XACML-based privacy management architecture, integration of the security framework's privacy management components on the service provider side, summery, adaptive control of redundant task execution for dependable volunteer computing-instruction, related work, statistical resource availability characterizing, root cause analysis of failures, fitting distribution to empirical availability data, availability prediction, a heuristics- based failure probability estimation, life cycle of a volunteer peer, failure probability estimation, least, failure probability dispatch policy, an enhanced workflow management mechanism, the task selection, evaluation results, baseline policies, time dependent Schrodinger's wave equation, performance evaluation, comparison with the simple redundant task dispatch policy, comparison with the greedy dispatch, effects of window size on the process time, improvement of the performance by identifying worker types

Unit-4 - Data Execution Models	***9 Hour***
Big data architectures, dataflow model for cloud computing frameworks in big data, introduction, cloud computing frameworks, batch, iterative, incremental processing frameworks, streaming processing frameworks, general dataflow frameworks, application examples, controllable data execution model, design of a processor core customized stencil computation – introduction, related work-customizable design and processors, micro architecture, stencil computation, customization design, flow, array padding and loop tiling, BW Optimizations, SIMD, DMA stencil computation and others, implementation, test results, introduction to electro migration alleviation techniques	
Unit-5 - Emerging Applications	***9 Hour***
Introduction to emerging big data, matrix factorization for drug target interaction prediction, classification based methods, neighborhood regularization logistic matrix – problem formation, logistic matrix factorization, neighborhood regularization, combined model, neighborhood smoothing, experimental settings, comparison, benefits, parameter sensitive analysis, predicting novel interactions, overview of neural network accelerators, architectures of hardware accelerators – ASIC, GPU, FPGA, modern storage accelerator, parallel programming models, middleware of neural networks, latest developments	

Learning Resources	*1. Emmanuel Udoh, Cloud, grid and High performance computing Emerging Applications, 1st Edition, IGI Global, 2011*	*2. Chao Wang, High performance computing for Big Data Methodologies and Applications, 1st Edition, Chapman & Hall Press Publications, 2020.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*10%*	-	*25%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*40%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com	*1 Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*1. Dr.P. Vijayakumar, SRMIST*

							L	T	P	C
Course Code	21ECE450T	**Course Name**	DESIGN OF CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*able to understand the design of human in the loop cyber physical systems*
CLR-2:	*design knowledge of energy cyber physical systems*
CLR-3:	*learn how Symbolic synthesis for cyber physical systems works*
CLR-4:	*design principles of Intelligent wireless sensor networks in cyber physical systems*
CLR-5:	*through simple hands-on exercise learn and implement humans in the loop software*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design the Cyber Physical systems with Industry 4.0 standards*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*explain the modeling and control of Energy CPS*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*implement synthesis models for real time CPS*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*deploy Wireless Sensor Networks using intelligent methods*	-	*3*	-	*3*		-	-	-	-	-	-	-	-	-	*2*
CO-5:	*experience the Human in the Loop CPS through app's*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Humans in the Loop Cyber Physical Systems (CPS) ***9 Hour***

Evolution of CPS – Humans as Elements in CPS - Human Sensing and Virtual Communities - Taxonomies For Human In The Loop CPS - Humans As Set Of Sensors - Humans As Communication Nodes - State Inference And Human Nature – Humans as processing nodes – Actuation in CPS –Robots as actuators – Technologies for supporting Human in Loop CPS - Applications of Human in Loops

Unit-2 - Energy CPS ***9 Hour***

System Description and Operational Scenarios - Key Design Drivers and Operational Scenarios - Architectural Design - Physics Based Composition of CPS for a Socio Ecological Energy Systems – Interaction variable based Automated modeling and control – Distributed Optimization

Unit-3 - Symbolic Synthesis for CPS ***9 Hour***

Symbolic Synthesis- its techniques – Problem Definition and Solving the Synthesis problem - Asynchronous Design Primitives – Construction of Symbolic models - Advanced Techniques for Construction of Symbolic Models - Continuous Time Controllers And Software Tools – Controller Timing and Control Design For Resource Efficiency – Computational complexity and time reduction – Controller Software Structures and Sharing of resources – Analysis and Simulation of Feedback Control system

Unit-4 - Intelligent Wireless Sensor Networks in CPS ***9 Hour***

Deployment of Wireless Sensor Networks in Cyber Physical Systems - Information Security and Cyber Physical Systems - Attacks and Vulnerabilities in Cyber Physical System - Attack Resilient Design – Application in Intelligence Level – Smart Grid – Smart Field Monitoring – Variant Smartness

Unit-5 - Humans in the Loop –Simple Hands on ***9 Hour***

A Sample Behavior change intervention application - Architecture – The Android App and Server Set up – Enhancing the sample app with Human in the loop Emotion Awareness – Choosing a Machine Learning Technique – Implementing Emotion Awareness – Installing the Android studio – Cloning the android project – Deploying the server protocols - Installing the Software and Cloning the Server's Project – Setting up the database and deploying the server on Tomcat – Handling emotions on the server – Creating the web interface – Creating the servers background thread – Processing incoming emotions– Handling new emotion interfaces – Providing Positive reinforcement – Creating a motivational dialog box.

Learning Resources	1. *David Nunes, Jorge SA Silva, And Fernando Boavida, a Practical Introduction to Human-In-The-Loop Cyber Physical Systems, 1st Edition, Wiley & IEEE PRESS, 2018.* 2. *Sherali Zeadally and Nafaa Jabeur, "Cyber Physical System Design with Sensor Networking Technologies," 1st Edition IET Press, London, 2016.*	3. *Raj Rajkumar, Dionisio De Niz, And Mark Klein, "Cyber Physical Systems" , 1st Edition, Addison Wesley Publishers, 2017*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	25%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	20%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Athif Shah,Chairman,AbeSemiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	1. *Dr. M. Sangeetha, SRMIST*
2. *Dr. S. A. Akbar, Director-CPS, Rtd. CSIR- CEERI, Pilani. saakbar158@gmail.com*	2. *Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	2. *Dr. P. Vijayakumar, SRMIST*

Course Code	21ECE451T	**Course Name**	CYBER PHYSICAL INTERFACE AND AUTOMATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECE251T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*study the cyber physical systems built-on Wireless sensor networks*															
CLR-2:	*learn the data management for cyber physical systems*															
CLR-3:	*gain knowledge on routing in WSN for cyber physical systems*															
CLR-4:	*analyze the security issues in cyber physical systems*															
CLR-5:	*enhance the scientific computing skills on medical cyber physical systems*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*integrate wireless sensor networks with CPS*	*1*	*3*	-	-	*1*	-	-	-	*1*	*1*	-	*3*	-	-	-
CO-2:	*apply data management concepts in CPS*	*2*	*3*	*1*	-	*1*	-	-	-	*2*	*1*	-	*3*	-	-	-
CO-3:	*implement routing protocol for CPS*	*2*	*3*	*2*	-	*1*	-	-	-	*2*	*1*	-	*3*	-	-	-
CO-4:	*design a resilient CPS*	*2*	*3*	*2*	-	*1*	-	-	-	*2*	*1*	-	*3*	-	-	-
CO-5:	*develop Cyber physical systems for interfacing and automation*	*3*	*3*	*3*	-	*1*	-	-	-	*1*	*1*	-	*3*	-	-	-

Unit-1 - Integrating Wireless Sensor Networks and Cyber-Physical Systems **9 Hour**

Wireless sensor networks, Cyber-physical systems, role of WSN technologies in CPS, CPS design challenges, WSN-CPS architecture, WSN-CPS challenges and characteristics, Opportunities

Unit-2 - Data Management in CPS with WSN **9 Hour**

Data management: WSN vs. WSN-CPS, Constraints of data management, Data management activities- Mobile data collection, Data processing, Data storage, Data querying, Data compression, Data analysis; Cyber-physical cloud computing- opportunities and challenges, Real time, Big Data, Data mining, Data integration, Load balancing

Unit-3 - Routing in WSN for CPS **9 Hour**

Design challenges and issues for routing in WSN, Routing protocols in WSN for CPS, Location-based routing protocols, Data-centric routing protocols, Hierarchical routing protocols, Future directions of routing protocols in WSN for CPS

Unit-4 - Resilient WSN for CPS **9 Hour**

Objectives of WSN for CPS, Information-security goals, Attacks against sensors-Types of attacks and vulnerabilities in CPS; Notion of attack resilience- Security and resilience, Random failures and intentional attacks, Challenges; Approaches for attack resilience

Unit-5 - Medical Cyber-Physical Systems **9 Hour**

Introduction, System Description and Operational Scenarios -Virtual Medical Devices, Clinical Scenarios, Key Design Drivers and Quality Attributes, Trends, Quality Attributes and Challenges of the MCPS Domain, High-Confidence Development of MCPS, On-Demand Medical Devices and Assured Safety, Smart Alarms and Clinical Decision Support Systems ; Closed-Loop System, Assurance Cases, Practitioners' Implications-MCPS Developer Perspective, MCPS Administrator Perspective, MCPS User Perspective, Patient Perspective, MCPS Regulatory Perspective, Summary and Open Challenges

Learning Resources	1. Sherali Zeadally, Nafaaˆ Jabeur. "Cyber-Physical System Design with Sensor Networking Technologies," Institution of Engineering and Technology, 2016. 2. Raj Rajkumar, "Cyber Physical Systems," 2nd Edition, Elsevier, 2015.	3. Edward D Lamie, "Computing Fundamentals Of Cyber Physical Systems," 2nd Edition, Newnes Elsevier Publication. 4. Rajeev Alur, "Principles of Cyber Physical Systems," 1st Edition, MIT Press, 2015.

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	30%	-	20%	-	20%	-
Level 2	*Understand*	30%	-	20%	-	20%	-
Level 3	*Apply*	20%	-	30%	-	30%	-
Level 4	*Analyze*	20%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. Lavanya A., SRMIST
2. Dr. S. A. Akbar, Director-CPS, Rtd, CSIR- CEERI, Pilani. saakbar158@gmail.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

Course Code	21ECE452T	**Course Name**	CLOUD AND DISTRIBUTED SYSTEMS FOR CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*design architecture of a cloud based distributed system*
CLR-2:	*understand process of designing fault-tolerant cloud based distributed systems*
CLR-3:	*understand and design distributed real-time system computing challenges*
CLR-4:	*understand distributed secure computing system and designing security models*
CLR-5:	*understand fundamental concepts of distributed system management*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*design architecture of a cloud based distributed system*	*3*	-	2	-	-	2	-	-	-	-	-	-	-	-	-
CO-2:	*explain various faults in cloud based distributed systems and how to design a fault tolerant system*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*design a distributed real-time system*	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*design security models for a secure distributed cyber physical system*	*1*	*3*	*3*	-	-	2	-	-	-	-	-	-	-	-	-
CO-5:	*understand key management issues in distributed cyber physical system*	*1*	*3*	2	-	-	-	-	-	-	-	2	-	-	-	-

Unit-1 - Cloud Based Distributed Systems ***9 Hour***

Distributed System Architectures, Strategies for Distributed Systems, selecting a Service Platform, Asynchronous Models, Synchronous Models, Distributed Shared Memory, Group Communication, Distributed File Systems, Distribution of Data Repositories, Distributed File System Access, Strategy for Scaling, Data Sharding, Threading, Queueing, Strategy for Resiliency.

Unit-2 - Fault-Tolerant Computing ***9 Hour***

system, Fault-tolerant Consensus, Replication Management in Partition-free and Partitionable Networks, Classes of Failure Semantics, Basic Fault tolerance Frameworks, Fault Tolerance Strategies, Fault-Tolerant Client-Server Database, Fault Tolerance of Local Servers, Distributed Fault-Tolerant Systems, Cluster architectures,

Unit-3 - Real-Time Networks ***9 Hour***

Temporal Specifications, Timing Failure Detection, Real-Time Communication, Flow Control and Scheduling, Clock Synchronization, Distributed Real-Time Architectures and Frameworks, Strategies for Real-Time Operation, The Event-triggered and Time-triggered Approach, Real-Time Databases, Operating Systems constraints, Time Services, Real-Time over the Internet, Integration of the Industrial Systems

Unit-4 - Security and Privacy in CPS's ***9 Hour***

Security and Privacy Issues in CPSs, Secure Networks, Internet-Wide Secure Communication, Security and Privacy for Cloud- Interconnected CPSs, Key Management in CPSs, CPS Key Management Challenges and Open Research Issues, Secure Registration and Remote Attestation of IoT Devices Joining the Cloud, Stack4Things Architecture, Secure Network Coding, Secure Distributed Architectures, Vulnerability, Attack and Intrusion, Fault Tolerance and Security, Mean time between failure (MTBF) in Distributed Systems, Trusted Computing Base (TCB), Secure Communication and Distributed Processing, Intranets and Firewall Systems, Authentication and Authorization Services, Data Encryption Standard, Symmetric and asymmetric cryptography, Diffie-Hellman and RSA encryption, Lightweight Crypto and Security, Lightweight Symmetric and Asymmetric Ciphers Implementations

Unit-5 - Management Information Base	***9 Hour***
Management Functions, Management Frameworks, Strategies for Distributed Systems Management, Generic Management Model, Centralized and Decentralized Management Model, OSI Management Model, Management and Configuration Tools, Distributed Management Environment, Managing Security on the Internet, Disaster Preparedness	

Learning Resources	*1. Security and Privacy in Cyber-Physical Systems Foundations, Principles, and* *2. Applications" by Glenn A. Fink and Sabina Jeschke, IEEE Press Wiley, 2018* *3. Distributed Systems for system architects, Paulo Verissimo and Luis Rodrigues,2001*	*4. Designing and Operating Large Distributed Systems Volume 2, by Thomas A. Limoncelli, Strata R. Chalup and Christina J. Hogan, Addison Wiley, 2014*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	30%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	25%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. M. J. Alam, SRMIST*
2. Dr. Madan Kumar Lakshmanan, Senior Scientist, CEERI, lmadank@gmail.com	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	*2. Dr. M. Sangeetha, SRMIST*

Course Code	21ECE453T	**Course Name**	MOBILE CYBER PHYSICAL SYSTEM	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*outline the context of the mobile cyber- physical system*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*identify different applications of community sensing*															
CLR-3:	*understand the security issues of CPS in the Smart grid application*															
CLR-4:	*develop a deep understanding of CPS automation in Transportation application*															
CLR-5:	*design mobile medical cyber-physical system*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*appreciate the features of the mobile cyber-physical system*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply CPS concept in community sensing applications*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze security issues in smart grid CPS*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*design CPS for Transportation application*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*implement CPS in mobile Health care*	*3*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Mobile CPS	***9 Hour***
Mobile CPS-Vehicular CPS, Mobile Supervision System, Smart Grid CPS, Cognitive Radio Network for Mobile CPS, Communication Model, Cognition Cycle, Communication Protocols, Quality of Service Architecture, Methods to Enhance System Efficiency, Challenges-Security, Survivability.	
Unit-2 - Community Sensing	***9 Hour***
Devices and Programs Involved in Community Sensing- Mobile Phones, platform for remote sensing using smartphones, Device Control, Wireless Community Networks, Applications of Community Sensing-Environmental Applications, Air Transportation, Earthquake Detection	
Unit-3 - CPS for Smart Grid Applications	***9 Hour***
Communications in Smart Grid, Cybersecurity Issues on Smart Grid- Device Issues, Networking Issues, Privacy Issues on Smart Grid- Personal Information, Privacy Concerns	
Unit-4 - CPS for Transportation Applications	***9 Hour***
Networked Automotive Cyber-Physical Systems, Arterial Traffic Condition Estimation- Traffic Model Assumptions, Graphical Model; Car Merging Assistant- Merging Issues, Merging Assistant for Mixed Traffic; Arterial Traffic Prediction, Road Traffic Delay Estimation.	
Unit-5 - Health Care Cyber-Physical System	***9 Hour***
Basics of Implementing Cyber-Physical Medication Systems, Medical Device Coordination and Integration, Medical Device Coordination Framework, Medical Device Integration Options- Plug and Play medical devices, Safe Interoperability of Medical Devices in the Event of Failure	

Learning Resources	1. Fei Hu,"Cyber-Physical Systems: Integrated Computing and Engineering Design," CRC Press (2013) 2. Rawat, D.B., Rodrigues, J.J.P.C., & Stojmenovic, I, "Cyber-Physical Systems: From Theory to Practice," CRC Press (2015).	3. Christophe Tricaud, YangQuan Chen, "Optimal Mobile Sensing and Actuation Policies in Cyber-physical Systems," Springer 2015. 4. Dietmar P.F. Moller, "Computing Fundamentals In Cyber Physical Systems," 1st Edition, Springer 2015.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	30%	-	20%	-	20%	-
Level 2	*Understand*	30%	-	20%	-	20%	-
Level 3	*Apply*	20%	-	30%	-	30%	-
Level 4	*Analyze*	20%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Dr. Lavanya A, SRMIST
2. Dr. S. A. Akbar, Director-CPS, Rtd, CSIR- CEERI, Pilani. saakbar158@gmail.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

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Regulations 2021

Volume – 14C

(Syllabi for Electronics and Communication Engineering w/s in Data Science Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE & TECHNOLOGY
(Deemed to be University u/s 3 of UGC Act, 1956)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ECE270T	**Course Name**	STATISTICS FOR DATA SCIENCE	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn about probability theory and random variables*
CLR-2:	*describe the random processes and Markov chain*
CLR-3:	*know to analyse descriptive statistics*
CLR-4:	*educate about Bayesian statistics and hypothesis testing*
CLR-5:	*gain knowledge on linear regression and its models*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the functions in probability and random variables*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*construct random processes using statistical functions*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-3:	*evaluate the descriptive and frequentist statistics*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-4:	*analyse Bayesian statistics and hypothesis testing models*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*describe the different linear regression models*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Probability Theory and Random Variables ***9 Hour***

Probability spaces, conditional probability, Discrete and Continuous random variables, Functions of random variables, generating random variables, Joint distributions of discrete and continuous variables, Independence, Functions of several random variables, generating multivariate random variables, Expectation operator, Mean and variance, Covariance, Conditional expectation

Unit-2 - Random Processes ***9 Hour***

Definition, Mean and autocovariance functions, Independent identically-distributed sequences, Gaussian process, Poisson process, Convergence of Random Processes: Types of convergence, Central limit theorem, Monte Carlo simulation, Markov Chains: Time-homogeneous discrete-time Markov chains, Recurrence, Periodicity, Convergence

Unit-3 - Descriptive Statistics ***9 Hour***

Histogram, Sample mean and variance, Order statistics, Sample covariance, Sample covariance matrix, Independent identically-distributed sampling, Frequentist statistics: sampling, mean square error, consistency, confidence intervals, parametric and non-parametric model estimation

Unit-4 - Bayesian Statistics and Hypothesis Testing ***9 Hour***

Bayesian parametric models, conjugate prior, Bayesian estimators, The hypothesis-testing framework, Parametric testing, Nonparametric testing: The permutation test, Multiple testing, Gaussian mixture models, multinomial mixture models

Unit-5 - Linear Regression ***9 Hour***

Linear models, Least-squares estimation, Prediction, Residuals, Bases and residuals Overfitting, Non-linear regression: Non-linear least squares, transformation to linear model – Generalized linear models: logistic regression models, Poisson regression

Learning Resources	1. *Michael Mitzenmacher and Eli Upfal; Probability and Computing, 2ed, Cambridge University Press, 2017* 2. *Robert V Hogg, Joseph W McKean and Allen T Cralg; Introduction to Mathematical Statistics, 8th ed, Pearson, 2018*	3. *Course notes of Carlos Fernandez-Granda, DS-GA 1002: Probability and Statistics for Data Science https://cims.nyu.edu/~cfgranda/pages/DSGA1002_fall17/index.html* 4. *Sheldon M Ross; A First Course in Probability, 10ed, Pearson, 2018*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	10%	-	10%	-	10%	-
Level 4	*Analyze*	20%	-	20%	-	20%	-
Level 5	*Evaluate*	20%	-	20%	-	20%	-
Level 6	*Create*	10%	-	10%	-	10%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1. *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1. *Mrs. S. Hannah Pauline, SRMIST*

Course Code	21ECE271T	**Course Name**	REGRESSION AND MULTIVARIATE DATA ANALYSIS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn about different regression techniques and their limitations*
CLR-2:	*describe the diagnostics, transformations and graphical plots for multivariate regression*
CLR-3:	*know to analyse variance and logistic regression*
CLR-4:	*educate about the interdependence techniques of multivariate data analysis*
CLR-5:	*gain knowledge on the dependence multi variate data analysis methods*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*identify the regression methods and visualize efficiently*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*construct graphs, identify and represent regression for multivariate data*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-3:	*evaluate regression parameters and test its exploratory applications*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-	-
CO-4:	*analyse multi-dimensional multi variate data*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*describe logistic regression and tree based methods analysis*	-	-	-	-	*2*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Simple and Multiple Regression ***9 Hour***

Bivariate Correlation and Regression, Data visualization, exploration, and assumptions, Categorical or Nominal Independent Variables, Quantitative Scales, Curvilinear Relationships and Transformations, Degree of Relationship, Parameter Estimates, Limitations to Regression Analysis, Standard, Sequential and Statistical regression

Unit-2 - Regression Diagnostics, Transformations, Graphical Representation ***9 Hour***

Outliers, Influential points, Graphical diagnostics, Remedies, Weighted Least Squares, Transformations in regression, Predicting total movie grosses after one week Modelling Lowe's sales, Scatter plot, Scatter plot matrix, Coplots and Trellis Graphics, Probability Plots

Unit-3 - Analysis of Variance and Covariance ***9 Hour***

chi square analysis, outliers, normality, linearity and homoscedasticity, Effects of covariates, Limitations to analysis of covariance – absence of outliers, multicollinearity and Singularity, Normality of Sampling Distributions, Homogeneity of variance, Regression, Sums of square, cross products, Significance test and Effect size, Choosing, Evaluation of Covariates, Test for homogeneity of Regression

Unit-4 - Multivariate Data Analysis – Interdependence Methods ***9 Hour***

Basic multivariate statistics–mean, variance, covariance, correlation, linear combination of variables, data appropriate for multivariate statistics, geometric concepts, distances, Principal Component Analysis, factor analysis, Types, Limitations, Rotation of Factors, Estimation of factor Scores, Cluster analysis, correspondence analysis, multidimensional scaling, hypothesis testing

Unit-5 - Multivariate Data Analysis – Dependence Methods, Logistic Regression ***9 Hour***

Multiple regression models, logistic regression canonical correlation, discriminant analysis, Multivariate Normal Distribution, Discriminant Analysis, Classification, Regression trees, Multivariate Analysis of Variance (MANOVA), Canonical Correlation Analysis

Learning Resources	1. *Trevor Hastie, Robert Tibshirani, Jerome Friedman (2017) the Elements of Statistical Learning - Data Mining, Inference, and Prediction, Second Edition.* 2. *Tabachnick, B. G., & Fidell, L. S. (2012). Using Multivariate Statistics, 6th Edition. Pearson.* 3. *Craig A. Mertler, Rachel A. Vannatta, Kristina N. LaVenia (2022) Advanced and Multivariate Statistical Methods, Practical Application and Interpretation, 7th Edition.*	4. *Afifi A., May S. and Clark V.A. (2012) Practical Multivariate Analysis, CRC Press, Taylor & Francis, Boca Raton.* 5. *Johnson R.A. and Wichern D.W. (2002) Applied Multivariate Statistical Analysis, Prentice Hall of India Pvt Ltd., New Delhi.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*10%*	-	*10%*	-	*10%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	*20%*	-	*20%*	-	*20%*	-
Level 6	*Create*	*10%*	-	*10%*	-	*10%*	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd	*1. Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	*1. Dr.S. Latha, SRMIST*

Course Code	21ECE272T	**Course Name**	DATA ANALYTICS USING SAS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand basic syntax of SAS*
CLR-2:	*demonstrate data with statistical graph using SAS/GRAPH*
CLR-3:	*explain statistical analysis and regression model*
CLR-4:	*describe variance model for data analytic using SAS*
CLR-5:	*gain knowledge on Mixed effects model*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express SAS programming language*	-	-	1	-	3	-	-	-	-	-	-	-	2	-	-
CO-2:	*evaluate different statistical graph for data analysis using SAS*	-	1	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*apply SAS for statistical analysis and regression model*	-	3	-	-	2	-	-	-	-	-	-	-	2	-	-
CO-4:	*analyze data using variance model*	-	3	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*demonstrate mixed effect model*	-	-	2	-	2	-	-	-	-	-	-	-	1	-	-

Unit-1 - A Brief Introduction to SAS — *9 Hour*

Basic Language: Rules and Syntax, Creating SAS Data Sets, The INPUT Statement, SAS Data Step Programming Statements and Their Uses, Data Step Processing, The proc step, SAS Graphics.

Unit-2 - Statistical Graphics Using SAS/GRAPH — *9 Hour*

SAS procedure for computing statistics, An Introduction to SAS/GRAPH, Quantile Plots, Empirical Quantile-Quantile Plots, Profile Plots of Means or Interaction Plots, Two-Dimensional Scatter Plots and Scatter Plot Matrices.

Unit-3 - Statistical Analysis of Regression Models — *9 Hour*

An Introduction to Simple Linear Regression model using PROC REG and PROC ANOVA, An Introduction to multiple regression analysis using PROC REG, case statistics and residual analysis, Types of Sums of Squares Computed in PROC REG and PROC GLM.

Unit-4 - Analysis of Variance Models — *9 Hour*

One-Way Classification-use PROC ANOVA and PROC GLM, , One-Way Analysis of Covariance using PROC GLM, A Two-Way Factorial in a Completely Randomized Design, Analysis of a two-way factorial using PROC GLM, Two-Way Factorial: Analysis of Interaction

Unit-5 - Analysis of Variance-Random and Mixed Effects Models — *9 Hour*

Introduction, One-Way Random Effects Model, Using PROC GLM to analyze one-way random effects models, Using PROC MIXED to analyze one-way random effects models, Two-Way Crossed Random Effects Model, Using PROC GLM and PROC MIXED to analyze two-way crossed random effects models.

Learning Resources	1. *Mervyn G. Marasinghe, William J. Kennedy, SAS for DataAnalysis Intermediate Statistical Methods, Springer, 2020.* 2. *Geoff Der, Brian S. Everitt, A Handbook of Statistical Analysesusing SAS, CRC press, 2002.*	3. *Lawrence S. Meyers, Glenn Gamst, A. J. Guarino,Data Analysis UsingSAS Enterprise Guide, Cambridge University press, 2009*

Learning Assessment

		Continuous Learning Assessment (CLA)					
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*		*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*35%*	-	*35%*	-	*35%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu*	1. *Dr. Damodar Panigrahy, SRMIST*

Course Code	21ECE273T	**Course Name**	PYTHON FOR DATA SCIENCES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic concept of variables, text, numericals, and list and control statements*
CLR-2:	*familiarize the students with the python dictionary's, lists, functions, file handling and exception handling*
CLR-3:	*understanding Data analysis using Data wrangling method*
CLR-4:	*using matplotlib, seaborn and pandas for Data Visualization*
CLR-5:	*provide fundamentals on Machine Learning, K Nearest Neighbors, linear regression, Naive Bayes classifier*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply python programming to solve problems*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-2:	*write python code with Dictionaries, Functions, Classes, files, and exception handling to solve problems*	-	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*demonstrate Data wrangling for effective Data analysis*	*2*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze data visually using matplotlib, pandas, seaborn visualization tools*	-	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-
CO-5:	*develop machine learning model using K Nearest neighbours, linear regression, and Naive Bayes for given dataset*	-	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Python and Programming Fundamentals	***9 Hour***
Introduction to Python Programming, Variables and simple Data types, Strings, numbers, Introducing Lists, Changing, Adding and removing elements, organizing a List, looping through lists, Avoiding index errors when working with Lists, Avoid indentation errors, Tuples, Control statements, If statements - elsif statement - if statements with lists	
Unit-2 - Algorithms, Data Structures and Performance Analysis	***9 Hour***
Dictionaries - Working with dictionaries, looping through a Dictionary, Nesting, User Input function, while loop with lists and dictionaries, Functions- Passing Arguments, Return Values, passing a list, Passing an arbitrary number of arguments and storing functions in modules, Classes - Creating and using a class, Working with classes and instances, Inheritance - importing classes, Files and exceptions - Reading from a file, Writing to a file, Storing data	
Unit-3 - Data Analysis	***9 Hour***
Data wrangling introduction, Subsetting a dataset, Generating and seeding random numbers, generating random numbers using probability distributions, Grouping the data aggression, Filtering, Transformation, Random sampling - introduction, Method: Customer churn model, Method: using sklearn, Method: using shuffle function, Concatenating, and appending data, Merging/Joining datasets	
Unit-4 - Data Visualization	***9 Hour***
An introduction to matplotlib, Basics, plot components, plotting with pandas, Relationship between variables, Distributions, Counts and frequencies, Pandas - subpackages - scatter matrix, Lag plots, Autocorrelation plots, Bootstrap plots, Seaborn - advanced plotting, Distribution, Faceting, Formatting - Title and axes, Customizing visualizations – Adding reference lines, shading regions, Annotations, colors	
Unit-5 - Python for Machine Learning	***9 Hour***
Introduction to machine learning- Problems Machine Learning Can Solve, Classifying Iris Species, meet the Data, Measuring Success: Training and Testing Data, Building Your First Model: k-Nearest Neighbors, Making Predictions, Evaluating the Model, classification and regression, K neighbors classification, analysing K neighbors classifier, K neighbors regression, Analyzing K neighbors regressor, linear regression, linear model for classification, Naïve bayes classifier	

Learning Resources	1. Eric Matthes, Python Crash Course, No starch Press, 2nd Edition 2019.Kirthi Raman, Ashish Kumar, Martin Czygan, Phuong Vo.T.H,, Python: Data Analytics and Visualization", Packt Publishing, 2017. 2. Stefanie Molin, Hands on Data Analysis with Pandas, Packt Publishing, 2019.	3. Andreas C. Muller and Sarah Guido, Introduction to Machine Learning with Python, O'Reilly Media, Inc.,2018 4. Joel Grus, Data Science from Scratch, O'Reilly Media, Inc, 2019.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	35%	-	35%	-	35%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	0%	-	0%	-	0%	-
Level 6	Create	0%	-	0%	-	0%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu	1. Mr. P. Muthukrishnan, SRMIST
2. Dr. Madan Kumar Lakshmanan, Senior Scientist, CEERI, lmadank@gmail.com	2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in	2. Dr.S. Krithiga, SRMIST

Course Code	21ECE274T	**Course Name**	MACHINE LEARNING FOR DATA ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the Basic Concepts of Data*
CLR-2:	*learn the Basic concepts of Classification Techniques*
CLR-3:	*explore the Advance methods in Classification Techniques*
CLR-4:	*analyse and understand the Clustering Techniques*
CLR-5:	*create insights to the concept of Reinforcement Learning*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the basic concepts of Data, Statistical description of Data, Data cleaning, Data reduction, Data Transformation and Discretization*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*discuss the Basic level Decision Tree, Bayes Classification, Rule Based Classification, Model Evaluation and Techniques to improve classification Accuracy*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the advance methods- Bayesian Network, Backpropagation, Support vector Machine, Frequent pattern classification, Lazy learns for classification problem*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyse the clustering techniques- Partitioning Methods, Hierarchical Methods, Density-Based Methods, and Grid-Based Methods*	-	2	3	-	-	-	-	-	-	-	--	-	-	-	-
CO-5:	*explore the concept of Reinforcement learning and its applications*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Data Objects and Attribute Types ***9 Hour***

Nominal Attributes, Binary Attributes, Ordinal Attributes, Numeric Attributes, Discrete versus Continuous Attributes - ***Basic Statistical Descriptions of Data-*** *Measuring the Central Tendency: Mean, Median, and Mode, Measuring the Dispersion of Data: Range, Quartiles, Variance, Standard Deviation, and Interquartile Range, Graphic Displays of Basic Statistical Descriptions of Data -* ***Data Pre-processing-*** *Data Quality: Why Pre-process the Data, Major Tasks in Data Pre-processing,* ***Data Cleaning-*** *Missing Values, Noisy Data, Data Cleaning as a Process,* ***Data Integration-*** *Entity Identification Problem, Redundancy and Correlation Analysis, Tuple Duplication, Data Value Conflict Detection and Resolution,* ***Data Reduction-*** *Overview of Data Reduction Strategies, Wavelet Transforms, Principal Components Analysis, Attribute Subset Selection, Regression and Log-Linear Models: Parametric Data Reduction, Histograms, Clustering, Sampling, Data Cube Aggregation,* ***Data Transformation and Data Discretization-*** *Data Transformation Strategies Overview, Data Transformation by Normalization, Discretization by Binning, Discretization by Histogram Analysis, Discretization by Cluster, Decision Tree, and Correlation, Concept Hierarchy Generation for Nominal Data*

Unit-2 - Classification: Basic Concepts ***9 Hour***

What Is Classification?, General Approach to Classification, ***Decision Tree Induction -*** *Decision Tree Induction, Attribute Selection Measures, Tree Pruning, Scalability and Decision Tree Induction, Visual Mining for Decision Tree Induction,* ***Bayes Classification Methods-*** *Bayes' Theorem, Naive Bayesian Classification,* ***Rule-Based Classification-*** *Using IF-THEN Rules for Classification, Rule Extraction from a Decision Tree, Rule Induction Using a Sequential Covering Algorithm,* ***Model Evaluation and Selection-*** *Metrics for Evaluating Classifier Performance, Holdout Method and Random Subsampling, Cross-Validation, Bootstrap, Model Selection Using Statistical Tests of Significance, Comparing Classifiers Based on Cost–Benefit and ROC Curves,* ***Techniques to Improve Classification Accuracy-*** *Introducing Ensemble Methods, Bagging, Boosting and AdaBoost, Random Forests, Improving Classification Accuracy of Class-Imbalanced Data.*

Unit-3 - Classification: Advanced Methods - Bayesian Belief Networks	**9 Hour**
Concepts and Mechanisms, Training Bayesian Belief Networks, **Classification by Backpropagation -** A Multilayer Feed-Forward Neural Network, Defining a Network Topology, Backpropagation, Inside the Black Box: Backpropagation and Interpretability, **Support Vector Machines-** The Case When the Data Are Linearly Separable, The Case When the Data Are Linearly Inseparable, **Classification Using Frequent Patterns -** Associative Classification, Discriminative Frequent Pattern– Based Classification, **Lazy Learners (or Learning from Your Neighbours) -** k-Nearest-Neighbour Classifiers, Case-Based Reasoning, **Other Classification Methods -** Genetic Algorithms, Rough Set Approach, Fuzzy Set Approaches, **Additional Topics Regarding Classification -** Multiclass Classification, Semi-Supervised Classification, Active Learning, Transfer Learning	
Unit-4 - Cluster Analysis: Basic Concepts and Methods	**9 Hour**
Requirements for Cluster Analysis, Overview of Basic Clustering Methods, **Partitioning Methods-** k-Means: A Centroid-Based Technique, k-Medoids: A Representative Object-Based Technique, **Hierarchical Methods-** Agglomerative versus Divisive Hierarchical Clustering, Distance Measures in Algorithmic Methods, BIRCH: Multiphase Hierarchical Clustering Using Clustering Feature Trees, Chameleon: Multiphase Hierarchical Clustering Using Dynamic Modelling, Probabilistic Hierarchical Clustering, **Density-Based Methods-** DBSCAN: Density-Based Clustering Based on Connected Regions with High Density, OPTICS: Ordering Points to Identify the Clustering Structure, DENCLUE: Clustering Based on Density Distribution Functions, **Grid-Based Methods-** STING: Statistical Information Grid, CLIQUE: An Apriori-like Subspace Clustering Method, **Evaluation of Clustering-** Assessing Clustering Tendency, Determining the Number of Clusters, Measuring Clustering Quality	
Unit-5 - Reinforcement learning	**9 Hour**
Basics, Important terms: Agent, Environment, Reward, state, Policy, value etc., **Reinforcement Learning Algorithms**– Value Based, Policy Based, Model Based learning, Reinforcement Learning Characteristics, Features of Reinforcement learning, **Types of Reinforcement Learning** - Positive, Negative, **Learning Models of Reinforcement** - Markov Decision Process, Q- Learning, Applications of Reinforcement learning, Challenges of Reinforcement learning	

Learning Resources	1. Data Mining Concepts and Techniques, Jiawei Han, Micheline Kamber, Jian Pei, 3rd edition, Elsevier, ISBN: 978-0-12-381479-1 2. Reinforcement Learning with Open AI, Tensor flow and keros using python., Abhishek Nandy Manisha Biswas Kolkata, West Bengal, India North 24 Parganas, West Bengal, India ISBN-13 (pbk): 978-1-4842-3284-2 ISBN-13 (electronic): 978-1-4842-3285-9	3. Hands-On Machine Learning with Scikit-Learn, Keras, and Tensor Flow: Concepts, Tools, and Techniques to Build Intelligent Systems 2nd Edition, by Aurélien Géron, ISBN-13: 978-1492032649., ISBN-10: 1492032646 4. Hands-on Scikit-Learn for Machine Learning Applications: Data Science Fundamentals with Python David Paper Logan, UT, USA ISBN-13 (pbk): 978-1- 4842-5372-4 ISBN-13 (electronic): 978-1-4842-5373-1

Learning Assessment							
	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	10%	-	15%	-
Level 2	Understand	15%	-	10%	-	15%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	15%	-	20%	-	15%	-
Level 6	Create	15%	-	20%	-	15%	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu	1. Dr.S. Kayalvizhi, SRMIST

							L	T	P	C
Course Code	21ECE275T	**Course Name**	TABLEAU FOR BUSINESS INTELLIGENCE	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand working with Tableau*
CLR-2:	*discuss the data visualization and its parameters*
CLR-3:	*inculcate Business intelligence using Tableau*
CLR-4:	*familiarize about the Geo spatial analytics*
CLR-5:	*expertise on the programming tool for Tableau sever interaction*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*understand the use of Tableau and data calculations*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*implement the graphs and charts using Tableau for data visualization*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*demonstrate design flow for business intelligence using Tableau*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*apply the Geo spatial analytics using Tableau*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*implement interaction mechanism for Tableau server*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction of Tableau	***9 Hour***
Introduction and getting started with Tableau, Connecting to Excel, CSV Text Files, Product Overview, Connecting to Databases, Working with Data, Analyzing, Formatting, Introduction to Calculations, Dashboard Development, Sharing, Data Calculations, Aggregate Calculations, User Calculations, Table Calculations, Logical Calculations, String Calculations, Number Calculations,	
Unit-2 – Visualization	***9 Hour***
Type Conversion, Parameters, Filtering Conditions, Filtering Measures, Histograms, Sorting, Grouping, Sets, Tree maps, word clouds and bubble charts, Pareto Charts, Waterfall Charts, Bump Charts, Funnel Charts, Bollinger Bands, Visual Analytics – Trends, Clustering, Distribution and Forecasting. Advanced visualization.	
Unit-3 - Business Intelligence with Tableau	***9 Hour***
Introduction to business intelligence with Tableau, Evaluation of Tableau, Tableau architecture, Navigation of Tableau, Design flow, types of files, data types on Tableau, data terminology, extracting data using Tableau, metadata, functions, sorting, and filters.	
Unit-4 - Advanced Analytics	***9 Hour***
Visualizing world indices correlation, Geo spatial analytics, Extended Geo spatial analytics with distance measure, Hardware and on-the-fly techniques, connecting to data source, working with extracts, Efficient calculation and other ways to improve performance.	
Unit-5 - Interaction with Tableau Server	***9 Hour***
Publishing a data source to Tableau server, Web authoring, Maintaining workbooks on Tableau server, Server settings and features, Programming Tool Integration	

Learning Resources	1. *Joshua N.Milligan, Learning Tableau 2020, Fourth Edition,Packt Publishing Ltd.2020* 2. *Marleen Meier and David Baldwin, Mastering Tableau 2021,Third Edition, Packt Publishing Ltd.2021*	3. *Shankar Arul, Tableau for Business users, Apress Berkeley, CA,2021 .ISBN-13 (Electronic): 978-1-4842-7786-7.* 4. *Alexander Loth, Visual, Analytics with Tableau, Wiley, 2019.* 5. *Joshua Milligan, Learning Tableau 10, 2nd Edition, Pakt Publishing,2016*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu*	1. *Dr. K. Harisudha, SRMIST*

Course Code	21ECE370T	**Course Name**	BLOCKCHAIN IN DATA ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*provide basic knowledge on blockchain technology*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-2:	*understand the principles of data analytics in blockchain*															
CLR-3:	*develop knowledge on blockchain analytics ecosystem*															
CLR-4:	*explore the benefits of visualization of blockchain data*															
CLR-5:	*analyze the blockchain data analysis models*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*express the fundamentals of blockchain technology*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply data analytics mechanism in blockchain*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*compile blockchain ecosystem for data analysis*	-	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*analyse and visualize blockchain analysis data*	-	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*incorporate the usage of popular models for block chain data analysis*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Introduction to Blockchain Technology	***9 Hour***
What is blockchain – Centralized vs. Decentralized Systems - Layers – Importance – Uses – Properties of blockchain – Blockchain transactions - Blockchain applications - Bitcoin blockchain - Ethereum network?	
Unit-2 - Data Analytics and Blockchain	***9 Hour***
Deriving value from data - Predicting future outcome with data - Exploring blockchain landscape - Blockchain types - Exploring blockchain data - Categorizing common data in a blockchain - Examining types of blockchain data for value - Aligning blockchain data with real world processes.	
Unit-3 - Blockchain Analytics Ecosystem	***9 Hour***
Aligning analytics with business goals - Surveying options for analytics Lab - Installation of blockchain environment (Self study) - Exploring the Blockchain Analytics Ecosystem - Fetching blockchain client Comparing on-chain and external analysis options, integrating external data, Identifying features building an analysis dataset	
Unit-4 - Analyzing and Visualizing Blockchain Analysis Data	***9 Hour***
Analyzing data clustering using popular models - association rules in data - Classification of blockchain data - Analysis of data classification using popular models - Prediction of future using regression - Analysis of time series data using popular models	
Unit-5 - Blockchain Data Analysis Models	***9 Hour***
Interaction with blockchain - Connection to a blockchain - examining blockchain client languages - Assessing blockchain needs - choosing the best fit - management of blockchain project - Tools for developing blockchain analytics models.	

Learning Resources	1. *Bikramaditya Singhal, Gautam Dhameja, and Priyansu Sekhar Panda, Beginning Blockchain:A Beginner's guide to building Blockchain solutions, First Edition,Apress, 2018.* 2. *Michael G. Solomon, Blockchain data analytics for dummies,First edition, Wiley, 2020.* 3. *Ganesh Prasad Kumble, Practical Artificial Intelligence and Blockchain: A guide to converging blockchain and AI to buildsmart applications for new economies, First Edition, Packt Publishing Ltd, 2020.*	4. *Brojo Kishore Mishra, Sanjay Kumar Kuanar, Sheng-Lung Peng, andDaniel D. Dasig Jr, eds, Handbook of IoT and Blockchain: Methods, Solutions, and Recent Advancements, First Edition, CRC Press, 2020. 5. Manav Gupta, Blockchain for dummies, Second edition, Wiley, 2018.* 5. *Pedro Franco, Understanding Bitcoin: Cryptography, engineering andeconomics, First Edition, Wiley, 2015.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	25%	-	25%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu*	1. *Dr. R. Jansi, SRMIST*

Course Code	21ECE371T	Course Name	DATABASE DESIGN AND MANAGEMENT	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of Database Management Systems, Architecture and Languages*
CLR-2:	*conceive the database design process through ER Model and Relational Model*
CLR-3:	*design Logical Database Schema and mapping it to implementation level schema through Database Language Features*
CLR-4:	*understand the practical problems of concurrency control and gain knowledge about failures and recovery*
CLR-5:	*explore the database implementation mechanism*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the various elements of Database Management Systems*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply E-R diagram for database design and normalization*	*2*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*express database program using Relational Algebra and Relational Calculus*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*evaluate the concepts of transaction, concurrency control, and recovery mechanism in database*	*2*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*compile database implementation mechanism*	*2*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 – Introduction to Database Systems	***9 Hour***
Introduction: Database System, Applications, Purpose of Database Systems, View of Data, Database Languages, Data Storage and Querying, Transaction Management, Database Architecture, SQL Concepts : Basics of SQL, DDL,DML,DCL, structure – creation, alteration, defining constraints – Primary key, foreign key, unique, not null, check, IN operator, aggregate functions, Built-in functions –numeric, date, string functions, set operations, sub-queries, correlated sub-queries, join, Exist, Any, All , view and its types., transaction control commands	
Unit-2 - Database Design	***9 Hour***
Entity-Relationship model - E-R Diagrams - Enhanced-ER Model - ER-to-Relational Mapping - Functional Dependencies - Non-loss Decomposition - First, Second, Third Normal Forms, Dependency Preservation - Boyce/Codd Normal Form -Multi-valued Dependencies and Fourth Normal Form - Join Dependencies and Fifth Normal Form	
Unit-3 - Relational Algebra	***9 Hour***
Relational Algebra and Calculus: Relational algebra: introduction, Selection, and projection, set operations, renaming, Joins, Division, syntax, semantics. Operators, grouping and ungrouping, relational comparison Calculus: Tuple relational calculus, Domain relational Calculus, calculus vs algebra, computational capabilities	
Unit-4 - Transaction Management	***9 Hour***
Transaction processing - Concurrency control - ACID property - Serializability of scheduling - Locking and timestamp-based schedulers - multi-version and optimistic Concurrency Control schemes -Database recovery	
Unit-5 - Implementation Technique	***9 Hour***
Redundant Array of Independent Disks (RAID) - File Organization - Organization of Records in Files - Indexing and Hashing - Ordered Indices - B+ tree Index Files - B tree Index Files - Static Hashing - Dynamic Hashing - Query Processing Overview - Algorithms for SELECT and JOIN operations -Query optimization using Heuristics and Cost Estimation	

Learning Resources	1. Data base Management Systems, Raghu Ramakrishnan, JohannesGehrke, McGraw Hill Education (India) Private Limited, 3rd Edition, 2003 2. Fundamental of Database Systems, Ramez Elmasri, Shamkant B.Navathe, Pearson Education, 6th edition, 2011 3. Data base System Concepts, A. Silberschatz, and Henry. F. Korth, S.Sudarshan, McGraw Hill Education(India) Private Limited l, 6thedition, 2011	4. Database Systems Design, Implementation, and Management, Peter Rob& Carlos Coronel, 7th Ed., 2011. 5. Principles of Distributed Database Systems, Ozsu, Pearson Publication,2011 6. Distributed Database Management Systems, Rahimi & Haug, Wiley, 2010

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu	1. Dr .B. Muruganandam, SRMIST
		2. Dr. Elizer, SRMIST

Course Code	21ECE372T	**Course Name**	DEEP LEARNING FOR DATA ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concepts of Data Science and Deep Learning*
CLR-2:	*implement Deep Learning methodologies for data analysis*
CLR-3:	*study deep learning techniques for image analysis and its applications*
CLR-4:	*learn deep learning techniques for video analysis*
CLR-5:	*demonstrate the concepts of deep learning in multimedia data analysis and its applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply basic concepts in Deep Learning for processing high dimensional data*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-2:	*incorporate deep learning methods for data analysis*	-	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*develop Computer Processing of an image using Deep Neural Network*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*analyze various types of video data using Deep Learning techniques*	-	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*implement Deep Learning in multimedia data analysis*	-	-	-	*3*	*3*	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Introduction to Deep Learning in Data Science ***9 Hour***

Data Analytics Basics, Enterprise Data Science, Predictive Analysis, Scalability of deep learning methods, Statistical learning for mining and analysis of bigdata, Computational Intelligence Methodology for Data Science, Challenges in Big Data Analytics - Data Challenges, Management Challenges, Process Challenges

Unit-2 - Deep Learning Methodologies for Data Analysis ***9 Hour***

Optimization for deep learning - model structure optimization, large-scale optimization, hyper-parameter optimization, Feature selection using deep learning, Novel methodologies using deep learning for classification, detection and segmentation, Non linear Feature Extraction for Big Data Analytics, Single layer convolutional neural network for cardiac disease classification using electro cardiogram signals, Deep learning on information retrieval and its applications

Unit-3 - Deep Learning in Image Analysis ***9 Hour***

Computer Processing of an Image: An Introduction, Case Studies- Apple Leaf Identification based on Optimized Deep Neural Network, Performance Analysis of VGG19 Deep Learning Network base Brain Image Fusion, Deep learning-based Tamil vowels prediction using segmentation and U-Net Architecture, Performance analysis of GAN architecture for effective facial expression synthesis, Deep CNN for Object classification

Unit-4 - Deep Learning in Video Data Analysis ***9 Hour***

Introduction to video data analysis, Uniqueness of video data, limitations of video data, conducting video data analysis, Video data analysis and computer vision, the future of video data in social science research, Case study - Discrete action sequences using deep emotional intelligence

Unit-5 - Data Analytics for Multimedia Search ***9 Hour***

Feature Extraction from Big Multimedia Data, Representation learning on large and small data, Concept based and event-based video search, Feature extraction facing volume, velocity, variety, large scale social multimedia analysis, Data storage and management for Big Multimedia, Applications of large scale multimedia search - Image tagging with Deep Learning: Fine grained Visual Analysis

Learning Resources	1. *Himansu Das, Chattaranjan Pradhan, Nilanjan Dey,“Deep Learning for Data Analytics”, Elsevier, May 2020.* 2. *Arun K. Somani Ganesh Chandra Deka “ Big Data Analytics Tools and Technology for Effective Planning ”, CRC Press, 2018* 3. *Alex Noel Joseph Raj, Vijayalakshmi G. V. Mahesh and Ruban Nersisson , "Handbook of Research on Deep Learning-Based Image Analysis Under Constrained and Unconstrained Environments", IGI Global, Dec 2020*	4. *Anne Nassauer, Nicolas M. Legewie, "Video Data Analysis", Sage Publications, March 2022* 5. *Debi Prasanna Acharjya, Anirban Mitra, Noor Zaman, “Deep Learningin Data Analytics”, Springer, 2022.* 6. *Stefanos Vrochidis, Benoit Huet, Edward Y. Chang, IoannisKompatsiaris , “Big Data Analytics for Large Scale Multimedia Search",WILEY, 2019* 7. *N. D. Lewis , “Deep Learning Step by Step with Python: A Very GentleIntroduction to Deep Neural Networks for Practical Data Science, 2016*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*20%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*5%*	-	*5%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu*	1. *Mrs. V. Padmajothi, SRMIST*

Course Code	21ECE373T	**Course Name**	JULIA FOR DATA SCIENCE	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*describe the various data types and data structures in Julia programming*
CLR-2:	*organise the control flow using Julia programming*
CLR-3:	*to compile data frames operations with Julia programming*
CLR-4:	*define statistics and its visualization in Julia programming*
CLR-5:	*understand the machine learning models and Principal Component Analysis*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the various data types and data structures in Julia programming*	3	2	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*express the control flow statements for programming in Julia programming*	-	3	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*analyse the data frames and the operations using Julia programming*	-	2	3	-	1	-	-	-	-	-	-	-	1	-	-
CO-4:	*apply Julia programming for statistics and its visualization models*	-	2	3	-	1	-	-	-	-	-	-	-	-	2	-
CO-5:	*implement the machine learning models for data science using Julia programming*	-	2	3	-	1	-	-	-	-	-	-	-	-	2	-

Unit-1 - Data Types and Data Structures in Julia	***9 Hour***
Introduction to Julia, Integer, Rational and complex numbers, Arithmetic and Logical operators, Algebraic operations, Strings, Arrays, Tuples and dictionary sets, Vector and matrix processing, Random packages.	
Unit-2 - Control Flow in Data Science using Julia	***9 Hour***
Decision making, Looping, Conditional evaluation, Repeated evaluation, Exception handling, Variables and functions in Julia, Anonymous functions, Functions with arguments, type assertion for function arguments, Varargs functions, User defined functions, Methods and constructors.	
Unit-3 - Operations in Data Frames with Julia	***9 Hour***
Data frames: Reading and writing, Filtering and sorting, Row and column operations, Replacing and changing entries Split-Array-Combine Strategy, Time series and dates in Julia, Time array: Accessing data, applying conditions, combining methods, Case study: E-commerce in data analysis	
Unit-4 - Statistics and Data Visualization in Julia	***9 Hour***
Interpolation, Macros and metaprogramming with data frames, Descriptive statistics, Deviation metrics, Sampling, Correlation analysis, Dimensionality reduction, Data visualization: Plotting of basic arrays, data frames, functions, line and scatter plots, Histogram	
Unit-5 - Machine Learning Models in Julia	***9 Hour***
Simple Linear regression, Multiple Linear regression, Logistic Regression, Polynomial Regression, Clustering, K-means clustering, unsupervised learning, Principal Component Analysis, Real Time case study within depth analysis of code.	

Learning Resources	*1. Logan Kilpatrick, Nolan Fortman. Julia Crash Course: Learn the world's fastest growing programming language, December 2022* *2. Zacharias Voulgaris. Julia for Machine Learning. Technics Publications, June 2020.*	*3. Paul D. McNicholas and Peter Tait. Data Science with Julia. Chapman and Hall/CRC, January 2019.* *4. Sambit Kumar Dash. Hands-on Julia Programming, Bpb Publications, October 2021.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	30%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	20%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Athif Shah, Chairman, Abe Semiconductor, abechennai@gmail.com*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University,meena68@annauniv.edu*	1. *Dr.P. Vijayakumar, SRMIST*
		2. *Mrs. S. Hannah Pauline, SRMIST*

Course Code	21ECE374T	**Course Name**	DATA PATTERN AND VISUALIZATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain knowledge in distribution and shape of the data*
CLR-2:	*identify various data sources and dealing with messy data*
CLR-3:	*explore the art of visualization*
CLR-4:	*knowing the data layout for visual effects*
CLR-5:	*familiarize with concepts on geometric modelling and virtual environments for visualization*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze univariate and multivariate data*	2	3	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*implement various methods to handle messy data*	-	-	2	3	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*incorporate appropriate data visualization technique*	-	-	2	-	3	-	-	-	-	-	-	-	2	-	-
CO-4:	*develop customized layouts by suitable visual encoding techniques*	-	-	2	-	3	-	-	-	-	-	-	-	2	-	-
CO-5:	*apply the concepts of geometric modelling and virtual environments to enhance data visualization*	2	-	2	-	3	-	-	-	-	-	-	-	2	-	-

Unit-1 - Data Shape Analysis *9 Hour*

Univariate data, Frequency distributions, Measures of central tendency, Spread, Population, sampling and estimation, Probability distributions, Multivariate data: Relationships between single categorical and single continuous variable, Relationships between two categorical variables, Relationship between two continuous variables, Covariance, Correlation coefficients, Comparing multiple correlations, Probability: Basics, A tale of two interpretations, Sampling from distributions, Binomial distribution, Problems in binomial distribution, Normal distribution, Problems in normal distribution, Three sigma rule and using z tables

Unit-2 - Relational Databases *9 Hour*

Data sources, Relational databases, SQL, JSON, XML, Other data formats, Handling data from online repositories, Dealing messy data, Analysis with messy data: Types, Unsophisticated methods for dealing missing data: Complete case analysis, Pairwise deletion, Unsophisticated methods for dealing missing data: Mean substitution, Hot deck imputation, Unsophisticated methods for dealing missing data: Regression imputation, Stochastic regression imputation, Multiple imputation, Analysis with sanitized data, Checking for out of bounds and data type, Checking for unexpected categories, outliers, typographical errors, Checking unlikely data, Other messiness

Unit-3 - Data Visualization Considerations *9 Hour*

Classification of visualization: complexity, Infographics vs data visualization, Exploration vs explanation, Information vs persuasive vs visualart, Looking data as designer, Role of designer, Looking data as reader, Creation of visualization for other people, Contextual considerations, Context of use, The goal and supporting data, Knowledge before structure, Choosing appropriate visual encodings: natural order, distinct values, redundant encoding, Defaults vs innovative formats, Readers context, Compatibility with reality, Patterns and consistency, Selecting structures: Comparisons, bad Structures, Abused structure and simplicity in designing

Unit-4 - Data Layouts *9 Hour*

Positioning: layout, Positioning: axes, Placement and proximity: Semantic distance and relative proximity, absolute placement, Representation of physical space, Logical and physical relationships, Patterns and grouped objects, Patterns of organizations: Graphs, layouts, Axis styles, Using circles and circular layouts, Applying encodings: Color, Leverage Common color, Cognitive interference and Stroop test, Color theory, Sizes: Conveying size, Size: Comparing size, Text and typography, Shapes and lines, Keys Vs direct labeling of data points

Unit-5 - Geometric Modeling and Virtual Environments for Visualization	***9 Hour***
3D Mesh compression- corner table representation, Geometry compression, connectivity compression, edge compression, other approaches, Retiling, Direct manipulation in virtual reality for scientific visualizations, The Data analysis pipeline, Advantages of direct manipulation in virtual environment, How scientific visualization differs from other VR applications, Basics of direct manipulation, system architecture issues, Distributed implementation, Time critical techniques	

Learning Resources	*1. Tony Fischetti, Data Analysis with R, second edition, Packt publishing, 2018.* *2. Noab Iliinsky, Julie Steele, Designing data visualizations, O' Reilly publishers,2011*	*3. Trevor Hastie, Robery Tibshirani, Jerome Friesman, The Elements of Statistical* *4. Learning, Data mining, Inference and prediction, Springer, 2013.* *5. Charles D. Hansen and Chris R. Johnson, Visualization Handbook, Academic Press, 2011*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd	*1. Dr..Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	*1. Dr. Revathi Venkataraman, SRMIST*
		2. Dr.S. Krithiga, SRMIST

Course Code	21ECE375T	Course Name	DATA SCIENCE FOR COMMUNICATION NETWORKS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*provide basic concepts of Data Science*
CLR-2:	*provide knowledge on different data sources for various communication networks*
CLR-3:	*emphasis on data visualization and different learning paradigms for communication networks*
CLR-4:	*handle the various data science problems in wireless communication networks*
CLR-5:	*familiarize with the applications of data science in Telecom Industry*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the concepts of data science in different communication network*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*plan the appropriate data sources needed in communication networks*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*apply data visualization and different learning paradigms necessary for different applications*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-4:	*analyze various data science problems in communication networks*	3	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*implement the data science in Telecom Industry*	3	3	-	-	2	-	-	-	-	-	-	-	3	-	-

Unit-1 - Introduction to Data Science ***9 Hour***

Introduction to Data Science: Causality and Experiments; Data Preprocessing: Data cleaning, Data reduction, Data transformation, Data discretization; Visualization and Graphing: Visualizing Categorical Distributions, Visualizing Numerical Distributions, Overlaid Graphs, plots, Summary statistics of exploratory data analysis, Randomness Probability. Introduction to Statistics: : Learning Curve, Sampling, Sampling means and Sampling Sizes; Technical elements of the Data Science, Analytics Toolkit, Components of the analytics toolkit, Applications of Data Science

Unit-2 - Data Source and Necessities for Large Scale Communication Networks ***9 Hour***

Data Sources of Internet Service Providers: Telephony call record details, IP traffic flow records generated by routers, Protocol transitions; Data Sources of Mobile Communication Networks: Subscriber-related data, Network-related data, and Application data. Vehicular networks: Traffic Flow data, Public safety/security data, Vehicular safety warning messages, Ride quality monitoring information, Location-aware social network information Mobile Social Networks: Service Provider-related data, User related data. Security and Privacy Concerns of data – Security in data acquisition, privacy and security in data storage, Data Privacy and Challenges of data privacy: Privacy in data analytics, Data policies for maintaining the privacy of data

Unit-3 - Data Visualization and Learning Paradigms ***9 Hour***

Data Visualization: Design principles for data visualization, Human perception of data, Effective interpretation with data, Modern visualization tools and techniques. Overview of Types of Learning Paradigms for Data Science; Data Mining vs. Machine Learning; Supervised vs. Unsupervised vs. Semi- Supervised Learning; Offline vs. Online vs. Active Learning

Unit-4 - Types of Data Science Problems in Wireless Networks ***9 Hour***

Introduction to various data science problem in wireless networks; Introduction to Regression - Linear Regression, Non-linear Regression, Logistics Regression, Classification – Neural Networks, Deep Learning, Support Vector Machine (SVM) k-Nearest Neighbour (k-NN), Clustering, Anomaly Detection Summarization

Unit-5 - Application of Data Science in Telecom Industry	***9 Hour***
ISP Network: Structure of large ISP Networks, Measuring the ISP network, Challenges of ISP data analysis , Traffic Flow Management, Application of data science in Telecommunication – Personalized Services - Customer Behaviour, Customer Demographics Network Management and Optimization, Social Media and Sentiment Analysis; Location-Based Initiatives, Customer Churn Prevention. Application of data science in Telecom Industry - Customer Experience, Customer Segmentation, Product Development, Real-time Analytics, Customer Sentiment Analysis., Fraud detection, Predictive analytics, Lifetime Value Prediction, Product Development, Price Optimization, Capacity management, Data integrity management, Propensity profiling management, offer performance management.	

Learning Resources	*1. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MITPress, 2012.* *2. Ethem Alpaydin, "Introduction to Machine Learning", Prentice Hall ofIndia, 2005* *3. Larry L Peterson & Bruce S Davie, "Computer Networks –A SystemsApproach", Morgan Koufmann (5th Edition)*	*4. Adi Adhikari and John DeNero, "Computational and Inferential Thinking: The Foundations of Data Science", GitBook, 2019* *5. Srinivasa, K.G., G M, Siddesh, H., Srinidhi, "Network Data Analytics: A Hands-On Approach for Application Development", Springer, 2018* *6. Kolaczyk, Eric D., "Statistical Analysis of Network Data: Methods and Models", Springer, 2009*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd	*1. Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	*1. Dr. M. Susila, SRMIST*

Course Code	21ECE376T	Course Name	BUSINESS DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concept of business analytic methods and modelling*
CLR-2:	*familiarize about the supervised learning for forecasting*
CLR-3:	*understand about the optimization models and their analysis*
CLR-4:	*inculcate the statistics and probability for data analytics*
CLR-5:	*discuss about the latest data warehousing*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the business analytical models and Data Dashboards using Excel*	*1*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*design of supervised learning models for forecasting*	*1*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*understand linear optimization models using spreadsheet*	*3*	*1*	-	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*apply various statistical techniques for business analytics*	-	-	-	*3*	*3*	-	-	-	-	-	-	-	*1*	-	*3*
CO-5:	*analyze data warehouse tools and mechanism*	-	-	-	*3*	*3*	-	-	-	-	-	-	-	*2*	-	*2*

Unit-1 - Introduction to Business Analytic Using Excel ***9 Hour***

Decision Making – Business Analytics Defined – Categorization of Analytical Methods and Models – Big Data – Business Analytics in Practice – Descriptive Statistics – Types of Data – Modifying Data in Excel – Creating Distributions from Data – Measures of Location – Measures of Variability – Analysing Distributions – Measures of Association between Two Variables.

Unit-2 - Regression & Forecasting ***9 Hour***

Linear and Logistic Regression & Forecasting – Simple Linear Regression Model – Least Square Method – Multiple Regression Model – Inference and Regression – Time Series Patterns – Forecast Accuracy – Moving Averages and Exponential Smoothening – Regression Analysis for Forecasting.

Unit-3 - Optimization Models ***9 Hour***

Spreadsheet Models & Linear Optimization Models – Building Good Spreadsheet Models – What-If Analysis – Useful Excel Functions for Modelling – Linear Optimization Models – Simple Maximization Problem – Simple Minimization Problem – Sensitivity Analysis.

Unit-4 - Statistics and Probability ***9 Hour***

Designing a Study - Preparing a Codebook - Getting to know IBM SPSS - Preparing the Data File - Creating a Data File and Entering Data - Descriptive Statistics - Using Graphs to Describe and Explore the Data - Manipulating the Data - Checking the Reliability of a Scale - Choosing the Right Statistic - Statistical Techniques to Explore Relationships among Variables. Descriptive analysis - Measure of central tendency, measure of spread, five points' summary, Probability Distributions, Probability in Business Analytics, Binomial distribution, Poisson distribution, Bayes theorem, central limit theorem, Correlation, covariance, confidence intervals, hypothesis testing, F-test, Z-test, t-test, ANOVA, chi-square test.

Unit-5 - Data Warehousing ***9 Hour***

Data Warehousing: Identify purpose of data warehousing - Identify between key components of a data warehouse - Distinguish between data warehouses and data lakes - Determine the role of different warehousing techniques - Data Warehousing Tools: Differentiate between utility of Relational DW, cubes, and in-memory scenarios - Compare techniques for data integration with regards to warehousing - Use warehousing tools - Use integration tools for warehousing.

Learning Resources	1 Anil Maheswari - "Data Analytics"- McGraw Hill Education (India) Private Ltd, Kindle Edition, 2021. 2 Tim Costello, Lori Blackshear – "Prepare Your Data For Tableau: A Practical Guide To The Tableau Data Prep Tool" –Apress – 1stEdition – 2020 3 Brian Larson - "Data Analysis with Microsoft Power BI" - McGraw-Hill Education - 1st Edition – 2020 4 Jeffrey D. Camm, James J. Cochran, Michael J. Fry, Jeffrey W.Ohlmann, David R. Anderson,Dennis J. Sweeney,Thomas A. Williams – "Business Analytics" – Cengage – 3rd Edition – 2019	5 James (JD) Long – "R Cookbook" - O'Reilly Media Inc. - 2nd Edition– 2019 6 Andy Field - "Discovering Statistics Using IBM SPSS Statistics" - Sage Publications Ltd - 5th Edition – 2018 7 Gowrishankar S, Veena A - "Introduction to Python Programming" - Chapman and Hall/CRC – 1st Edition – 2018. 8 Sandip Rakshit - "R Programming for Beginners" - McGraw Hill Education - 1st edition 21 July 2017.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd	1 Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai	1 Dr. K. Harisudha, SRMIST

Course Code	21ECE377T	**Course Name**	BIG DATA ANALYTICS STRATEGIES FOR THE SMART GRID	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*understand the basics of smart grid*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*design architecture of smart grid*															
CLR-3:	*summarize WAMS architecture*															
CLR-4:	*illustrate application of big data analytics*															
CLR-5:	*apply big data analytics in smart grid*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the basics of smart grid*	-	-	-	-	3	-	-	-	-	-	-	-	-	-	2
CO-2:	*compile architecture of smart grid*	-	-	3	-	-	-	-	-	-	-	-	-	-	-	2
CO-3:	*implement phasor measurement units*	1	-	-	-	3	-	-	-	-	-	-	-	-	-	2
CO-4:	*develop big data analytic framework in smart grid*	-	-	-	-	3	-	-	-	-	-	-	-	-	-	2
CO-5:	*apply data management in smart grid applications*	1	-	-	-	3	-	-	-	-	-	-	-	-	-	2

Unit-1 - Introduction to Smart Grid and Communication Technologies in Smart Grid ***9 Hour***

Basics of power systems, definition of smart grid, need for smart grid, smart grid domain, enablers of smart grid, smart grid priority areas, regulatory challenges, and smart-grid activities in India. Communication Technologies in Smart Grid: Introduction to Communication Technology, Two Way Digital Communications Paradigm, Synchro- Phasor Measurement Units (PMUs) – Wide Area Measurement Systems (WAMS)- Introduction to Internet of things (IoT)- Applications of IoT in Smart Grid

Unit-2 - Smart Grid Architecture ***9 Hour***

Smart grid architecture, standards-policies, smart-grid control layer and elements, network architectures, IP-based systems, power line communications, supervisory control and data acquisition system, advanced metering infrastructure. The fundamental components of Smart Grid designs, Transmission Automation, Distribution Automation, Renewable Integration

Unit-3 - Phasor Measurement Units ***9 Hour***

Importance of PMUs, Phasor Measurement Units and Phasor Data Concentrators Wide Area Monitoring: WAMS concept, data collection, WAMS architecture, Monitoring systems placement, Advanced data processing. Time-frequency representation: Hilbert–Huang analysis, Wavelet analysis, Dynamic harmonic regression, Multivariant multi scale analysis: Multi-signal Prony analysis, Data fusion principles

Unit-4 - Application of Big Data Analytics in Smart Grid ***9 Hour***

Big data characteristics in smart grid, Data sources in smart grids, Data analysis techniques, Procedures of data Mining in Smart Grids, Big data analytics in smart grid-Fault detection, Predictive maintenance/condition-based maintenance, Transient stability analysis, Electric device state estimation/health monitoring, Power quality monitoring, Topology identification, Renewable energy forecasting, load forecasting, load profiling

Unit-5 - Smart Grid Data Management and Applications ***9 Hour***

Overview of Deep Learning, artificial neural network, Pricing and energy forecasting in Demand Response, case study on Energy Forecast, Smart Meter Data Management -PHEVs: Internet of Vehicles - Smart Buildings.

Learning Resources	1. *Smart Grids, Infrastructure, Technology and Solutions, S. Borlase, CRC Press, 2013, 1stEdition.* 2. *Renewable and Efficient Electric Power System, G. Masters, Wiley–IEEE Press,2013, 2nd Edition.* 3. *Wide Area Monitoring of Interconnected Power Systems, R. Messina, IET publisher, 2015, 1st Edition* 4. *Interconnected Power Systems Wide-Area Dynamic Monitoring and Control Applications, Yong Li, D. Yang, Fang Liu, Y. Cao, Springer-Verlag Berlin Heidelberg, 2016, 1st Edition* 5. *Power System Stability and Control, Prabha Kundur, McGraw Hill Education, 2006, 1st Edition.*	6. *Introduction to Machine Learning with Python, Andreas C. Mueller and Sarah Guido, O'Reilly Media, Inc.* 7. *Smart Grid Technology: A Cloud Computing and Data Management Approach, S. Misra and S. Bera, Cambridge University Press, 2018, 1st Edition.* 8. *Smart Grid Communication Infrastructure: Big Data, Cloud Computing and Security, F. Ye, Y. Qian and R.Q. Hu, Wiley IEEE Press, 2018, 1st Edition.* 9. *Zhang, Y., Huang, T. & Bompard, E.F. Big data analytics in smart grids: a review. Energy Inform 1, 8 (2018). https://doi.org/10.1186/s42162-018-0007-5*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	35%	-	35%	-	35%	-
Level 4	Analyze	25%	-	25%	-	25%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1. *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1. *Dr. Damodar Panigrahy, SRMIST*

Course Code	21ECE470T	Course Name	CLOUD AND DISTRIBUTED COMPUTING FOR DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the fundamental ideas behind Cloud Computing, the evolution of the paradigm, its applicability; benefits, as well as current and future challenges*
CLR-2:	*learn about AWS IoT Analytics*
CLR-3:	*understand the fundamental ideas behind AWS IoT Analytics Commands*
CLR-4:	*explore distributed system models and computer clusters for scalable parallel computing*
CLR-5:	*learn about parallel processing for data intensive computing*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*explain the fundamental ideas behind cloud computing, cloud models and current trends*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-2:	*comprehend AWS IoT analytics*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*interpret commands of AWS IoT analytics*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*-*	*3*
CO-4:	*apply distributed system model and understand the design principles of computer clusters*	*3*	*-*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*3*	*-*
CO-5:	*illustrate the fundamental concepts parallel processing*	*3*	*3*	*3*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*

Unit-1 - Introduction to Cloud Computing	***9 Hour***
Introduction to Cloud Computing: Why Clouds? What is a Cloud? What's new in today's Clouds? - Evolution of cloud computing-1 Cloud Computing: Basic Concepts and Terminology-Network-Centric Computing-Goals and Benefits-Risks and Challenges-Roles and Boundaries Cloud Characteristics- Cloud Service Models-Cloud Deployment Models-Cloud Service Providers and the Cloud Ecosystem-Amazon Web Services (AWS), Google Clouds, Microsoft Azure Cloud-SLA Management in Cloud Computing: A Service Providers Perspective	
Unit-2 - AWS IoT Analytics	***9 Hour***
What Is AWS IoT Analytics? - Why Use AWS IoT Analytics? -How to Use AWS IoT Analytics -AWS IoT Analytics Message Payload Restrictions- Getting Started with AWS IoT Analytics-Pipeline Activities -Pipeline Activities -Automating Your Workflow -SQL Support -Visualizing AWS IoT Analytics Data with Quick Sight-Logging AWS IoT Analytics API Calls with CloudTrail	
Unit-3 - AWS IoT Analytics Commands	***9 Hour***
BatchPutMessage-CancelPipeline Reprocessing -CreateChannel -CreateDatasetContent -CreateDatastore -CreatePipeline -DeleteChannel -DeleteDataset- DeleteDatasetContent -DeleteDatastore -DeletePipeline -DescribeChannel -DescribeDataset -DescribeDatastore -DescribeLoggingOptions-DescribePipeline - GetDatasetContent -ListChannels-ListDatasetContents -ListDatasets -ListDatastores-ListPipelines-ListTagsForResource-PutLoggingOptions- RunPipelineActivity SampleChannelData-StartPipelineReprocessing-TagResource -UntagResource -UpdateChannel-UpdateDataset-UpdateDatastore-UpdatePipeline	
Unit-4 - Distributed Cloud Computing	***9 Hour***
System Models for Distributed and Cloud Computing: Clusters of Cooperative computers-Grid Computing Infrastructures-Peer-to-Peer Network families- Software Environments for Distributed Systems and clouds: Service Oriented Architecture(SOA)-Trends towards distributed operating systems-Parallel and distributed programming models-Cluster Development trends-Design Objectives of Computer Clusters, Fundamental Cluster Design Issues-n Design Principles of Computer Clusters Single System Image features--High availability through redundancy, fault tolerant cluster configurations	

Unit-5 - Technologies and Techniques	***9 Hour***
Load balancing techniques for Data Intensive computing – Resource Management for Data Intensive Clouds – SALT - Parallel Processing, Multiprocessors and Virtualization in Data intensive Computing - Challenges in Data Intensive Analysis and Visualization - Large-Scale Data Analytics Using Ensemble Clustering - Ensemble Feature Ranking Methods for Data Intensive Computing Application - Record Linkage Methodology and Applications- Semantic Wrapper	

Learning Resources	*1 Dan C. Marinescu, Cloud Computing Theory and Practice, 2nd Edition, Elsevier Inc., 2018* *2 Hwang, K., Dongarra, J. and Fox, G.C., 2013. Distributed and cloud computing: from parallel processing to the internet of things. Morgan ufmann.* *3 Furht, Borko, Escalante, Armando, "Handbook of Data Intensive Computing", Springer 2011*	*4 Rajkumar Buyya, James Broberg, Andrzej Go scinski, Cloud Computing Principles and Paradigms, Wiley Publications, 2017.* *5 Bahga, A. and Madisetti, V., 2013. Cloud computing: A hands-on approach. CreateSpace Independent Publishing Platform. AWS IoT Analytics User Guide*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	*-*	-	*10%*	-	-	-
Level 6	*Create*	*-*	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Mr. Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd	*1. Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	*1. Mr. Maria Dominic Savio.M, SRMIST*

Course Code	21ECE471T	**Course Name**	DATA MINING TECHNIQUES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify data, patterns and applications suitable for data mining*
CLR-2:	*forecast trends to make informed decisions using data mining*
CLR-3:	*understand various classification algorithms*
CLR-4:	*group data with similar properties using clustering*
CLR-5:	*separate contaminated data from data set*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the basic concepts of Data Mining*	3	2	-	-	1	-	-	-	-	-	-	-	3	-	-
CO-2:	*compile various patterns of Data Mining Techniques*	-	3	1	-	2	-	-	-	-	-	-	-	-	1	-
CO-3:	*analyze data using classification algorithms*	-	-	2	3	1	-	-	-	-	-	-	-	3	-	-
CO-4:	*produce distinct groups within dataset using clustering algorithm*	-	1	3	-	2	-	-	-	-	-	-	-	2	-	-
CO-5:	*implement method of outlier data detection techniques*	2	-	1	3	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Concepts of Data Mining — *9 Hour*

Why Data mining? What is Data mining? - Kinds of data meant for mining - Kinds of patterns that can be mined - Applications suitable for data mining - Issues in Data mining - Data objects and Attribute types - Statistical descriptions of data - Need for data pre-processing and data quality - Data cleaning -Data integration - Data reduction - Data transformation - Data cube and its usage.

Unit-2 - Data Mining Techniques — *9 Hour*

Mining frequent patterns: Basic concepts - Market Basket Analysis - Frequent item sets, Closed item sets - Association rules-Introduction - Apriori algorithm-theoretical approach - Generating Association rules from frequent item sets - Improving efficiency of Apriori - Pattern growth approach - Mining frequent item sets using Vertical data format - Strong rules vs. weak rules - Association analysis to Correlation analysis - Comparison of pattern evaluation measures.

Unit-3- Classification Algorithms — *9 Hour*

Classification: Basic concepts - General approach to Classification - Decision tree induction - Algorithm for Decision tree induction - Numerical example for Decision tree induction - Attribute selection measure - Tree pruning - Scalability and Decision tree induction - Bayes' Theorem - Naïve Bayesian Classification - IF-THEN rules for classification - Rule extraction from a decision tree - Metrics for evaluating classifier performance - Cross validation - Bootstrap - Ensemble methods- Introduction - Bagging and Boosting - Random Forest: Introduction.

Unit-4 - Cluster Analysis — *9 Hour*

Introduction - Requirements and overview of different categories - Partitioning method: Introduction - k-means - k-medoids - Hierarchical method: Introduction -Distance measures in algorithmic methods- Distance measures in algorithmic methods - BIRCH technique - DBSCAN technique - STING technique - CLIQUE technique - Evaluation of clustering techniques.

Unit-5 - Outlier Analysis Techniques — *9 Hour*

Outliers: Introduction - Challenges of outlier detection - Outlier detection methods: Introduction - Supervised and Semi-supervised methods -Unsupervised methods - Statistical and Proximity based methods - Statistical approaches - Statistical data mining - Data mining and recommender systems - Data mining for financial data analysis - Data mining for Intrusion detection.

Learning Resources	1. *Jiawei Han and Micheline Kamber, "Data Mining: Concepts and Techniques", 3rd Edition, Morgan Kauffman Publishers, 2011.* 2. *Charu C. Aggarwal, "Data Mining the Textbook", Springer, 2015.*	3. *Mohammed J. Zak and Wagner Meira Jr., Data Mining And Analysis, "Fundamental Concepts And Algorithms", Cambridge University Press, 2014.*

Learning Assessment							
		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Formative CLA-1 Average of unit test (50%)*		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1 *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1 *Mr. A. Joshua Jafferson, SRMIST*

Course Code	21ECE472T	Course Name	SOCIAL MEDIA DATA ANALYTICS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*identify the various concepts for data identification*
CLR-2:	*familiarize the learners with various analysis tools*
CLR-3:	*enable the learners to develop skills required for information interpretation*
CLR-4:	*acquire the knowledge of social influence parameter of the system*
CLR-5:	*outline the behavior analysis of group and individual*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the various concepts for data identification*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-2:	*familiarize the learners with various analysis tools*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	*1*	-
CO-3:	*enable the learners to develop skills required for information interpretation*	*1*	-	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*acquire the knowledge of social influence parameter of the system*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*outline the behavior analysis of group and individual*	*1*	-	-	-	*3*	-	-	-	-	-	-	-	-	*1*	-

Unit-1 - Social Media Data Identification	***9 Hour***
Attributes of data-casting a net-regular expression-iterative cleansing process-subset of people-predictive analytics-descriptive analytics-structured data-unstructured data-big data	
Unit-2 - Social Media Data Analysis	***9 Hour***
Four dimensions of analysis taxonomy-depth of analysis-machine capacity-domain analysis-external social media-internal social media-velocity of data-validating the hypothesis-deep analysis software	
Unit-3 - Information Interpretation	***9 Hour***
Social analytics process-finding the right data-customizing and modifying tools-analyzing consumer -common visualization charts-common pitfalls-visually representing unstructured data-case study-information interpretation	
Unit-4 - Social Influence Analysis	***9 Hour***
Influence Related Statistics-edge and node measure-Social Similarity and Influence-Influence Maximization in Viral Marketing-Expert Location without Graph Constraints -Expert Location with Score Propagation-Expert Team Formation-Other Related Approaches-Expert Location Systems.	
Unit-5 - Behavior Analytics	***9 Hour***
Individual Behavior Analysis- Individual Behavior Modeling- Individual Behavior Prediction Collective Behavior: Collective Behavior Analysis-Collective Behavior Modeling- Collective Behavior Prediction- Exploring Facebook's Social Graph API's- Analyzing Social Graph Connections	

Learning Resources	1 *Mathew Ganis, Avinash Koihrkar Social Media Analytics IBM Press 2015 / 1st edition* 2 *Charu C. Aggarwal, Social Network Data Analytics, Springer, ISBN: 978-1-4419-8461-6* 3 *Reza Zafarani Mohammad Ali Abbasi Huan Liu, Social Media Mining, Cambridge University Press, ISBN:10: 1107018854*	4 *Marshall Sponder, Social Media Analytics: Effective Tools for Building, Interpreting, and Using Metrics, McGraw Hill Education, 978- 0-07-176829-0*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd	1 Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai	1. Dr.C. Vimala, SRMIST

							L	T	P	C
Course Code	21ECE473T	**Course Name**	DATA SCIENCE FOR IOT ENGINEERS: A SYSTEMS ANALYTICS APPROACH MEDIA ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*explain the Basic Concepts of IoT technology*															
CLR-2:	*explore the statistical and machine learning techniques*															
CLR-3:	*incorporates the machine learning algorithm on IoT applications*															
CLR-4:	*analyse the techniques of data analytics*															
CLR-5:	*create data analytics based IoT applications*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the basic concepts of IoT, simulation and estimation techniques*	3	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*analyse the Statistical and machine learning techniques for IoT*	2	3	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-3:	*evaluate the applications of machine learning techniques for IoT*	-	-	3	-	-	-	-	-	-	-	-	-	-	3	-
CO-4:	*apply the data analytics techniques on IoT*	-	-	3	-	-	-	-	-	-	-	--	-	3	-	-
CO-5:	*incorporate the Data analytics on IoT applications*	-	-	3	-	-	-	-	-	-	-	-	-	-	3	-

Unit-1 - Introduction to IoT	***9 Hour***
The internet of things -IoT application domains, IoT reference model, Performance evaluation and modelling of IoT systems, IoT Architecture, Discrete-event simulation technique for IoT - Recertification of IoT devices: a simple model, Recertification of IoT devices: a more complex model, Generating random numbers, Simulation designs, Estimation techniques, Validation of a simulation model	
Unit-2 - Statistical and Machine Learning Techniques for IoT	***9 Hour***
Multivariable linear regression, Time series, Principal Component Analysis (PCA), Hierarchical clustering, k-means algorithm, naive bayes classifier, Support Vector Machines, Hidden Markov Models, Digital Twins.	
Unit-3 - Machine Learning Techniques Case Studies	***9 Hour***
Outliner and fraud detection using k means, fault detection using PCA, market analysis using linear regressing, weather forecasting using time series, face detection using SVM, passenger travel pattern using k nearest neighbour, smart agriculture using naive bayes	
Unit-4 - Data Analytics Technologies	***9 Hour***
Data Analysis and Machine Learning Effort in Healthcare, Data Analytics and Predictive Analytics in the Era of Big Data, Risk Modelling and Data Science, Hadoop Technology	
Unit-5 - IoT/Data Analytics Case Studies	***9 Hour***
Defragmenting Intelligent Transportation, Connected and Autonomous Vehicles, Smart Home Services Using the Internet of Things, Emotional Insights via Wearables, Home Healthcare and Remote Patient Monitoring	

Learning Resources	1 *An Introduction to IoT Analytics, Harry G. Perros, 1st edition, CRC Press, Taylor & Francis Group, 2021.* 2 *Data Science for IoT Engineers: A Systems Analytics Approach, P. G. Madhavan, Mercury Learning and Information, 2022*	3 *Internet of Things and Analytics Handbook, edited by Hwaiyu Geng, Wiley, 2017* 4 *Research articles on data analytics/Machine learning for IoT.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*10%*	-	*15%*	-
Level 2	*Understand*	*15%*	-	*10%*	-	*15%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*25%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*25%*	-
Level 5	*Evaluate*	*15%*	-	*20%*	-	*20%*	-
Level 6	*Create*	*15%*	-	*20%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Mr. Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1 *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1 *Dr.S. Kayalvizhi, SRMIST*

Course Code	21ECE474T	Course Name	BIG DATA ANALYTICS TOOLS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*gain knowledge about the various tools and techniques used in big data analytics*
CLR-2:	*learn the fundamentals of Hadoop and the related technologies*
CLR-3:	*understand the basics of development of applications using MapReduce, HDFS, Pig, Hive*
CLR-4:	*learn the basics of Apache Spark, Flink and understand the importance of NoSQL databases*
CLR-5:	*learn about Enterprise Data Science and data visualization tools*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*use the various tools and techniques in big data analytics*	3	3	-	2	-	-	-	-	-	-	-	-	-	2	-
CO-2:	*implement Hadoop and related technologies to big data analytics*	3	3	-	2	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*construct big data application using MapReduce, HDFS, Pig, Hive*	3	3	-	2	-	-	-	-	-	-	-	-	2	-	3
CO-4:	*apply Apache Spark and Flink to applications and NoSQL databases*	3	-	3	-	2	-	-	-	-	-	-	-	2	3	-
CO-5:	*understand the applications of Enterprise Data Science and data visualization tools*	3	3	3	-	2	-	-	-	-	-	-	-	-	3	-

Unit-1 - Big Data Overview **9 Hour**

Overview of Big Data Analytics- Introduction to data analytics and big data- Big Data Mining- Technical elements of the Big Data platform- Analytics Toolkit, Components of the Distributed and Parallel Computing for Big Data analytics toolkit-- Cloud computing and Big Data- In-Memory Computing Technology for Big Data- Hadoop Ecosystem- The core modules of Hadoop

Unit-2 - Hadoop and YARN **9 Hour**

Introduction to Hadoop-Mapreduce -Scaling Out-Data flow, Combiner Functions -Hadoop Streaming -HDFS-Hadoop Filesystems-Introduction to YARN- YARN-Job Scheduling - Hadoop I/O -Data Integrity - Compression - Serialization - File based Data Structures - Developing a Mapreduce Application

Unit-3 - Pig and Hive **9 Hour**

Introduction to Pig - Basics of Pig Latin- Introduction to Hive- Installing and running Hive- Introduction to HiveQL- Introduction to Zookeeper- Installing and running Zookeeper- The Zookeeper Service- Flume Architecture

Unit-4 - NoSQL **9 Hour**

Introduction to Sqoop- Introducing Oozie- Apache Spark- limitations of Hadoop and overcoming the limitations- Introduction to Apache Flink- Batch analytics using Flink- Installing Flink- Big Data Mining with NoSQL- Why NoSQL? NoSQL databases- Introduction to HBase- Introduction to MongoDB, Cassandra

Unit-5 - Data Visualization Tools **9 Hour**

Enterprise Data Science Overview- Data Science Solutions in the enterprise- Enterprise data science – Machine Learning and AI- Enterprise Infrastructure solutions- Visualizing Big Data- Using Python and R for visualization- Big Data Visualization Tools- Data Visualization with Tableau- Case Studies: Spark- Case Studies: NoSQL

Learning Resources	1 *Tom White, Hadoop: The Definitive Guide, 3rd Edition, O'Reilly, 2012.* 2 *Sridhar Alla,Big Data Analytics with Hadoop3,Packt,2018*	3 *Nataraj Dasgupta, Practical Big Data Analytics, Packt, 2018.* 4 *DT Editorial Services, Big Data Black Book, 2016.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Mr.Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1 *Dr. Bhuvaneshwari, Professor, Mit, Anna University, Chennai*	1 *Mr. Maria Dominic Savio.M, SRMIST*

Course Code	21ECE475T	**Course Name**	TOOLS FOR REAL-TIME DATA PROCESSING AND ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*create foundation innovative real-time data processing solutions*
CLR-2:	*handle large amount of data in real time using Apache Storm*
CLR-3:	*learn real time stream processing*
CLR-4:	*build storages services and analytics tools*
CLR-5:	*deploy AI and IoT application in real time hardware platform*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze large amounts of data in real-time*	*3*	*1*	-	-	-	2	-	-	-	-	-	-	-	-	-
CO-2:	*develop storm cluster and storm topology for real time data*	*1*	-	2	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*process real time data in Azure*	-	-	2	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-4:	*implement storage services and analytics tools for results*	-	*2*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-5:	*write program on NVIDIA Jetson Nano*	-	*3*	-	-	-	2	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Real-Time Data Processing	***9 Hour***
Overview of real-time data processing, Characteristics of real-time data, Use cases for real-time data processing, real time data processing tools, Introducing the Big Data Technology Landscape and Analytics Platform,	
Unit-2 - Apache Storm	***9 Hour***
Getting Acquainted with Storm, Storm architecture and its components, How and when to use Storm, Processing Data with Storm, Setting Up Storm on a Single Machine, Setting Up a Storm Cluster, Monitoring the Storm Cluster, Introduction to Trident and Optimizing Storm Performance	
Unit-3 -Microsoft Azure Basics	***9 Hour***
Enterprise Analytics Fundamentals, Getting Data into Azure, Storing Ingested Data in Azure, Real-Time Processing in Azure, Real-Time Micro-Batch Processing in Azure, Batch Processing in Azure	
Unit-4 - Storage Services and Analytics Tools	***9 Hour***
Interactive Querying in Azure, Hot and Cold Path Serving Layer in Azure, Intelligence and Machine Learning, Managing Metadata in Azure, Protecting Your Data in Azure, Performing Analytics	
Unit-5 -Jetson Nano	***9 Hour***
Introduction to NVIDIA Jetson Nano, NVIDIA Jetson Nano Hardware Specifications What Can We Do with NVIDIA Jetson Nano?, Setting Up and Running, Administering NVIDIA Jetson Nano, NVIDIA Jetson Nano Programming, NVIDIA Jetson Nano I/O Programming, NVIDIA Jetson Nano Camera, Deep-Learning Computation	

Learning Resources	*1 Sumit Gupta, Shilpi Saxena, "Real-Time Big Data Analytics", Packt publishing, 2016.* *2 Ankit Jain, Anand Nalya, "Learning Storm: Create real-time stream processing applications with Apache Storm", Packt publishing, 2014.*	*3 Zoiner Tejada, " Mastering Azure Analytics ", O'Reilly Media, 2017* *4 Agus Kurniawan, " IoT Projects with NVIDIA Jetson Nano AI-Enabled Internet of Things Projects for Beginners ", Apress, 2021.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Mr. Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1 *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1 *Mr. Joshua Jaferson A, SRMIST*

Course Code	21ECE476T	Course Name	DATA ANALYTICS WITH SPARK USING PYTHON	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the overview of the big data ecosystem including the genesis and evolution of the spark*
CLR-2:	*construct the basic programming building blocks of Spark using RDDs*
CLR-3:	*explore the advanced constructs to program using Spark core API*
CLR-4:	*analyze the Various Spark optimization techniques*
CLR-5:	*implement the integration of Spark and SQL*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*express the big data ecosystem especially Spark*	-	*2*	-	*3*	-	-	-	-	-	-	-	*2*	-	-	*3*
CO-2:	*generate basic programming building blocks of Spark using RDDs*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*develop advanced programs using Spark core API*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the application and various optimization techniques of Spark*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*implement integration of Spark and Structured Query Language*	-	*3*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introducing Big Data, Hadoop, and Spark	***9 Hour***
Introduction to Big Data, Distributed Computing, and Hadoop - Introduction to Apache Spark : Apache Spark Background - Uses for Spark - Programming Interfaces to Spark - Submission Types for Spark Programs-Input/Output Types for Spark Applications - The Spark RDD - Functional Programming Using Python: Data Structures - Python Object Serialization - Python Functional Programming Basics - Anatomy of a Spark Application	
Unit-2 - Programming with RDDs	***9 Hour***
Loading Data into RDDs: Creating an RDD from a File - Methods for Creating RDDs - Creating an RDD from an Object File, Data Source and Programmatically - Operations on RDDs: RDD Transformations and Actions - Transformations on Pair RDDs, Sets and Numeric RDDs - Join Transformations - Joining Datasets in Spark	
Unit-3 - Advanced Programming Using the Spark Core API	***9 Hour***
Shared Variables in Spark: Broadcast Variables and Accumulators - Partitioning Data in Spark : Controlling Partitions, Repartitioning Functions - RDD Storage Options : RDD Caching, Persisting RDDs - Checkpointing RDDs - Data Sampling with Spark	
Unit-4 - Spark Application and Optimization	***9 Hour***
Spark Environment Variables and Spark Configuration Properties - Optimizing Spark: Filter Early, Filter Often, Optimizing Associative Operations, Understanding the Impact of Functions and Closures, Considerations for Collecting Data, Avoiding Inefficient Partitioning, Diagnosing Application Performance Issues	
Unit-5 - Spark SQL	***9 Hour***
Architecture - Getting Started with Data Frames - Using Data Frames - Caching, Persisting, and Repartitioning Data Frames - Saving Data Frame Output - Accessing Spark SQL - Using Spark with HBase - Machine Learning with Spark	

Learning Resources	*1 Data Analytics with Spark Using Python, by Jeffrey Aven, Released June 2018, First edition Addison- Wesley Professional*	*2 Learning Spark by Holden Karau, Andy Konwinski, Patrick Wendell, and Matei Zaharia, Published by O'Reilly Media,2015* *3 Spark: The Definitive Guide by Bill Chambers and Matei Zaharia, 2018, Published by O'Reilly Media*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	35%	-	30%	-
Level 4	*Analyze*	30%	-	35%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Ms. Roshni Rajan, SDE II, Amazon, US.*	1 *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1 *Dr. E. Chitra, SRMIST*
2 *Mr. S. Ashish, Software Engineer, TCS – Digital, Chennai*		

Course Code	21ECE477T	**Course Name**	BIG DATA AND HEALTH CARE ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide basic insight on Big data analytics in health care*
CLR-2:	*gain knowledge about the various data sources in health care analytics*
CLR-3:	*learn the concepts of data mining techniques in health care*
CLR-4:	*understand the concepts of advanced data analytic tools in Health care*
CLR-5:	*explore big data analytics for disease diagnosis*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the basic concepts of big data analytics in health care*	3	-	-	-	-	-	-	2	-	-	-	-	-	-	-
CO-2:	*incorporate various data sources in health care analytics*	3	-	-	-	-	-	-	-	-	-	-	3	-	-	-
CO-3:	*implement the methods of data mining techniques in health care*	3	-	-	-	-	-	-	-	-	-	-	2	-	-	-
CO-4:	*express the concept of advanced data analytic tools in Health care*	-	3	-	-	-	-	-	-	-	-	-	3	-	-	-
CO-5:	*analyze disease using data analytic mechanism and standard*	-	3	-	-	-	-	-	-	-	-	-	3	-	-	-

Unit-1 - Big Data Analytics for Health Care ***9 Hour***

Data type, Characteristics of big data in health care, Analytical tools in health care: Hadoop distribution file system, MapReduce, Hive, Pig and Pig Latin, Zookeeper, Hbase, Need of big data in therapeutic intervention, Biological data capturing and processing: Architectural framework, data modeling, Maintaining of threshold quality of data, Interpretation of processed of clinical data: Qualitative approach, Quantitative approach, Patient data management for digital therapeutic, Advantages and limitations, Case study to predict creatine kinase- model creation.

Unit-2 - Health Care Data Source and Basic Analytics ***9 Hour***

Health care data sources, Advanced data analytics for health care, Applications and practical systems for health care, History of EHR, Components of EHR, Coding system: ICD, CPT, SNOMED-CT, LOINC, RxNorm ICF, DRG, UMLS, DICOM, Benefits of HER, Challenges of using EHR data, Phenotyping algorithm

Unit-3- Mining of Sensor Data in Health Care ***9 Hour***

Mining sensor data in Medical Informatics, Challenges in Health Care data analysis, Sensor data mining applications, Nonclinical health care applications, Mining information from clinical text, Current Methodologies: Rule based approaches, Pattern based algorithms, Machine learning algorithm, Clinical text Corpora and Evaluation Metrics, Challenges of Processing clinical reports, clinical applications.

Unit-4 - Advanced Data Analytics for Health Care ***9 Hour***

Statistical Prediction models : Linear Regression, Generalized addictive model, Logistic Regression, Bayesian model, Advanced Prediction models: Multiple Instance learning, Reinforcement learning, Sparse methods , Kernal methods, Survival models, Evaluation and Validation

Unit-5 - Disease Diagnosis Using Cloud Computing and Artificial Intelligence in Health Care Analytics ***9 Hour***

Big data respiratory in health care, Management and analysis of bigdata in healthcare, commercial platform for healthcare data analytics, Mathematical model of infectious disease and their development: SIR, SEIR, Agent based model, system architecture design and predictive analytics using machine learning, Electronic health records, Healthcare data management and its limitations: Data interoperability, data quality, data insecurity, policy setting, theoretical framework, case study to predict skin cancer using big data analytics and AI techniques

Learning Resources	1 *Peter Ghavami, "Big Data Analytics Method", Walter de Gruyter Inc, 2nd Edition, 2020* 2 *Pantea Keikhosrokiani, "Big data Analytics for Health care: Data sets, Techniques, Life cycles, Management, and Applications, Elsevier, 2022.* 3 *Chandan K.Reddy, Charu C. Agarwal, "Health care and data analytics", CRS Press, 2015*	4 *Dietrich, D., Heller, B., & Yang, B., "Data science & big data analytics: discovering, analyzing, visualizing and presenting data", Wiley, 2015.* 5 *Nataraj Dasgupta, Practical Big Data Analytics, Packt, 2018.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	15%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	25%	-	25%	-	25%	-
Level 4	*Analyze*	35%	-	25%	-	35%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 *Mr. Baraneedhara Karthikeyan, Director, Skylim Infotech Pvt Ptd*	1 *Dr. Bhuvaneshwari, Professor, MIT, Anna University, Chennai*	1 *Dr. T. Rajalakshmi, SRMIST*

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SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ECC305T	Course Name	DIGITAL LOGIC SYNTHESIS USING HDL	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the Hardware description language and digital design flow*
CLR-2:	*illustrate the basic of combinational circuit and various modelling style in HDL*
CLR-3:	*introduce sequential circuit design using HDL*
CLR-4:	*enable to Understand the finite state machine and complex circuit design*
CLR-5:	*understand the basic of circuit design using CMOS*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basic of Hardware description language and digital design flow*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*explain various modelling style in HDL and design of combinational circuit*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*illustrate the sequential logic circuit design*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*interpret on complex designs and improve the design performance of FSM*	*2*	*2*	-	*3*	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*summarize the circuit design of combinational circuit using CMOS logic*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Introduction HDL ***9 Hour***

Overview of digital design with HDL. Basic concept Verilog- Module and ports - task and function-Introduction to synthesis and synthesis design flow. VHDL-Introduction and comparison with Verilog

Unit-2 - Combinational Logic Design ***9 Hour***

Data flow, Gate level, behavioural and switch level modelling. Combinational circuit design - Half adder and Full adder Arithmetic Circuits Multiplexers, Decoders and Encoders

Unit-3 - Sequential Logic Design ***9 Hour***

Sequential Logic Design - Flip-Flop, Synchronous and Asynchronous Reset. , Synchronous Counters, Shift Register. Timing and Performance Evaluation, Asynchronous Counter Design, Memory Modules and Design, Sequential Design Guidelines -Use of Blocking Assignments, Non-blocking Assignments

Unit-4 - Complex Designs Using Verilog RTL ***9 Hour***

ALU Design, Finite State Machines, Moore versus Mealy Machines. FSM Encoding Styles, Sequence Detectors Using FSMs. Design of carry select, and carry save adder. Wallace tree and booth multiplier, analyse the synthesis process for a combinational and sequential circuit.

Unit-5 - CMOS Circuits ***9 Hour***

Performance, Power dissipation and delay of CMOS inverter circuit. Design of logic gates using static and dynamic CMOS design. Design and analyse low power circuit

Learning Resources		
Learning Resources	*1. Samir palnitkar, "Verilog HDL", Pearson education, Second Edition,20O3.* *2. Jan.M.Rabaey., Anitha Chandrakasan Borivoje Nikolic, "Digital Integrated Circuits", Second Edition,2016* *3. Michael D. Ciletti, Advanced Digital Design with Verilog HDL, Second Edition, Pearson,2011*	*4. Neil H.E Weste and Kamran Eshraghian, "Principles of CMOS VLSI Design", 2nd Edition, Addition Wesley, 1998* *5. Jayaram Bhasker, A VHDL Primer, 3rd edition., Prentice Hall, 2011*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	30%	-	30%	-	25%	-
Level 2	Understand	40%	-	40%	-	45%	-
Level 3	Apply	15%	-	15%	-	20%	-
Level 4	Analyze	15%	-	15%	-	10%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.T.Leela Krishna, Senior Solution Engineer Synopsys India Pvt. Ltd	1. Dr.N.B.Balamurugan, Associate Professor, Department of Electronics and Communication Engineering, Thiagarajar College of Engineering	1. Dr.V.Sarada, SRMIST

Course Code	21ECC306T	Course Name	CMOS ANALOG AND MIXED SIGNAL IC DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Program Outcomes (PO)												Program Specific Outcomes		
CLR-1:	*identify CMOS Analog and Mixed-Signal Circuit Design*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*analyze Device Overview*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*understand and analyse different oscillator circuits and PLL*															
CLR-4:	*understand peripheral circuits*															
CLR-5:	*analyze Package and Layout*															
Course Outcomes (CO):	*At the end of this course, learners will be able to:*															
CO-1:	*identify CMOS Analog and Mixed-Signal Circuit Design*	1	-	3	-	-	-	-	-	-	-	-	2	-	-	-
CO-2:	*analyze Device Overview*	1	-	-	3	-	2	-	-	-	-	-	-	-	-	-
CO-3:	*construct various oscillators and switched capacitors circuits*	1	-	3	2	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*discuss peripheral circuits*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*understand the layout and package*	1	2	3	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - CMOS Analog and Mixed-Signal Circuit Design **9 Hour**

An overview Introduction, Notation, Symbology, and Terminology, Technology, Circuit topology, and methodology, Analog and Mixed-Signal Integrated Design Concepts,

Unit-2 - Devices: An Overview **9 Hour**

Introduction, The PN junction, Photo-devices, FETs, Process Fitting, Ratio Concept, MOSFET Parameter Exercise, Spice Example.

Unit-3 - Oscillators and PLL **9 Hour**

Ring oscillator, Two stage and three stage ring oscillator, LC oscillators: Colpitt, Cross coupled oscillator, ,Voltage controlled oscillators, Tuning range of VCOs, Phase Locked Loop: Basic PLL topology & Characteristic Parameters, Phase detector, Charge Pump PLL, Problem of lock acquisition, Non ideal effects in PLL: PFD/CP, Jitter in PLLs, Transient response of PLL in the locked state, Delay Locked Loops, Delay Locked Loops-Continuation, Applications of PLL: Frequency multiplication, Skew reduction and jitter reduction. Case Study: Design of PLL for frequency multiplication and analyse its performance parameters

Unit-4 - Peripheral Circuits **9 Hour**

Oscillator, Non-overlapping Generator, Interface Circuitry, I/O Pad, Schmitt Trigger Circuit, Voltage Level Shifters, Power on Reset.

Unit-5 - Layout and Packaging **9 Hour**

Introduction, Process, Floor planning, ESD and I/O Pad Layout, Analog Circuit Layout technique, Digital Circuit Layout technique, Packaging.

Learning Resources		
	1. *CMOS Analog and Mixed-Signal Circuit Design Practices and Innovations, By Arjuna Marzuki, Published February 1, 2022 by CRC Press.* 2. *Cmos: Mixed–Signal Circuit Design (IEEE Press Series on Microelectronic Systems, R. Jacob Baker, Wiley–Blackwell (4 July 2002).* 3. *Allen, Holberg, “CMOS analog circuit design”, 3rd Edition, Oxford University Press, 2004.*	4. *Behzad Razavi, “Design of analog CMOS integrated circuits”, 2nd Edition, McGraw Hill, 2017.* 5. *Gray, Meyer, Lewis, Hurst, “Analysis and design of Analog Integrated Circuits”, 5th Edition, Willey International, 2009.* 6. *Adel S. Sedra, Kenneth C. Smith, “Microelectronic Circuits” 7th Edition, Oxford University Press,2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	25%	-	15%	-
Level 2	Understand	25%	-	25%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-		-	-	-
Level 6	Create	-	-		-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Mr.T.Leela Krishna, Senior Solution Engineer Synopsys India Pvt. Ltd	1 Dr.N.B.Balamurugan, Associate Professor, Department of Electronics and Communication Engineering, Thiagarajar College of Engineering	1. Dr.S.Yuvaraj, SRMIST

Course Code	21ECC333L	**Course Name**	CMOS ANALOG AND DIGITAL VLSI LABORATORY	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand MOS circuit basics*
CLR-2:	*analyze Current mirror and amplifier circuits*
CLR-3:	*understand the design of op-amp and adders*
CLR-4:	*understand the concept of counters*
CLR-5:	*design CMOS circuits using SLM*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify the MOS circuits with their types*	-	*3*	*3*	-	-	-	-	-	-	-	-	2	-	-	*2*
CO-2:	*analyze Current mirror and amplifier circuits*	-	2	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*analyze the design of op-amp and digital adders*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*understand the concept of counters and adders*	-	2	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*understand the concept of SLM*	-	2	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Cycle -1 ***30 Hour***

1. *Basic MOS Circuits: MOSFET as a switch & Inverter using SPICE.*
2. *Basic MOS current mirror circuit using SPICE.*
3. *Cascode current mirror, Wilson current mirror circuit using SPICE.*
4. *Common gate amplifier using SPICE.*
5. *One-stage op-amp using SPICE.*

Cycle -2 ***30 Hour***

6. *Design of Half and Full adder using Verilog.*
7. *Design of Up/Down Counter using Verilog.*
8. *Design of 4-bit Carry-look-ahead adder using Verilog.*
9. *Design of CMOS and, or, Nand gate using Switch-level modeling.*
10. *Pseudo-NMOS design using Switch-level modeling*

Learning Resources	1. *Lab manual prepared by the Department of ECE, SRM IST, Kattankulathur.*

Learning Assessment									
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 4	*Analyze*	-	*30%*	-	*30%*	-	*30%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100%*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys	*1. Dr.S.Meenakshi, Professor, Anna University*	*1. Dr.S.Yuvaraj, SRMIST*

Course Code	21ECC403T	**Course Name**	RF INTEGRATED CIRCUITS AND SYSTEMS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*21ECC201J, 21ECC201TJ*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the general concepts that are essential to the analysis and design of RFIC systems*
CLR-2:	*discuss the various transceiver architectures relevant to the current wireless communication systems and their relative performances*
CLR-3:	*introduce the design of basic building blocks of RF systems*
CLR-4:	*define the various classes of power amplifier and their performances*
CLR-5:	*develop foundation to the analysis and design of frequency synthesizers*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe the basic concepts and do noise analysis in RF circuit design*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*evaluate the performance of different transceiver architectures*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*classify and compare different Low noise amplifiers and Mixers*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*demonstrate the various classes of power amplifier according to their performance*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*analyze oscillators and synthesizers at RF frequencies*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Fundamental Concepts in RFIC Design and Systems ***9 Hour***

Introduction to RF design: RF design trade-offs, review of Communication Concepts, impedance transformation and matching, RF Inductors, capacitors and varactors, MOS device operation. Introduction to RF Systems: Basic RF Concepts, dB, dBm, voltage gain, channel, ACR, AACR, noise factor, NF of a cascaded system, sensitivity, Harmonic distortion, gain compression, P1dBc modulation, inter modulation, IM3, IIP3, SFDR, spectral mask..

Unit-2 - Transmitter and Receiver Architectures ***9 Hour***

General considerations, receiver architectures, transmitter architectures and OKK transceivers, linearity improvement techniques, nonlinearity calculations

Unit-3 - Low Noise Amplifiers and Mixers ***9 Hour***

LNA: General considerations, LNA topologies: CS, CG, inductive degenerated, shunt feedback, noise-cancelling, Reactance-cancelling LNAs. Mixers: Introduction to mixers, passive and active down conversion mixers, Improved mixer topologies and Up conversion mixers.

Unit-4 - Power Amplifiers ***9 Hour***

General considerations, classification of power Amplifiers, operation and characteristics of Class A, Class B and Class C, amplifiers, High efficiency power Amplifiers, cascode output stages, power Combining, Linearization techniques, polar modulation, out phasing.

Unit-5 - Oscillators and Frequency Synthesizers ***9 Hour***

Basic principles, Voltage-Controlled Oscillators (VCO), LC VCO, phase noise, mathematical model of VCO, quadrature oscillators, basic concepts of PLL, Type-I PLLs, Type-II PLLs, and phase noise in PLLs, integer-N frequency synthesizers and fractional synthesizers.

Learning Resources	1. *Razavi, RF Microelectronics, 2nd ed., Pearson, 2012* 2. *Phillip E. Allen and Douglas R. Holberg- CMOS Analog Circuit Design Oxford University Press -3rd Ed., -2011*	3. *Thomas H. Lee, Cambridge, The Design of CMOS Radio-Frequency Integrated Circuits, UK: Cambridge University Press, 2004* 4. *Ludwig, RF Circuit Design, 2nd ed., Pearson, 2009*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*25%*	-	*25%*	-	*25%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	*10%*	-	*10%*	-	*10%*	-
Level 6	*Create*	*5%*	-	*5%*	-	*5%*	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S.Meenakshi, Professor, Anna University*	1. *Dr. E. Sivakumar, SRMIST*

Course Code	21ECC404T	**Course Name**	PHYSICAL DESIGN AND AUTOMATION	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the graph theory concepts required for physical design of a VLSI system IC*
CLR-2:	*learn the methods involved in partitioning and clustering of a design layout*
CLR-3:	*learn the representation used in Floor planning and Placement process*
CLR-4:	*describe the Routing algorithms and Timing Analysis*
CLR-5:	*gain knowledge of practical physical design issues on physical layout*

		Program Outcomes (PO)												**Program Specific outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*utilize mathematical tools for physical design problems*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*expose to hierarchical modeling concepts and the necessary knowledge to perform partitioning and clustering algorithms*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*design a compact IC using floor planning and placement methodologies*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the routing process to achieve the performance of the digital design*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*design performance aware VLSI*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Data Structures and Basic Algorithms	***9 Hour***
VLSI Physical design flow- Challenges in VLSI design flow-Basic Graph theory-Complexity analysis, issues-Analysis in NP hardness-Graph search algorithms-Spanning tree algorithms-Shortest path algorithms-Min- cut and max-cut algorithms, and Steiner tree algorithms-Computational Geometry Algorithms: Line sweep-Extended line sweep-Basic Graph Structures: Atomic operations of Layout Editors-Basic Graph Structures: Linked list of blocks-Basic Graph Structures: Bin-based, and Neighbor pointer-Corner Stitching-Atomic operations using Corner stitching	
Unit-2 - Partitioning and Clustering	***9 Hour***
Introduction to Partitioning-Types of Partitioning-Mathematical Partitioning Formulations-Introduction to Move-based partitioning algorithms-KL algorithm-FM Algorithm-Metrics of Clustering-Challenges in Clustering-Hierarchical Clustering-Agglomerative Clustering-Rajaraman and Wong algorithm--Hyper edge coarsening-Modified Hyper edge coarsening Multi-level coarsening algorithm- Edge coarsening	
Unit-3 - Floor planning and Placement	***9 Hour***
Introduction to Floor planning-Floor planning problem formulation and classification- Floorplan topologies-Metrics of Floor planning- Floorplan slicing methods-Algorithms for Slicing floorplan-Floorplan representation: Corner block list-Problems in Corner block list-Non-slicing methods: O-tree-Problems in O-tree-Non-slicing methods: B-tree-Problems in B-tree-Introduction to Placement-Problem formulation and classification-Top –down partition-based placement frame work- Enhancement of Min- cut placement-Placement algorithm using Simulated annealing-Placement algorithm using Genetic algorithm	
Unit-4 - Routing and Compaction	***9 Hour***
Global Routing-Problem Formulation-Classification of Global Routing-Maze routing algorithm-Lee's algorithm-Line Probe algorithms-Detailed Routing: Problem formulation-Classification of Detailed routing-Single layer routing-Single row routing-Two-layer channel routing algorithms: Left Edge algorithm-Two-layer channel routing algorithms: Dogleg Routing algorithm-Compaction: Classification and constraint-based compaction-Virtual grid-based compaction and recent trend in Compaction-3/2 and 2D Compaction	

Unit-5 - Design Issues	**9 Hour**
Elmore Delay based routing constructions-Non- Hunan Interconnect Synthesis-Optimization of Non- Hunan-Van Ginneken's Algorithm-Two phase approach and buffer aware tree construction: C algorithm-Buffer aware tree generation-Buffered path with blockage avoidance: Dynamic programming approach-Buffered path with blockage avoidance -Graph-based approach-Buffered tree with blockage avoidance: Tree adjustment and simultaneous tree and buffer insertion approach	

Learning Resources	*1. Sherwani, Naveed A.. Algorithms for VLSI Physical Design Automation. United States: Springer, 2014.* *2. Sung Kyu Lim, "Practice Problems in VLSI physical design Automation", Springer, 2010*	*3. Sait, Sadiq M.., Youssef, Habib. VLSI Physical Design Automation: Theory and Practice. Singapore: World Scientific, 2001.* *4. Charles J. Alpert, Dinesh P. Mehta, Sachin S. Sapatnekar, Handbook of Algorithms for Physical Design* *5. Automation. United Kingdom: CRC Press, 2019.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys	*1. Dr.S.Meenakshi, Professor, Anna University*	*1. Dr. K. Ferents Koni Jiavana, SRMIST*

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

Course Code	21ECE260T	**Course Name**	INDUSTRIAL ELECTRONICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	**The purpose of learning this course is to:**
CLR-1:	*know the basic components of industrial electronics*
CLR-2:	*understand the block diagram and working principle of rectifiers*
CLR-3:	*understand the working principle of choppers and applications*
CLR-4:	*apply the components for switching applications*
CLR-5:	*implement the different devices in industrial electronics*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	**At the end of this course, learners will be able to:**	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define types of semiconductor devices for industrial applications*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*examine the working principle and construction of rectifiers*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*design the choppers for industrial electronics*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*analyze the working principle of analog and digital switches*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*illustrate the different applications of industrial electronics*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Devices in Industrial Applications	***9 Hour***
PN junction, Transistors, BJT, Mode of operation, MOSFET operation principles, transistor devices in switching mode, Thyristors, Working principle, block diagram, Control of thyristors on direct current, Control of thyristors on alternating current, Diac, Triac, Quadrac, Protection of Thyristors, Protection against Voltage Surges, Protection against Direct Overcurrent, MOS-Controlled Thyristor, The Power Transistor, Power MOSFET	
Unit-2 - Controlled Rectifiers	***9 Hour***
Single-Phase Rectifiers, Single-Phase, Full-Wave Circuit with Centre-Tapped Secondary, Single-Phase, Full-Wave Bridge Rectifiers, Three-Phase Rectifiers, Three-Phase Half-Wave Controlled Rectifier, Three-Phase, Full-Wave Rectifiers, Rectifier Efficiency and Derating Factor of Rectifier Transformers, Dual Converters	
Unit-3 - DC Choppers	***9 Hour***
Introduction, Principle of a DC Chopper, Step-down and Step-up Choppers, Step-down Chopper Analysis with DC Motor Load, Step-up Chopper, Choppers Based on the Quadrants of Operation, Second-Quadrant Chopper, Two-Quadrant Chopper, Four-Quadrant Chopper, Speed Control of a Chopper-Controlled DC Series Motor, Morgan Chopper, Applications, Advantages and Drawbacks of DC Choppers	
Unit-4 - Switching and Power Supply	***9 Hour***
Switching Devices, Generators, Multivibrators, Pulse-Pairs, Timers, Logic Elements, Overcurrent and Overvoltage Protection Modules, Voltage Stabilizers and Regulators, Other Functional Modules for Automatic Devices, Universal Overcurrent Protective Relay, Universal Overcurrent Protective Relay, Improvement of Microprocessor-Based Protective Relays	
Unit-5 - Industrial Applications	***9 Hour***
Introduction, Uninterruptible Power Supplies Batteries, Inverters, Rectifiers, High-Voltage DC Transmission, Twelve-Pulse Line Frequency Converters, Control of HVDC Converters, DC Circuit-Breakers, Induction Heating, Principle of Induction Heating, Voltage Source versus Current Source Inverters, Practical Circuit for Induction Heating, Welding, Typical SMPS Using a Flyback Chopper	

Learning Resources	1. *V. R. Moorthi, "Power Electronics Devices, Circuits and Industrial Applications" Oxford University Press, 2005*	2. *Vladimir Gurevich," Electronic Devices on Discrete Components for Industrial and Power Engineering" Taylor & Francis, 2008*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	*40%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr. G. P. Mishra, Dept. of ECE, NIT Raipur*	1. *Dr. Soumyaranjan Routray, SRMIST*
	2. *Dr. K. P. Pradhan, Dept of ECE, IIITDM Kancheepuram*	2. *Dr. Rajesh Agarwal, SRMIST*

Course Code	21ECE261T	**Course Name**	MEASUREMENTS AND INSTRUMENTATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the fundamentals of measurements and errors*
CLR-2:	*illustrate the basic of Electromechanical Instruments*
CLR-3:	*introduce signal generating circuits*
CLR-4:	*explain the working of Oscilloscopes for displaying signals*
CLR-5:	*demonstrate the concepts of Test Systems which are computer controlled*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the various methods of measurements*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*analyze electromechanical and digital indicating instruments*	-	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*implement signal generator and Analyzer*	-	*2*	-	*2*	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*acquire knowledge on different types of oscilloscopes and Data Acquisition System*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	*1*	-	-
CO-5:	*utilize the concepts of Computer Controlled Test Systems*	-	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - Measurements and Errors	***9 Hour***
Accuracy, Precision, Significant Figures, Types of Errors, Statistical Analysis, Limiting Errors - Bridge Measurements (AC and DC bridges), Bourdon Tube, Pressure Gauge, and Measurement of Flow. Analysis of Linear Systems: Time Domain Response, zero order and First order time domain system, First Order response for Step Input, Ramp Input &Impulse Input	
Unit-2 - Electromechanical and Digital Indicating Instruments	***9 Hour***
PMMC Mechanism, DC Ammeters and Voltmeters, Series and Shunt Type Ohmmeter - Alternating Current Indicating Instruments (Moving Iron instruments, electrodynamometer instrument) - D/A and A/D Converters Digital Voltmeters, Vector Voltmeter, Guarding Techniques, Automation in Voltmeter	
Unit-3 - Signal Generation and Analysis	***9 Hour***
Sine Wave Generator, Sweep Frequency Generator, Pulse and Square wave Generator - Function Generator Analyzer, Wave Analyzer, Distortion Analyzer - Harmonic Distortion Analyzer, Spectrum Analyzer, Logic Analyzer.	
Unit-4 - Oscilloscopes and Data Acquisition Systems	***9 Hour***
Simple CRO, Dual Beam, Dual Trace Sampling Oscilloscope. Analog and Digital Storage Oscilloscope - Data Acquisition Systems (DAS) - Single channel, Multi-channel, Computer based DAS	
Unit-5 - Computer Controlled Test Systems	***9 Hour***
Testing an Audio Amplifier, testing a Radio Receiver, Instruments used in Computer Controlled Instrumentation, Microprocessor based System and - Measurement case studies - Interfacing transducers to Electronic control and measuring system	

Learning Resources	1. Albert.D. Helfrick and William. D. Cooper, "Modern Electronic Instrumentation and Measurement Techniques", PHI. Learning Private Limited 2010 2. S. K. H. S. Kalsi, "Electronic Instrumentation", Tata McGraw Hill Publishing Company Ltd., 2010, 3rd edition. 3. Earnest .O Doeblin, "Measurement Systems Application and Design", McGraw Hill International editions, 5th edition, 2009.	4. A.K. Sawhney, "A course in electrical and electronic measurements and instrumentation",Dhanapat Rai & Sons, 2000 5. A.J. Bouwens, "Digital Instrumentation", McGraw Hill, 1986 Dominique Placko, "Fundamentals of Instrumentation and Measurement", ISTE Ltd., 2007 6. Alan S. Morris and Reza Langari, "Measurement and Instrumentation: Theory and application", Academic Press, 2015

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Amrendra Kumar, Keysight*	1. *Dr. D. Kalpana, Assistant Professor, MIT, Chennai*	1. *Dr. R. Manohari, SRMIST*
2. *Mr. B. Anandhan, Director, Base Electronics and Systems*	2. *Dr. S. Rajendiran, Assistant Professor, PEC, Pondicherry*	

Course Code	21ECE262T	**Course Name**	LOW POWER SENSORS TECHNOLOGY	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*low Power VLSI concepts and Power Analysis*
CLR-2:	*describe the Low Power very fast Dynamic logic circuits*
CLR-3:	*design of low power VLSI Techniques and Memories*
CLR-4:	*concepts of sensors fundamental, emerging sensor technologies and applications*
CLR-5:	*design parameters for sensor prototype and associated electronics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyze the leakage mechanism influencing different leakage currents and its impact on CMOS design*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*design of Dynamic CMOS latches, Flip-flops and power reduction*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*optimization of speed and switching activity using special techniques also optimization in arithmetic level*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*organize the sensor technology and its application*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*develop the various design parameter for sensor prototype and low-power sensors applications*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Low Power VLSI and High-Level Power Estimation and Analysis ***9 Hour***

Needs for low power VLSI-Short circuit current in CMOS inverter-CMOS leakage current-Static Current-Basic principles of low power design-Network restructuring and reorganization- Generic design flow for Low Power-System Level-Algorithm level-Power estimation for hardware implementations

Unit-2 - Low Power Very Fast Dynamic Logic Circuits ***9 Hour***

Single clock latches and Flip-flops-High throughput CMOS circuit techniques-Fast and efficient CMOS functional circuits-Circuit Penalization-Voltage scaling based circuit techniques-Circuit Technology-Independent-Dependent power reduction

Unit-3 - Special Low Power VLSI Design Techniques and Arithmetic Operators ***9 Hour***

Glitch reduction-Clock gating-FSM-State encoding-Bus invert encoding-Data path –Precomputation design techniques-control-Signal gating design technique. Low power techniques for SRAM cell and DRAM cell.

Unit-4 - Sensors Basics, Protypes and Applications ***9 Hour***

Sensor basics-sensor types-Measurement Systems-Applications-Emerging sensors and sensor technologies-sensor protypes and applications

Unit-5 - Development of Sensor Prototypes and Applications ***9 Hour***

Development of sensor prototypes and associated electronics – A low power 65/14 nm stacked CMOS image sensors-Ultra-low-power current sensorutilizing Magnetoelectric nanowires -low Power bio-impedance sensor interfaces: review and electronic design methodology.

Learning Resources	1. *Yeap, Gary K. Practical low power digital VLSI design. SpringerScience & Business Media, 2012.* 2. *Piguet, Christian. Low-power CMOS circuits: technology, logicdesign and CAD tools. CRC press, 2018.*	3. *Syed Kamrul Islam Mohammad Rafiqul Haider. Sensors and Low Power Signal Processing,2010* 4. *Roy, Kaushik, and Sharat C. Prasad. Low-power CMOS VLSI circuit design.John Wiley & Sons, 2009.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*35%*	-	*35%*	-	*35%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Mr. Leela Krishan Thota, Sr. Solution Engineer, Synopsys	*1. Dr.S. Meenakshi, Professor, Anna University*	*1. Dr.P. Radhika, SRMIST*

Course Code	21ECE263T	Course Name	MICRO, NANO ELECTROMECHANICAL DEVICES	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the properties of micro and nano electromechanical devices materials*
CLR-2:	*explore the existing micro and nano fabrication technologies*
CLR-3:	*recall the micro mechanics principles and design concepts of micro sensors and micro actuators*
CLR-4:	*familiarize with micro sensor and actuator use case design*
CLR-5:	*reinstate the concepts of quantum mechanics and nano fabrication*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*propose the selection of suitable material for the intended application*	*3*	-	-	-	-	-	*1*	-	-	-	-	-	-	*2*	-
CO-2:	*explain the fundamental fabrication process flow of microsystems design*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*link the micro mechanics principles and concepts for micro sensors and micro actuators design*	*2*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-4:	*apply the acquired knowledge for the design of micro sensor and actuator*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*comprehend the theoretical foundations of quantum mechanics and Nano systems*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Introduction to MEMS and NEMS	***9 Hour***
Introduction to Design of MEMS and NEMS, Overview of Nano and Microelectromechanical Systems, Applications of Micro and Nanoelectromechanical systems, Materials for MEMS and NEMS: Crystal structure – Orientation effects – crystal defects – Impurities in Silicon – Properties of Silicon and Gallium Arsenide - Polymer – Polyimide, PMMA, PDNS, LCP, SU8, Perylene.	
Unit-2 - Micro and Nano Fabrication Technologies	***9 Hour***
Substrates and wafer- Photolithography, Ion Implantation, Diffusion, Oxidation, CVD, Sputtering Etching techniques, Micromachining: Bulk Micromachining, Surface Micromachining, LIGA. - Micro system packaging-materials, die level, device level, system level - Packaging techniques – die preparation - Surface bonding-wire bonding - sealing	
Unit-3 - Mechanics for Microsystem Design and Applications	***9 Hour***
Basic concepts – Bending of thin plates – Mechanical vibration – Thermo mechanics - Fracture mechanics – Fluid mechanics at micro systems- Design considerations - Process design-mask layout design – Mechanical design. Fundamentals – Micro systems and microelectronics - working principle of microsystems – Micro sensors, acoustic sensor, Bio sensor, chemical sensor, pressure sensor, Temperature sensor - micro actuation techniques – Actuation using thermal forces, actuation using SMA, Actuation using piezo electric effect, Actuation using electrostatic forces – micro gripper – micro motors – micro valves – micro pumps, types – micro heat pipes	
Unit-4 - Sensors and Actuators	***9 Hour***
MEMS Sensors: Design of Acoustic wave sensors, Vibratory gyroscope, Capacitive Pressure sensors, Piezoelectric energy harvester, and piezoresistive strain sensor. Design of Actuators: Actuation using thermal forces, Actuation using shape memory Alloys, Actuation using piezoelectric crystals, Actuation using Electrostatic forces. Case Study: RF Switch, Comb drive actuator	
Unit-5 - Nano Mechanics and Devices	***9 Hour***
Atomic Structures and Quantum Mechanics, Schrodinger Equation, Requirements of nano systems - Development of nano electronics and structuring – Application of NEMS – Deposition of coatings – Three dimensional materials – Dewatering. Applications of Molecular nanotechnology (MNT) - Direct self-assembly- device assembly - Electrostatic self-assembly-nano tubes – Nano wire and carbon-60 - Dielectrophoretic nano assembly. Nano electronics with tunneling devices – Nano electronics with super conducting devices - Molecular nano technology	

Learning Resources	1. *Hsu, Tai-Ran. MEMS and microsystems: design, manufacture, and nanoscale engineering. John Wiley & Sons, 2008.* 2. *Marc Madou, ―Fundamentals of Microfabrication‖, CRC press 1997.* 3. *Stephen D. Senturia, Micro system Design‖, Kluwer Academic Publishers,2001* 4. *Chang Liu, ―Foundations of MEMS‖, Pearson education India limited, 2012* 5. *Sergey Edward Lyshevski, ―MEMS and NEMS: Systems, Devices, and Structures, CRC Press, 2002* 6. *Mohamed Gad – el- Hak, The MEMS HAND book, CRC press 2005*	7. *Charles P.Poojlejr Fran K J.Owners , " Introduction to Nano Technology ", Willey student Edition 2008* 8. *Goser.K, Dienstuhl .J, Nano Electronics & Nanosystems, Springer International Edition, 2008.* 9. *Michael Pycraft Inrushes, Nano Electro Mechanics in Engineering & biology, CRC press New York, 2002.* 10. *Gregory Timp, Nano Technology, Spinger International Edition, 1999.* 11. *Julian W.Gardner,Vijay K.Varadan, Osama O.Awadel Karim, Microsensors MEMS and Smart Devices, John Wiley & sons Ltd.,2001.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. P. Eswaran, SRMIST*
2. *Mr. Leela Krishna Thota, Sr. Solution Engineer II, SRG, Synopsys India Pvt. Ltd*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE361T	**Course Name**	CONSUMER ELECTRONICS AND TROUBLESHOOTING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the basic components of consumer electronics*
CLR-2:	*understand the block diagram and working principle of consumer electronics*
CLR-3:	*apply the preamplifier and post amplifier circuit for signal conditioning*
CLR-4:	*understand the working principle of smart consumer electronics products*
CLR-5:	*implement the different troubleshooting techniques in consumer electronics*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define types of microphones with features*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*examine the working principle and construction of loudspeakers*	*3*	-	*1*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*design the pre-amplifier and feedback circuit configurations for consumer electronics*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*analyze the working principle of television and smart consumer electronics products*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*illustrate the different troubleshooting and maintenance techniques*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 – Microphone and Types ***9 Hour***

Microphone, Characteristics of Microphones, Carbon Microphones, Crystal Microphones, Dynamic Microphones, Crystal Microphones, Capacitor Microphones, Electret and Gun Microphones, Wireless and dual-unit microphones, Headphones and headsets and its types, Types of Headphones, Hearing Impairment, Hearing Aids

Unit-2 - Loudspeakers and Speaker Baffles ***9 Hour***

Ideal Loudspeakers, Basic Loudspeakers, Types of Loudspeakers, Loudspeaker Construction, Permanent Magnet, Voice Coil, Loudspeaker Impedance, Acoustic Impedance and resonance, Woofers, Midrange and extended range speakers, High frequency Loudspeakers, Baffles, Infinite baffles system

Unit-3 – Amplifiers ***9 Hour***

Circuit Configurations and No. of Stages, Interstage coupling, Gain control, Frequency Response Control, Negative Feedback, Low Noise Consideration, Requirements for audio preamplifiers, Low level amplifier circuits and universal preamplifiers, Operational Amplifier, TAA 300 IC , 1W Class B Audio Amplifiers, TAA 320 IC and peak up amplifiers

Unit-4 - Colour TV Standards ***9 Hour***

Dispersion and recombination of lights, Attributes of colours , Luminance and Chrominance signals, Colour Picture tubes and colour TV cameras , Colour TV systems and broadcasting of TV programs , In-car computers , Electronic Ignition , Electronic Ignition Lock system and antilock system , Electronically controlled suspension , Ultrasonic car safety belt system, Air bag system, Vehicle proximity detection system and car navigation system , Types of microwave ovens and cooking system, Air conditioning System and components

Unit-5 – Trouble Shooting ***9 Hour***

Mean time between failures (MTBF), Mean time to repair (MTR), Maintenance policy, potential problems, preventive maintenance, corrective maintenance, Fundamental Trouble Shooting Procedures, Fault location, Fault location, Trouble Shooting Techniques, Divergent, convergent and feedback path circuit

Learning Resources	1. *S. P. Bali, Consumer Electronics, Pearson Education, 2008* 2. *R. G. Gupta, Audio and Video Systems by RG Gupta, Tata McGraw Hill Education Pvt Ltd, New Delhi, 2010*	3. *RS Khandpur, Modern Electronic Equipment: Trouble shooting, Repair and Maintenance, Tata McGraw Hill Education Pvt Ltd, New Delhi*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	*40%*	-	*30%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*20%*	-	*20%*	-	*30%*	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys	*1. Dr. G. P. Mishra, Dept. of ECE, NIT Raipur*	*1. Dr. Soumyaranjan Routray, SRMIST*

Course Code	21ECE362T	**Course Name**	QUALITY AND RELIABILITY ENGINEERING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concept of statistical quality control*
CLR-2:	*implement the control chart for proportion or fraction defectives*
CLR-3:	*illustrate Lot by lot sampling*
CLR-4:	*analyze the failure of data*
CLR-5:	*improve reliability by applying different techniques*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the theory of control chart for variables*	*3*	*1*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*articulate control chart for variables*	*3*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*
CO-3:	*illustrate the concept of acceptance sampling*	*3*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-4:	*apply life testing for reliability test*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*design the techniques for improvement of reliability*	*3*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Introduction and Process Control for Variables ***9 Hour***

Introduction, definition of quality, basic concept of quality, definition of SQC, benefits and limitation of statistically quality control (SQC), Quality assurance, Quality cost-Variation in process- factors – process capability – process capability studies and simple problems – Theory of control chart- uses of control chart – Control chart for variables $\bar{X}$ *chart, R chart and ▯(S) chart.*

Unit-2 - Process Control for Attributes ***9 Hour***

Control chart for attributes –control chart for proportion or fraction defectives – p chart and np chart – control chart for defects – C and U charts, State of control and process out of control identification in charts.

Unit-3 - Acceptance Sampling ***9 Hour***

Lot by lot sampling – types – probability of acceptance in single, double, multiple sampling techniques – O.C. (Operating Characteristics) curves – producer's Risk and consumer's Risk. AQL (acceptable quality level), LTPD (lot tolerance percent defective), AOQL (Average out going quality limit) concepts-standard sampling plans for AQL (acceptable quality level) and LTPD- uses of standard sampling plans.

Unit-4 - Life Testing and Reliability ***9 Hour***

Life testing – Objective – failure data analysis, Mean failure rate, mean time to failure, mean time between failure, hazard rate, system reliability, series, parallel and mixed configuration – simple problems. Maintainability and availability – simple problems. Acceptance sampling based on reliability test – O.C Curves.

Unit-5 - Quality and Reliability ***9 Hour***

Reliability improvements – techniques- use of Pareto analysis – design for reliability – redundancy unit and standby redundancy – Optimization in reliability – Product design – Product analysis – Product development – Product life cycles.

Learning Resources	1. *Montgomery, Douglas C. "Introduction to Statistical Quality Control", Hoboken, NJ: Wiley, 7th edition, 2013.* 2. *Grant, Eugene .L"Statistical Quality Control ", McGraw-Hill, 1996*	3. *L.S. SRINATH, "Reliability Engineering" Affiliated East west press, 1991.* 4. *Monohar Mahajan, "Statistical Quality Control", Dhanpat Rai & Sons, 2001.* 5. *R.C.Gupta, "Statistical Quality control", Khanna Publishers, 1997*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*25%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*30%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S.Meenakshi, Professor, Anna University*	1. *Dr. Arijit Bardhan Roy, SRMIST*
		2. *Dr. Damodar Panigrahy, SRMIST*

Course Code	21ECE363T	**Course Name**	ELECTRONIC PACKAGING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	21ECC101J	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explore different types of electronic packaging, their functions and challenges*
CLR-2:	*identify electrical issues encountered and their corrective actions during packaging*
CLR-3:	*study of IC assembly and multi-chip types and design*
CLR-4:	*design PCB using CAD tools and study of surface mount technologies*
CLR-5:	*illustrate electric testing for IC performance and design for testability methods*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand different electronic packaging types*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*analyze electrical issues in packaging*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-	-
CO-3:	*design for chip level packaging*	*3*	-	*2*	-	-	-	-	-	-	-	-	*2*	*2*	-	-
CO-4:	*design of PCBs which minimize the electromagnetic interference and operate at higher frequency*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*analyze the concepts of testing methods*	*3*	-	*2*	-	-	-	-	-	-	-	-	*3*	*3*	-	-

Unit-1 - Introduction to Electronic Systems Packaging **9 Hour**

Micro-systems and technologies, functions of electronic packaging, hierarchy of packaging, IC packaging techniques: MEMS packaging, consumer and medical electronics packaging, trends, and challenges, controlling factors on packaging technology, materials for microelectronic packaging and properties, ceramics, polymers, and metals in packaging, compatible substrate materials for high density interconnect

Unit-2 - Electrical Issues in Electronic Packaging **9 Hour**

Electrical issues encountered in systems packaging, signal and power distribution, concept of electromagnetic interference and transmission lines, clock distribution, noise sources, digital and RF issues, design process, electrical design: interconnect capacitance, resistance, and inductance fundamentals; packaging roadmaps-hybrid circuits-resistive, capacitive, and inductive parasitic

Unit-3 - Fundamentals of Chip Level Packaging **9 Hour**

Classifications of IC assembly technologies and their requirements, bonding techniques: tape automated bonding, flip chip, wafer level packaging, reliability, wafer level burn-in and test, single chip packaging: functions, types, materials processes, properties, characteristics, trends, multi-chip packaging: types, design, comparison and trends, system - in - package (SIP): discrete passives, integrated, and embedded, future trends

Unit-4 – PCB's and Fundamentals of Board Assembly **9 Hour**

Printed circuit board, CAD tools for PCB design, standard fabrication, micro via boards, board assembly: surface mount technology, through hole technology process control and design challenges, thermal management, heat transfer fundamentals, thermal conductivity and resistance, conduction, convection, and radiation- cooling requirements

Unit-5 - Electrical Testing **9 Hour**

Electrical testing, overview of reliability, basic concepts and environmental interactions, thermal mismatch, and fatigue, thermo mechanically induced, electrically induced, and chemically induced failure analysis, electrical testing: system level electrical testing, interconnection tests, active circuit testing, design for testability

Learning Resources	1. *Tummala, Rao R., Fundamentals of Microsystems Packaging, McGraw Hill, 2001.* 2. *Blackwell (Ed), the Electronic Packaging Handbook, CRC Press, 2000.* 3. *Tummala, Rao R, Microelectronics Packaging Handbook, McGraw Hill, 2008.*	4. *Bosshart, Printed Circuit Boards Design and Technology, McGraw Hill, 1988.* 5. *Michael L. Bushnell &Vishwani D. Agrawal, Essentials of Electronic Testing for Digital, memory & Mixed signal VLSI Circuits, Kluwer Academic Publishers, 2000.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*40%*	-	*40%*	-	*40%*	-
Level 2	*Understand*	*40%*	-	*40%*	-	*40%*	-
Level 3	*Apply*	*10%*	-	*10%*	-	*20%*	-
Level 4	*Analyze*	*10%*	-	*10%*	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Abhijeet Pathak, Western Digital, Bangalore, India*	1. *Dr.S. Meenakshi, Professor, AnnaUniversity*	1. *Dr. Aditya Nath Bhatt, SRMIST*
		2. *Dr. Soumyaranjan Routray, SRMIST*

Course Code	21ECE364T	Course Name	DIGITAL SIGNAL PROCESSORS, ARCHITECTURES AND APPLICATIONS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic concepts in programmable DSPs*
CLR-2:	*understand the basic architecture of TMS series processors*
CLR-3:	*familiarize the students with the programming of DSP processors with different addressing modes*
CLR-4:	*acquire knowledge of the different DSP architectures and instruction sets*
CLR-5:	*provide strong foundation for designing real world applications using DSP processors*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basic features and needs for programmable DSPs.*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*demonstrate a good understanding in the TMS320C5X processor and its applications*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*develop programming proficiency using the various addressing modes and instructions of the target TMS320C3X processor*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*demonstrate the detailed study of the instructions, addressing modes in the TMS320C54X processor and its applications*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-5:	*analyse the recent development in DSP system design and verify it with different case studies*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Basics of Programmable DSP's	***9 Hour***
Introduction to programmable DSPs - Architectural features of PDSPs - Multiplier and Multiplier accumulator - Modified bus structure & bus architecture in P- DSPs. -Multiple access memory – Multiport Memory – VLIW architecture – Pipelining –special addressing modes in P-DSPSs- on-chip peripherals.	
Unit-2 - TMS320C5X Processor	***9 Hour***
Architecture of TMS320C5X processor – Status register – On chip memory – On chip peripherals – Addressing modes – Instruction sets of C5X processor– Pipelining in C5X – Programs in C5X for processing real time signals	
Unit-3 - TMS320C3X Processor	***9 Hour***
Architecture of TMS320C3X processor – Memory organization – Data formats – Addressing modes of C3X processor – Instruction sets of C3X processor –Programs in C3X processor	
Unit-4 - TMS320C54X Processor	***9 Hour***
Architecture of TMS320C54X processor – Memory Organization – On chip peripherals - Addressing modes of C54X processor – Instruction sets of C54X processor – Programs in C54X processor	
Unit-5 - Recent Trends in DSP System Design	***9 Hour***
Overview of the application on DSP systems – Evolution of FPGA based DSP system – Introduction to FPGA – Design flow for FPGA based system design – FPGA based DSP system design- Distributed arithmetic algorithm –Case studies	

Learning Resources	1. *B. Venkataramani and M. Bhaskar, ―Digital Signal Processors –Architecture, Programming and Applications‖ – Tata McGraw – Hill Publishing Company Limited. New Delhi, 2011.* 2. *Avtar Singh and S. Srinivasan, Digital Signal Processing –Implementations using DSP Microprocessors with Examples fromTMS320C54xx, Cengage Learning India Pvt.Ltd, Delhi 2012.*	3. *Lapsley et al., DSP Processor Fundamentals, Architectures &Features‖, S. Chand & Co, 1 st Edition, 2000.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S. Meenakshi, Professor, Anna University*	1. *Dr.R. Prithiviraj, SRMIST.*

Course Code	21ECE365T	Course Name	DESIGN VERIFICATION OF VLSI CIRCUITS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*features of Verilog and system Verilog in verification domain*
CLR-2:	*system Verilog Verification methodology*
CLR-3:	*explains Test cases, coverage analysis*
CLR-4:	*fundamentals on IP Verification*
CLR-5:	*introduction to UVM based Verification methodology*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*learning Verilog Basics and programming concepts*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*fundamentals of system Verilog for writing programs*	-	*3*	*1*	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the OOPS concepts of system Verilog for advanced learning*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*evaluate the IP Verification methodology*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyse the significance of UVM in advanced verification domain*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Verilog HDL **9 Hour**

Operators, Basic concepts, Identifiers, , Value set, Data types, Parameters ,Operands, Operators, Modules and ports, Gate-level modelling, Dataflow Modelling, Behavioural modelling, Test bench- Tasks and Functions, Switch level modelling, Tri state gates, User defined primitives, Combinational UDP, Sequential UDP

Unit-2 - System Verilog **9 Hour**

Introduction to System Verilog – Literal values-data Types, Arrays, Data Declarations-attributes-operators, expressions, procedural statements, and control flow.

Unit-3 - Object Oriented Analysis of System Verilog **9 Hour**

Simple Verification Features-Clocking Blocks- Introduction to objects, its properties, methods, constructors- casting – chaining - Data hiding and encapsulation –Polymorphism -Random Stimulus -Basic Classes-Polymorphism and Virtuality-Class-Based Random Stimulus -Interfaces in Verification -Cover group Coverage-Queues and Dynamic and Associative Arrays (QDA)-Introduction to Assertion-Based Verification (ABV)

Unit-4 - Advanced Feature in System Verilog **9 Hour**

System Verilog assertion API and coverage API. IP Verification- Real Time IP Verification Analysis -Introduction to UVM - UVM Evolution -UVM Structural Pieces and Classes-Phases, Reporting.

Unit-5 - UVM Verification Methodology **9 Hour**

Writing UVM Testbench - UVM Classes and Field Macros -UVM Environment Architecture- TB Top, Test, Environment, Agent, Sequencer, Driver, Monitor, Scoreboard-Sequence and Sequence Item-Factory Overriding- Functional Coverage UVM: Signal level Functional Coverage -Transaction level Functional Coverage-Integrating Functional Coverage into UVM Testbench.

Learning Resources	*1. Samir palnitkar," Verilog HDL", Pearson education, Second Edition, 2003.* *2. J. Bhasker, a Verilog HDL Primer, Second Edition, Star Galaxy, 1999.* *3. System Verilog 3.1a –Language Reference Manual (Accellera Extensions to Verilog 2001), 2004.*	*4. System Verilog for Verification: A Guide to Learning the Testbench Language Features by Chris Spear & Greg Tumbush (3rd Edition),2013*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Vinod Srinivasan- Senior Verification Engineer – Qualcomm India (P) Ltd.,*	1. *Dr. J. Ramesh - Professor- ECE-PSG College of Technology, Peelamedu Coimbatore.*	1. *Dr.K. Suganthi, SRMIST*
		2. *Dr.J. Selvakumar, SRMIST*

Course Code	21ECE460T	**Course Name**	EMERGING PROCESSOR BASED SYSTEM DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*define the fundamentals of ARM architecture*
CLR-2:	*understand the uses of ARM peripherals and debugging*
CLR-3:	*explain the memory hierarchy and cache organization of ARM processor*
CLR-4:	*introduce the ARM Interrupts and Exceptions Processing*
CLR-5:	*discuss the applications of ARM Processors*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*describe ARM processor features and their use*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2
CO-2:	*understand the architectural model and debug issues on ARM processors and peripherals*	-	2	2	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*explain ARM memory types, interaction with caches for memory management*	-	-	2	1	1	-	-	-	-	-	-	-	-	-	-
CO-4:	*discuss the interrupt and exceptions architecture to handle and program the interrupt controller*	-	-	2	2	-	-	-	-	-	-	-	-	-	2	-
CO-5:	*analyze the features and architecture of ARM7 in embedded applications*	-	-	3	2	2	-	-	-	-	-	-	-	-	2	2

Unit-1 - ARM Architecture and Instruction Sets ***9 Hour***

ARM Processor Modes-ARM CPU Registers: General Registers, Status Registers-Change ARM Processor Mode- Instruction Pipeline- The ARM Architecture: The Acorn RISC Machine, Architectural inheritance, ARM development tools - ARM Instructions: Condition Flags and Conditions, Branch Instructions, Arithmetic Operations, Comparison Operations, Logical Operations, Data Movement Operations, Immediate Value and Barrel Shifter, Multiply Instructions, LOAD and Store Instructions, Software Interrupt

Unit-2 - Architectural Support for System Development ***9 Hour***

The ARM memory interface: ARM bus signals, Simple memory interface, Control logic, Wait states, DRAM, Peripheral access- The Advanced Microcontroller Bus Architecture: Arbitration, Bus transfers, Bus reset, Test interface, Advanced Peripheral Bus, Advanced High performance Bus -The ARM reference peripheral specification: AHB multiplexed bus scheme, Base components, Memory map, Interrupt controller, Counter-timers, Reset and pause controller, System design - Hardware system prototyping tools - The ARMulator, System - The JTAG boundary scan test architecture with Test signals - The ARM debug architecture - Embedded Trace - Signal processing support -ARM Processor Cores:ARM7TDMI

Unit-3 - Memory Hierarchy and Cache ***9 Hour***

Memory size and speed, On chip memory, Unified and Harvard caches, Cache organization techniques - Memory Hierarchy and Cache memory, SRAM, DRAM, Peripheral Devices - Caches and Memory management units, Logical and Physical caches - Cache Architecture, Architecture of a Cache memory, Operation of cache controller, Relationship between cache and main memory, Set associativity, Write buffers, Measuring cache efficiency - Cache policy, write policy thorough - coprocessor and caches, Cleaning cache memory, ARM cached cores

Unit-4 - ARM Interrupts and Exceptions Processing ***9 Hour***

ARM Exceptions: Exception handling, Arm Processor exceptions and modes, Vector table, Exception Priorities, Return from Exception Handlers, Link registers offsets, Exceptions Vector Table - Interrupts and Interrupts Processing: Interrupt Types, Interrupt Controllers, Primary and Secondary Interrupt Controllers- Interrupt Processing: Vector Table Contents, Hardware Interrupt Sequence, Interrupts Control in Software, Interrupt Handlers, Non-nested Interrupt Handler.

Unit-5 - Embedded ARM Applications	***9 Hour***
ARM710T, The ARM71OT cache organization, Cache power, Sequential accesses, Power optimization, ARM710TMMU, ARM710T write buffer- The ARMSIO, ARMS 10 characteristics, Double bandwidth cache- The VLSI Ruby II Advanced Communication Processor, Ruby II organization, Packaging - The VLSI ISDN Subscriber Processor, VIP organization, Memory interface, SO and Keypad interface, Clocks and timers.	

Learning Resources	1. *Wang, "Embedded and Real-Time Operating Systems", Springer, 2017* 2. *Steve furber "ARM System-on-Chip Architecture", Pearson Education, 2000.* 3. *Andrew Sloss ET all, "ARM system developers guide" Designing and optimizing system, Elsevier, 2004.*	4. *Vahid, Frank and Givargis, Tony, "Embedded system design: a unified hardware/software introduction", Vol. 52, 2002, Wiley New York.* 5. *Xiao, Perry, "Designing Embedded Systems and the Internet of Things (IoT) with the ARM mbed", 2018, Wiley Online Library.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr. Solution,Engineer, Synopsys*	1. *Dr.S. Meenakshi, Professor, Anna University*	1. *Dr. A. Ruhan Bevi, SRMIST*

Course Code	21ECE461T	**Course Name**	SEMICONDUCTOR MEMORY DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*explain the basic and detailed architecture of SRAM*
CLR-2:	*explain the basic and detailed architecture of DRAM*
CLR-3:	*elaborate different types of non-volatile memory*
CLR-4:	*understand the reliability issue and failure prediction in memory*
CLR-5:	*discuss the advanced memory technology, packing and its future direction*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge on SRAM and its operation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*acquire knowledge on DRAM architecture and its operation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*analyse non-volatile memories and interpret its working*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*gain knowledge in reliability issues and reliability model of memory*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*understand the construction and basic of advanced memory and memory packing*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Static Random Access Memory — ***9 Hour***

Introduction semiconductor memories- SRAM Cell Structures (NMOS, CMOS) – MOS SRAM Cell and Peripheral Circuit Operation-Bipolar SRAM Technologies- Silicon On Insulator (SOI) Technology- Advanced SRAM Architectures and Technologies-Application Specific SRAMs.

Unit-2 - Dynamic Random Access Memory — ***9 Hour***

DRAM Technology Development-CMOS DRAMs - DRAMs Cell Theory and Advanced Cell Structures --Application Specific DRAMs

Unit-3 - Non-Volatile Memory — ***9 Hour***

Masked Read-Only Memories (ROMs)-High Density ROMs-Programmable Read-Only Memories (PROMs)-CMOS PROMs-Erasable (UV) - Programmable Road-Only Memories (EPROMs)-Floating-Gate EPROM Cell-One-Time Programmable (OTP) EPROMs- Electrically Erasable PROMs (EEPROMs)-EEPROM Technology and Architecture-Non-volatile SRAM-Flash Memories (EPROMs or EEPROM)-Advanced Flash Memory Architecture.

Unit-4 - Memory Reliability — ***9 Hour***

General Reliability Issues-RAM Failure Modes and Mechanism-Non-volatile Memory Reliability- -Design for Reliability-Reliability

Unit-5 - Advanced Memory Technologies and Memory Packing — ***9 Hour***

Ferroelectric Random-Access Memories (FRAMs)-Gallium Arsenide (GaAs) FRAMs – Analog Memories-Magneto-resistive Random-Access Memories (MRAMs)-. Memory Hybrids and MCMs (2D)-Memory Stacks and MCMs (3D)- -High Density Memory Packaging Future Directions

Learning Resources	1. *Ashok K. Sharma, “Semiconductor Memories”, Two-Volume Set, Wiley-IEEE Press, 2003.* 2. *Ashok K. Sharma, “Semiconductor Memories: Technology Testing and Reliability” Wiley, 2014.* 3. *Brent Keeth, R. Jacob Baker, Brian Johnson, Freng Lin, “DRAM Circuit Design , Wiley-IEEE Press, 2007*	4. *Fundamental and High Speed Topics”, Wiley-IEEE Press, 2nd Edition, 2008.* 5. *Betty Prince, “High Performance Memories: New Architecture DRAMs and SRAMs Evolution and Function”, Wiley, Revised Edition, 1999.*

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	40%	-	40%	-	25%	-
Level 2	*Understand*	40%	-	40%	-	45%	-
Level 3	*Apply*	20%	-	20%	-	20%	-
Level 4	*Analyze*	-	-	-	-	10%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.T.Leela Krishna, Senior Solution Engineer Synopsys India Pvt. Ltd*	1. *Dr. N. B. Balamurugan, Associate Professor, Department of Electronics and Communication Engineering, Thiagarajar College of Engineering, Madurai*	1. *Dr.V. Sarada, SRMIST*

Course Code	21ECE462T	**Course Name**	MACHINE LEARNING AND ARTIFICIAL INTELLIGENCE FOR ELECTRONICS DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*provide fundamental concepts of Machine Learning*
CLR-2:	*introduce neural networks and its algorithm*
CLR-3:	*study how machine learning can help in physical design*
CLR-4:	*automatic sizing and layout of analog ICs using deep learning and artificial neural networks (ANNs)*
CLR-5:	*apply ANNs to the placement part of the layout generation process*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basics of machine learning*	*1*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*1*	*-*	*-*	*-*
CO-2:	*understanding of ML algorithms through practice coding*	*1*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*
CO-3:	*apply concepts of machine learning for resizing analog IC*	*1*	*-*	*2*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*3*	*-*	*-*
CO-4:	*develop machine learning models for IC placement*	*-*	*2*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*3*	*-*
CO-5:	*analyze the Machine learning models for lithography and mask pattering*	*3*	*2*	*-*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*3*	*-*	*3*	*-*

Unit-1 - Fundamentals of Machine Learning	***9 Hour***
Machine learning, Types of machine learning and its comparison. Basic types of data and data pre- processing, modelling and evaluation, supervised learning: classification and regression, unsupervised learning, Bayesian concept learning.	
Unit-2 - Practice Algorithms	***9 Hour***
Platform for machine learning, Machine learning python libraries, machine learning classifiers using scikit- learn: k-nearest neighbours, decision tree using scikit -learn, introduction to NN, MLP, optimizers, early stop, regularization, Deep learning: improvement of Deep neural network, convolutional network	
Unit-3 - ML for Electronics Design I	***9 Hour***
Using ANN to size analog IC: Design flow, Problem and Dataset Definition, Regression–Only Model, Using the ANN for Circuit Sizing, Classification and Regression Model, Test Case–Regression: Single-Stage Amplifier with Voltage Combiners, Two-Stage Miller Amplifier, classification and regression model case studies	
Unit-4 - ML for Electronics Design II	***9 Hour***
ANN for automatic analog IC placement: Layout Synthesis by Deep Learning, development of ANN model: Circuit Used for Tests, Dataset Architecture, Neural Network Architecture: Preprocessing the Data, Metrics to Evaluate the Models, Experimental Results, case studies: Machine Learning for Design Space Exploration in HLS	
Unit-5 - ML for Electronics Manufacturing	***9 Hour***
ML for Lithography and physical design: Machine Learning for Compact Lithographic Process Models: Importance of Lithographic Patterning Process to the Economics of Computing, Representation of the Lithographic Patterning Process, Machine Learning of Compact Process Models, Lithography Hotspot Detection, Machine Learning for Optical Proximity Correction, Machine Learning for SRAF Insertion, Machine Learning for Lithography Simulation.	

Learning Resources	1. *Saikat Dutt, Subramanian Chandramouli, Amit Kumar Das, Machine Learning, Pearson Education India, 2018.* 2. *Joao P. S. Rosa, Daniel J. D. Guerra, Nuno C. G. Horta, Using Artificial Neural Networks for Analog Integrated Circuit Design Automation, Springer, https://doi.org/10.1007/978-3-030-35743-6, 2019.* 3. *Elfadel, Ibrahim Abe M., Duane S. Boning, and Xin Li, eds. Machine learning in VLSI computer- aided design. Springer, 2019*	4. *Gavin Hackeling, Machine Learning with scikit-learn, Packet publishing, O'Reily, 2018* 5. *Huang, Guyue, et al. "Machine learning for electronic design automation: A survey." ACM Transactions on Design Automation of Electronic Systems (TODAES) 26.5 (2021): 1-46. https://doi.org/10.1145/3451179* 6. *Phil Kim, MATLAB Deep Learning: With Machine Learning, Neural Networks and Artificial Intelligence, Apress, ISBN-13 (pbk): 978-1-4842-2844-9, 2017.*

Learning Assessment

		Continuous Learning Assessment (CLA)					
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)		Summative Final Examination (40% weightage)	
	Bloom's Level of Thinking	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	20%	-
Level 3	Apply	30%	-	25%	-	20%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	10%	-
Level 6	Create	-	-	5%	-	5%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Bhaskar Sahu, Schneider Electric Ltd, bhaskar.sahu@se.com	1. Dr. K. S. Swarup, IIT Madras, ksswarup@iitm.ac.in	1. Dr. S. Malarvizhi, SRMIST
2. Dr.S. Paramasivam, ESAB, paramsathya@yahoo.com	2. Dr.S. Chandramohan, Professor, CEG, Anna university, c_dramo@annauniv.edu	

Course Code	21ECE463T	**Course Name**	SCRIPTING LANGUAGE FOR ELECTRONIC DESIGN AUTOMATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic features of TCL*
CLR-2:	*construct TCL scripts for EDA*
CLR-3:	*identify the basic constructs in Tk*
CLR-4:	*explain the basic concepts of PERL*
CLR-5:	*summarize the advanced features of PERL*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss the basic features of TCL*	-	2	-	2	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*illustrate the advanced features of TCL scripting language*	-	2	-	3	2	-	-	-	-	-	-	-	-	-	2
CO-3:	*demonstrate the concepts of TK*	-	-	-	3	2	-	-	-	-	-	-	-	-	-	2
CO-4:	*explain the basics of PERL*	-	-	3	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	*describe the advanced concepts of PERL to write the script for automation*	-	2	-	-	2	-	-	-	-	-	-	-	-	-	-

Unit-1 - TCL Basics	***9 Hour***
Tool Command Language (TCL) fundamentals, language syntax, variables, expressions-String processing –TCL Lists-control structure command-Procedureand scope-TCL arrays, Working with files and Programs	
Unit-2 - Advanced TCL	***9 Hour***
Quoting issues and Regular expressions-Script libraries and Packages-Reflection and debugging-Namespaces-Internationalization-Event driven programming-Socket programming	
Unit-3 – Tool Kit basics	***9 Hour***
TK(Tool Kit) fundamentals-The pack geometry manager, The grid geometry manager, The place geometry manager, Binding commands to events-TK widgets	
Unit-4 - PERL Basics	***9 Hour***
History and Concepts of PERL-Scalar Data-Arrays and List Data –Control structures –Hashes-Basics I/O-Regular Expressions–Functions- Miscellaneous control structures-Formats	
Unit-5 - Advanced Concepts of PERL	***9 Hour***
Directory access-File and Directory Manipulation-Process Management-Packages and Modules.	

Learning Resources	*1. John K. Ousterhout, Ken Jones, "Tcl and the Tk Toolkit", Pearson Education, Second Edition, 2010.* *2. Chromatic "Modern Perl "Fourth Edition, 2015*	*3. LarryWall, Tom Christiansen, John want, "Programming PERL", Oreilly Publications, 4th ed 2012* *4. Naveed Sherwani, Algorithms for VLSI physical design Automation, Kluwer Academic Publishers, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Ms.Shivangi Soni, Application Engineer Sr,Synopsys Inc., shivangisoni.0104@gmail.com	1. Dr. J.Ramesh ,Professor, PSG College of Technology, Coimbatore jr.ece@psgtech.ac.in	1. Mrs.N. Saraswathi, SRMIST.

Course Code	21ECE464T	**Course Name**	STATISTICAL ANALYSIS AND OPTIMIZATION FOR VLSI	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic statistical modeling*
CLR-2:	*compute the performance of the statistical model*
CLR-3:	*apply convex optimization for curve fitting*
CLR-4:	*implement genetic algorithm for optimization of VLSI design*
CLR-5:	*calculate of power estimation by using GA routing procedure*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*summarize the basic statistical modeling*	*1*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*articulate statistical performance*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-3:	*illustrate the convex optimization*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*apply Genetic algorithm for VLSI design*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*describe GA routing procedure and power estimation*	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - Statistical Modeling	***9 Hour***
Modeling sources of variations, Monte Carlo techniques, Process variation modeling- Pelgrom's model, Principal component-based modeling, Quad tree-based modeling, Performance modeling- Response surface methodology, delay modeling, interconnect delay models.	
Unit-2 - Statistical Performance, Power, and Yield Analysis	***9 Hour***
Statistical timing analysis, parameter space techniques, Bayesian networks Leakage models, High level statistical analysis, Gate level statistical analysis, dynamic power, leakage power, temperature and power supply variations, High level yield estimation and gate level yield estimation.	
Unit-3 - Convex Optimization	***9 Hour***
Convex sets, convex functions, geometric programming, trade-off, and sensitivity analysis, generalized geometric programming, geometric programming applied to digital circuit gate sizing, Floor planning, wire sizing, Approximation and fitting- Monomial fitting, Maxmonomial fitting, Polynomial fitting.	
Unit-4 - Genetic Algorithm	***9 Hour***
Introduction, GA Technology-Steady State Algorithm-Fitness Scaling-Inversion GA for VLSI Design, Layout and Test automation- partitioning-automatic placement, routing technology, Mapping for FPGA-Automatic test generation- Partitioning algorithm Taxonomy-Multi-way Partitioning Hybrid genetic-encoding- local improvement-WDFR Comparison of CAS-Standard cell placement GASP algorithm-unified algorithm.	
Unit-5 - GA Routing Procedures and Power Estimation	***9 Hour***
Global routing-FPGA technology mapping-circuit generation-test generation in a GA framework-test generation procedures, Power estimation- application of GA Standard cell placement-GA for ATG-problem encoding- fitness function-GA Vs Conventional algorithm	

Learning Resources	1. *Ashish Srivastava, Dennis Sylvester, David Blaauw, "Statistical Analysis and Optimization for VLSI: Timing and Power "Springer, 2008.* 2. *Stephen Boyd, Lieven Vandenberghe, "Convex Optimization", Cambridge University Press, 2009.* 3. *Pinaki Mazumder, E. Mrudnick, "Genetic Algorithm for VLSI Design, Layout and Test Automation", Prentice Hall, 2014.*	4. *S Rajasekharan, G.A Vijaya Lakshmi Pai, Neural Networks, Fuzzy logic, and Genetic algorithms, Synthesis and Applications, Prentice Hall of India, 201* 5. *Jorge Nocedal, Stephen Wright, "Numerical Optimization",Springer, 2014*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*35%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S.Meenakshi, Professor, Anna University*	1. *Dr. Damodar Panigrahy, SRMIST*

Course Code	21ECE465T	**Course Name**	DEVICE AND PROCESS MODELING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*develop a firm foundation in the use of Computer-Assisted techniques for IC device and process Design*															
CLR-2:	*determine key indicators of device performance by linking process simulation to device simulation*															
CLR-3:	*generate two-dimensional (2D) or three-dimensional (3D) structures including doping profiles and electrical contacts*															
CLR-4:	*simulate numerically the electrical behavior of a single semiconductor device in isolation or several physical devices combined in a circuit*															
CLR-5:	*understand the physics-based analytical modeling approach to predict device operation at specific conditions, environment and physical characteristics*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*understand the physics-based modelling of semiconductor devices and their fabrication process*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*design, analyze and optimize semiconductor technologies and devices with fundamental and accurate models*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*create a two-dimensional (2D) or three-dimensional (3D) device with multiple regions using geometric operations*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*compute terminal currents, voltages, and charges based on a set of physical device equations that describes the carrier distribution and conduction mechanisms*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*apply numerical models in virtual environment for device optimization*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Technology – Process Flow **9 Hour**

Process simulation flow, Conventional role of TCAD in IC processing, Process steps involved in the manufacturing of an IC, Steps involved in device simulation, History of process simulation, Evolution of TCAD, TCAD-based electrical characterization, Process synthesis, TCAD and compact model, Parameter extraction, TCAD for nanoelectronic, Materials used in integrated circuits

Unit-2 - IC Technology **9 Hour**

Process simulation: Oxidation, Ion implantation, Diffusion, Lithography, Etching, Metallization, Synopsys TCAD Tools, Process-to-device simulation: Device generation, Device simulation

Unit-3 - Generating Geometric Structures **9 Hour**

Introduction to Sentaurus Structure Editor, Modeling Unit and Modeling Range, creating a New Structure, Basic 2D Shapes, editing 2D Shapes, simplifying 2D Structures, Electrical and Thermal Contacts, Defining Areas for Mesh Refinement or Doping, Mesh Refinement Definition, Defining Doping Profiles: Constant Doping Profiles, Analytic Doping Profiles, External 2D and 3D Doping Profiles, Particle Doping Profile

Unit-4 - Creating and Meshing Device Structure **9 Hour**

Typical tool flow with device simulation using Sentaurus Device, Command File, Electrode Section, Physics Section, Plot Section, Math Section, Solve Section, Parameter File, Example: Simulation of PN Junction diode and MOSFET, Abrupt and Graded Heterojunctions, Physical Models and the Hierarchy of Their Specifications - Region-specific and Material-specific Models, Interface-specific Models, Electrode-specific Models, Parameters for Composition-dependent Materials

Unit-5 - Physics in Sentaurus Device	***9 Hour***
Electrostatic Potential, Equilibrium Solution, Quasi-Fermi Potential with Boltzmann Statistics, Fermi Statistics, Carrier Transport Models, Numeric Parameters for Continuity Equation, Current Potential, Semiconductor Band Structure -Selecting the Bandgap Model, Effective Masses and Effective Density-of-States, Overview of Sentaurus Workbench, Mixed-Mode CMOS Inverter Simulation	

Learning Resources	*1. G.A. Armstrong, C.K. Maiti, "TCAD for Si, SiGe and GaAs Integrated Circuits", Published by The Institution of Engineering and Technology, London, United Kingdom, 2007.* *2. Robert W.Dutton, Zhiping Yu, "Technology CAD Computer Simulation of Processes and Devices", Kluwer Academic Publishers, 1993.* *3. Yung-Chun Wu • Yi-Ruei Jhan, "3D TCAD Simulation for CMOS Nanoeletronic Devices", Springer Nature Singapore Pte Ltd. 2018*	*4. Yogesh Singh Chauhan, Darsen Duane Lu, Vanugopalan Sriramkumar, Sourabh Khandelwal, Juan Pablo Duarte, Navid Payvadosi, Ai Niknejad, Chenming Hu , "FinFET Modeling for IC 'Simulation and Design: Using the BSIM-CMG Standard", Academic Press - Elsevier ,2015.* *5. Synopsys Sentaurus TCAD Manual.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	40%	-	40%	-	40%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys	1 Dr.S.Meenakshi, Professor, Anna University	1. Dr. Maria Jossy A, SRMIST

Course Code	21ECE466T	Course Name	LOW POWER CIRCUIT DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn the Low Power VLSI concepts and Power Analysis*
CLR-2:	*gain Knowledge on the Low Power very fast Dynamic logic circuits*
CLR-3:	*design of low power VLSI Techniques and arithmetic*
CLR-4:	*understand the concept of Adiabatic Techniques and Memories*
CLR-5:	*apply the Low Power CMOS Circuits.in VLSI applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*manifest the Knowledge of Low power VLSI, Power estimation and its impact on future of CMOS*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*design Dynamic CMOS latches, Flip-flops with power reduction*	*3*	*3*	*3*	*1*	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*optimize speed and switching activity using special techniques*	*3*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*relate Adiabatic and energy recovery techniques to trade dynamic power dissipation for delay in switching circuits*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*apply low power technique concepts in various Applications*	-	*3*	*3*	-	*3*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Low Power VLSI and Power Analysis ***9 Hour***

Introduction - Needs for low power VLSI, Short circuit current of CMOS inverter-CMOS leakage current, Basic Principles of Low power design-Reduced switching voltage, reduced capacitance. Generic design flow for low power applications, Low power design flow. System level power analysis.

Unit-2 - Low Power Very Fast Dynamic Logic Circuits ***9 Hour***

TSPC Latches and Flip-Flops, Differential Single-clock Latches and Flip-flops-DVSL Static RAM latch, Single transistor clocked differential latch TSPC Double pipeline, CDPD technique, Voltage scaling based circuit techniques- Multiple voltage Techniques, Low voltage swing

Unit-3 - Special Low Power VLSI Design Techniques and Arithmetic Operators ***9 Hour***

Introduction: Glitch reduction, Gate-level, Block-Level control. Clock gating-Flip flop-based design, FSM-Gated clock FSM, State encoding, FSM Partitioning Bus Invert encoding, Data Paths: Precomputation design, Low power arithmetic operators: Adder, Any multiplier implementation

Unit-4 - Adiabatic Techniques and Memories ***9 Hour***

Introduction: Adiabatic Computation, Complementary Adiabatic logic., Adiabatic Power supplies Implementation Issues, Adiabatic Power supplies, Power efficiency of adiabatic logic, Pass transistor Logic synthesis, Low power techniques for SRAM cell

Unit-5 - Applications of Low Power VLSI Design ***9 Hour***

High Speed, Low power using MTCMOS, MTCMOS-DSP, Power consumption of CMOS Adders and Multipliers, Delay Balanced Multipliers for low power/low voltage DSP core, Power Analysis Techniques: Glitch reduction technique

Learning Resources	1. *Yeap, Gary K. Practical low power digital VLSI design. Springer Science & Business Media, 2012.* 2. *Roy, Kaushik, and Sharat C. Prasad. Low-power CMOS VLSI circuit design.* 3. *John Wiley & Sons, 2009.*	4. *Piguet, Christian. Low-power CMOS circuits: technology, logic design and CAD tools. CRC press, 2018.* 5. *Chandrakasan, Anantha P., and Robert W. Brodersen, eds. Low-power CMOS design. New York: IEEE press, 1998*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S.Meenakshi, Professor, Anna University*	1. *Dr. P. Aruna Priya, SRMIST*

Course Code	21ECE467T	**Course Name**	HIGH SPEED IC DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basic need of high-speed circuits*
CLR-2:	*understand the different clocking styles*
CLR-3:	*familiarize the students with the different non clocking styles for high-speed circuits*
CLR-4:	*acquire knowledge of the different latching strategies*
CLR-5:	*provide strong foundation for designing real world applications using different clock generation techniques*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the basic features and needs for clocking styles*	3	-	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*demonstrate a good understanding in the advanced clock logic styles and its applications*	2	-	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*develop a good proficiency in the different non-clocking logic styles*	2	-	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*demonstrate a good understanding in the working of different latching strategies*	2	-	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*analyse the different clock generation techniques*	2	-	3	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Clocked Logic Styles ***9 Hour***

Single rail domino logic styles, Domino CMOS, Multiple output domino logic, compound domino logic, NORA logic, Dual-Rail domino structures, Differential domino, cross-coupled domino, Modified dual-rail domino logic.

Unit-2 - Advanced Clock Logic Styles ***9 Hour***

Latched domino structures, sample-set differential logic, Enable/disable CMOS differential logic, Latch domino, Differential current switch logic, switched output differential structure, clocked pass-gate logic, dynamic complementary pass gate logic.

Unit-3 - Non-Clock Logic Styles ***9 Hour***

Static combinational CMOS logic, pulsed static logic, Differential cascode voltage switch logic, Differential split-level logic, cascode non-threshold logic, CMOS pass gate & transmission gate logic, DCVS logic with pass gate, complementary pass gate logic.

Unit-4 - Latching Strategies ***9 Hour***

Basic Latch design, storage elements, static and dynamic latches, latch clocking, pseudo-inverter latch, True single-phase clocking, Double edge triggered flip-flops, DCVS latches, static RAM latches, Race free latches for precharged logic, cross-coupled differential output.

Unit-5 - Clocking Styles ***9 Hour***

Clocking styles, clock jitter, clock skew, clock generation, PLL based designs, off-chip oscillator-based design, Delay locked loops, clock distribution, Distributed buffers, placement optimization & standard wiring, Water-main clock distribution techniques, Asynchronous clocking techniques

Learning Resources	1. *Kerry Bernstein, Keith M. Carrig, "High Speed CMOS Design Styles", Kluwer Academic Publishers, 2002.* 2. *Evan Sutherland, Bob Stroll, David Harris," Logical Efforts, Designing Fast CMOS Circuits", Kluwer Academic Publishers, 1999*	3. *David Harris, "Skew Tolerant Domino Design", IEEE Journal of Solid- State Circuits, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	20%	-	20%	-	20%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	30%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S. Meenakshi, Professor, Anna University*	1. *Dr.R. Prithiviraj, SRMIST.*

Course Code	21ECE468T	**Course Name**	SYSTEM AND NETWORK ON CHIP	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn System on chip fundamentals, their applications*
CLR-2:	*identify new techniques for maximizing performance and minimizing power usage*
CLR-3:	*create insights to the concept of network - on – chip*
CLR-4:	*acquire knowledge on router architecture designs*
CLR-5:	*provide in depth knowledge about fault tolerance network - on – chip*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*discuss the basic principle of System on Chip design*	-	-	*3*	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*manipulate to do optimization of power in combinational and sequential logic machines for SoC Design*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*apply the knowledge of router architecture to design interconnects on Network on Chip*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze different routing algorithms, security and services for Network on Chip*	-	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*synthesize a thorough grasp of three dimensional networks - on-chip architectures*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - System-On-Chip Design ***9 Hour***

System-on-Chip, SoC Development life cycle, IP Design Decision, SoC Design Flow, High Level Design methodology, Core Development, Processor Subsystem core, Low Power Soc Design, Constituents of SoC-Embedded Processor Subsystem for system on chip-Embedded memories- Protocol, Mixed Signal, RF control blocks, Third Party IP cores.

Unit-2 - SOC Synthesis and Static Time Analysis ***9 Hour***

SoC synthesis, Design rule constraints, SoC Design Synthesis, High Fanout Nets, Low power Synthesis SoC static Timing Analysis, SoC physical Design Verification-Electromigration-Electrostatic Discharge protection - IR and Cross Talk Analysis, Electrical Rule check, Design Rule violation Check-Design Tape out.

Unit-3 - Introduction to Network on Chip ***9 Hour***

Introduction to NoC – OSI layer rules in NoC - Interconnection Networks in Network-on-Chip Network Topologies - Switching Techniques - Routing Strategies - Flow Control Protocol Quality-of-Service Support, Switching Techniques and Packet Format - Asynchronous FIFO Design -GALS Style of Communication - Wormhole Router Architecture Design - VC Router Architecture Design – Adaptive Router Architecture Design

Unit-4 - Routing Algorithm ***9 Hour***

Packet routing-QoS, congestion control and flow control – router design – network link design – Efficient and Deadlock-Free Tree-Based Multicast Routing Methods - Path-Based Multicast Routing for 2D and 3D Mesh Networks- Fault- Tolerant Routing Algorithms - Reliable and Adaptive Routing Algorithms Security in Networks-on-Chips-Formal Verification of Communications in Networks-on Chips, Test and Fault Tolerance for Networks-on-Chip, Infrastructures-Monitoring Services for Networks-on Chips

Unit-5 - Three-Dimensional Integration of Network-on-Chip ***9 Hour***

Three-Dimensional Networks-on-Chips Architectures. – A Novel Dimensionally-Decomposed Router for On-Chip Communication in 3D Architectures - Resource Allocation for QoS on ChipCommunication – Networks-on-Chip Protocols-On-Chip Processor Traffic Modelling for Networks-on Chip

Learning Resources	1. *Veena S. Chakravarthi, "A Practical Approach to VLSI System on Chip (SoC) Design" Springer 2020* 2. *Wayne Wolf, Modern VLSI Design – System – on – Chip Design, Prentice Hall, 3rd Edition, 2008* 3. *Chrysostomos Nicopoulos, Vijaykrishnan Narayanan, Chita R.Das" Networks-on - Chip" Architectures Holistic Design Exploration", Springer* 4. *Fayezqebali HqhahedWatheq E1-Kharashi "Networks-on-Chips theory and practice CRC press 2007*	5. *Konstantinos Tatas and Kostas Siozios "Designing 2D and 3D Network-on-Chip Architectures" 2013* 6. *Hoi-jun yoo, Kangmin Lee, Jun Kyoung Kim, "Low power NoC for high performance SoC desing", CRC press, 2008.* 7. *Vijay.k Madisetti Chonlameth Arpikanondt, "A Platform-Centric Approach to System-onChip (SOC) Design", Springer, 2005.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Leela Krishan Thota, Sr.Solution Engineer, Synopsys*	1. *Dr.S.Meenakshi, Professor, Anna University*	1. *Dr. Kasthuri Bha J K, SRMIST*

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

(With exit option of Diploma)

(Choice Based Flexible Credit System)

Regulations 2021

Volume – 14E

(Syllabi for Electronics and Computer Engineering Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

							L	T	P	C
Course Code	21ECC212T	**Course Name**	DATA STRUCTURES AND ALGORITHMS	**Course Category**	C	PROFESSIONAL CORE	3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn about basic lists and array operations*
CLR-2:	*impart knowledge on stacks and queues*
CLR-3:	*identify and analyse trees and their implementation*
CLR-4:	*acquire the knowledge about graphs*
CLR-5:	*practice coding for various searching, sorting algorithms and hash functions*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement abstract data types using arrays and linked list*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply the different linear data structures like stack and queue to various computing problems*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*implement different types of tree structures to solve problem*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*draw graph structures and perform various operations on graphs to find solutions*	*1*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*analyse the various sorting and searching algorithms, hashing technique and hash functions*	*1*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Linear Data Structures –Array and List	***9 Hour***
Operations on Arrays, Two-dimensional Arrays, singly linked lists- circularly linked lists- doubly-linked lists, Operations on arrays and lists, Insertion, Deletion, Merge, Traversal, Applications of Linked Lists	
Unit-2 - Linear Data Structures – Stacks, Queues	***9 Hour***
Operations on a Stack, Linked Representation of Stacks, Applications of Stacks, Types of Queues, Circular Queue – Priority Queue – deQueue, Applications of Queues.	
Unit-3 - Non-Linear Data Structures – Trees	***9 Hour***
Heaps, Binomial Heaps, Applications of Heaps, Directed Graphs, Representation of Graphs, Graph Traversal Algorithms, Shortest Path Algorithms, and Applications of Graphs.	
Unit-4 - Non-Linear Data Structures –Heaps and Graphs	***9 Hour***
Heaps, Binomial Heaps, Applications of Heaps, Directed Graphs, Representation of Graphs, Graph Traversal Algorithms, Shortest Path Algorithms, Applications of Graphs	
Unit-5 - Searching, Sorting and Hashing Techniques	***9 Hour***
Linear Search, Binary Search, Interpolation Search, Jump Search, Bubble Sort , Insertion Sort, Selection Sort , Merge Sort , Quick Sort, Radix Sort , Heap Sort, Shell Sort ,Tree Sort ,Comparison of Sorting Algorithms, Hash Tables , Hash Functions , Different Hash Functions	

Learning Resources	1	*Mark Allen Weiss, —Data Structures and Algorithm Analysis in C 2nd Edition, Pearson Education, 1997.*	3	*Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, Introduction to Algorithms", Second Edition, Mcgraw Hill, 2002.*
	2	*Reema Thareja, —Data Structures Using C, Second Edition , Oxford University Press, 2011*	4	*Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, —Fundamentals of Data Structures in C, Second Edition, University Press, 2008*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	20%	-	20%	-	20%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	10%	-	10%	-	10%	-
Level 6	Create	10%	-	10%	-	10%	-
	Total	100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1 Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	1 Dr. Meenakshi, Professor of ECE, CEG, Anna University	1 Dr.J. Subhashini, SRMIST
2 Mr. Saivineeth, ML Accelerator Architect @ Google	2 Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai	

Course Code	21ECC213J	Course Name	ANALOG DEVICES AND CIRCUITS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*describe the basic structure, operation and characteristics of BJT and MOSFET*
CLR-2:	*study the basic principles, configurations and practical applications of op-amp*
CLR-3:	*design BJT and MOSFET amplifier for a given configuration*
CLR-4:	*understand the effects of feedback on amplifier circuits, and study RC and LC oscillator circuits to determine the frequency of oscillation*
CLR-5:	*explore the various types of power amplifier circuits*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*ascertain the operating characteristics of BJT and MOSFET*	-	-	3	-	-	-	-	-	-	-	-	2	2	-	-
CO-2:	*determine the characteristics of op amp for designing amplifiers and rectifiers*	-	-	-	-	-	-	-	-	-	-	-	2	-	2	-
CO-3:	*analyze and design bipolar amplifier circuits to meet certain specifications with appropriate frequency response characteristics*	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*apply principles of feedback in the design of amplifier circuits and oscillator circuits*	-	2	3	-	-	-	-	-	-	-	-	-	-	-	2
CO-5:	*categorize the classes of power amplifiers, with focus on maximum amplifier efficiency*	-	2	3	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Transistor Characteristics ***15 Hour***

BJT- Physical structure, Device operation of BJT, Current-Voltage characteristics of Common Emitter, Common Base and Common Collector BJT configuration, BJT biasing circuits –Voltage divider, MOS-FET - Physical structure, Device operation and I-V characteristics of E-MOSFET and D-MOSFET, MOSFET as an amplifier, Biasing Circuits for MOSFET: Gate bias.

***Practice**: BJT Biasing Circuits, BJT and MOSFET Switching Circuits*

Unit-2 - Operational Amplifier and its Applications ***15 Hour***

Internal structure of operational amplifier, characteristics of operational amplifier, Inverting & Non-inverting voltage amplifiers, Voltage follower, AC amplifier, Differential amplifier, Instrumentation amplifier, Differentiator and Integrator circuit, Active rectifiers.

***Practice**: Basic op-amp circuits, Integrators and Differentiators, Active rectifiers*

Unit-3 - Analysis of Transistor Amplifier ***15 Hour***

AC analysis of Common-Emitter BJT amplifier using hybrid-π model, AC analysis of Common-Base BJT amplifier configuration using hybrid-π model, AC analysis of Common-Collector BJT amplifier using hybrid-π model, Frequency response analysis of a basic BJT CE amplifier, AC analysis of Common-Source MOSFET amplifier configuration, AC analysis of Common-Gate MOSFET amplifier configuration, AC analysis of Common-Drain MOSFET amplifier configuration, Frequency response analysis of a basic FET CS amplifier, Design of multistage amplifier

***Practice:** Design and analyze BJT amplifier configurations, Design and analyze multistage amplifier configurations*

Unit-4 - Feedback Amplifiers and Oscillators **15 Hour**

Basic feedback concepts, general feedback structure, Properties of negative feedback, Feedback Topologies: Voltage-Series & Current-Series feedback connections, Feedback Topologies: Voltage-Shunt & Current-Shunt feedback connections, Practical Feedback Amplifier Circuits. Oscillators: Principles of Oscillation, Types of Oscillators: RC Phase Shift Oscillator, Wein Bridge Oscillator, Hartley Oscillator, Colpitts and Clapp Oscillators, Crystal Oscillators

***Practices**: Design and analyze negative feedback amplifier configurations, Design and analyze RC oscillators, Design and analyze LC oscillators.*

Unit-5 - Power Amplifiers **15 Hour**

Definition and amplifier types, Q point placement, Class A amplifier, Class B and Class AB push-pull amplifiers, Class C amplifiers, Class D, IC Biasing and Amplifiers with Active Load: BJT current sources: 2- & 3-transistor current sources using BJT, Analysis of BJT differential amplifier with active load, Analysis ofFET differential amplifier with active load

***Practice**: BJT & FET Current Sources, Design and analyze BJT CE amplifier with active load, Design and analyze FET CS amplifier with active load*

Learning Resources	*1 David A. Bell, Electronic Devices and Circuits, 5th ed., Oxford University Press, 2015* *2 Donald Neamen, Electronic Circuits: Analysis and Design, 3rd ed., McGraw-Hill Education, 2011* *3 Roy Choudhury, Shail Jain, Linear Integrated Circuits, 4th ed., New Age International Publishers, 2014.* *4 Muhammad Rashid, Microelectronic Circuits: Analysis & Design, 2nd ed., Cengage Learning, 2010*	*5 Adel S. Sedra, Kenneth C. Smith, Microelectronic Circuits: Theory and Applications, OUP, 20146. Robert L. Boylestad, Louis Nashelsky, Electronic Devices and Circuit Theory, 11th ed., Pearson Education, 2013* *6 Albert P. Malvino, David J. Bates, Electronic Principles, 8th ed., Tata McGraw Hill, 2015*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	-	15%	15%	-
Level 2	Understand	20%	-	-	20%	20%	-
Level 3	Apply	25%	-	-	25%	25%	-
Level 4	Analyze	25%	-	-	25%	25%	-
Level 5	Evaluate	10%	-	-	10%	10%	-
Level 6	Create	5%	-	-	5%	5%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1 Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr.T. Rajalakshmi, SRMIST*
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarr Software's Pvt Ltd.	*2 Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECC215J	**Course Name**	OBJECT ORIENTED DESIGN AND PROGRAMMING	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*utilize class and build domain model for real-time programmers*
CLR-2:	*utilize C++ programs using method overloading and operator overloading for real-time programmers*
CLR-3:	*construct inline, friend and virtual function, and create application development programs for real-time*
CLR-4:	*utilize exception handling and collection for real-time object oriented programming*
CLR-5:	*construct UML Component and deployment diagram for design of application*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concept of class and build domain model*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*develop C++ programs using method overloading and operator overloading*	-	*3*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-3:	*write program using inline, friend and virtual function, construct program using standard template*	-	-	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*construct C++ program using templates and exception handling*	-	*3*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-5:	*create UML Component and deployment diagram*	-	*3*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	*3*	-

Unit-1 - Basic OOPS and Constructor ***15 Hour***

Comparison of Procedural and Object Oriented Programming- OOPS and its features-I/O Operations, Data Types, Variables, static- Constants, Pointers, Type Conversions –Features: Class and objects- -Feature Abstraction and Encapsulation - Application of Abstraction and Encapsulation - Types of constructor (Default, Parameter)- Static constructor and copy constructor- Feature Polymorphism: Constructor overloading - Method Overloading – Example of method overloading.

Practices on: *I/O operations, Classes and object diagram, methods of constructor*

Unit-2 - Polymorphism and Overloading ***15 Hour***

Method Overloading: Different parameter with different return values - Constructor and Method overloading - Operator Overloading and types - Overloading Assignment Operator - Overloading Unary Operators - Example for Unary Operator overloading - Overloading Binary Operators - Example for Binary Operator overloading - Polymorphism : Operators Overloading - UML Interaction Diagrams - Sequence Diagram - Collaboration Diagram - Example Diagram - Feature: Inheritance - Inheritance and its types - Feature Inheritance: Single and Multiple - Inheritance: Multilevel- Inheritance: Hierarchical - Inheritance: Hybrid-Inheritance: Example Programs - Inheritance and its types-

Practices on: *Constructor and Method Overloading- polymorphism: Operator Overloading*

Unit-3 - Overview of Inheritance, Abstract Class and Templates ***15 Hour***

Advanced Functions: Inline, Friend – Advanced Functions: Virtual, Overriding- Advanced Function: Pure Virtual function -Example for Virtual and pure virtual function- Abstract class and Interface - Example Program - Virtual Function and Abstract class - - UML Class Diagram and its components - Class Diagram relations and Multiplicity -UML Component Diagram - Class Diagram - Access specifies – public, private - Access specifies - protected, friend, inline - UML use case Diagram, use case, Scenario - Use case Diagram objects and relations - Method, Constructor and Destructor - Example program for constructor - Methods and Constructor, Use case.UML Component Diagram - UML Deployment Diagram - Example Package, Deployment , Package diagram - - Templates: Introduction- Function templates- Example programs Function templates - Class Templates- Example programs for Class and Function templates - Templates- Exceptional Handling: try and catch

Practices on*: Inheritance and its type- virtual function and abstract classes – UML class and object diagram – UML Interaction diagram – Templates.*

Unit-4 - Exception Handling and UML	***15 Hour***
Exceptional Handling: Multilevel exceptional - Exceptional Handling: throw and throws- Exceptional Handling: finally - Exceptional Handling: User defined exceptional - Example Programs using C++ - Exceptional Handling - Dynamic Modeling: Package Diagram - UML Diagrams Introduction- I/O operations - Feature :Class and Objects - Examples of Class and Objects - UML State Chart Diagram - Example State Chart Diagram - UML Activity Diagram - Example Activity Diagram - State Chart and Activity Diagram-Generic -UML Component, UML Interaction Diagram Deployment, Package diagram. ***Practices on: State** chart and activity diagram - Exception handling – UML component and activity diagram*	
Unit-5 - STL Container and File Handling	***15 Hour***
STL: Containers: Sequence and Associative Container - Sequence Container: Vector, List- Sequence Container: Deque, Array- STL : Stack - STL Containers - Associative Containers: Map, Multimap- Iterate and Specialized iterate- Functions of iterator - Algorithms: find(), count(), sort() - Algorithms: search(), merge() - STL Associative containers and algorithms - Function Object : for each(), transform()-Example for Algorithms - Streams and Files: Introduction - Classes and Errors - Disk File Handling Reading Data and Writing Data - Streams and File Handling- storing objects in files ***Practices on:** STL container – STL Associative container and algorithm – Stream and file handling.*	

Learning Resources	*1 Grady Booch, Robert A. Maksimchuk, Michael W. Engle, Object-Oriented Analysis and Design with Applications, 3rd ed., Addison-Wesley, May 2007* *2 Reema Thareja, Object Oriented Programming with C++, 1st ed., Oxford University Press, 2015* *3 Sourav Sahay, Object Oriented Programming with C++, 2nd ed., Oxford University Press, 2017*	*4 Robert Lafore, Object-Oriented Programming in C++, 4th ed., SAMS Publishing, 2008* *5 Ali Bahrami, Object Oriented Systems Development", McGraw Hill, 2004* *6 Craig Larmen, Applying UML and Patterns, 3rd ed., Prentice Hall, 2004*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 2	*Understand*	*20%*	*-*	*-*	*10%*	*20%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*20%*	*-*	*-*	*30%*	*30%*	*-*
Level 5	*Evaluate*	*10%*	*-*	*-*	*20%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Mr. Mohan, Embedded 360, Chennai	*1 Dr. R. Venkatesan, Sr. Scientist, NIOT, Chennai*	*1 Dr. J. Selvakumar, SRMIST*
2 Mr. Sai Vineeth, ML Silicon Architect, Google Cloud TPU, USA	*2 Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*2 Mrs. S. T. Aarthi, SRMIST*

Course Code	21ECC233L	Course Name	DATA STRUCTURES LABORATORY	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							0	0	4	2

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn about basic lists and array operations*
CLR-2:	*impart knowledge on stacks and queues*
CLR-3:	*identify and analyse trees and their implementation*
CLR-4:	*acquire the knowledge about graphs*
CLR-5:	*practice coding for various searching, sorting algorithms and hash functions*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement abstract data types using arrays and linked list using C Programming*	-	*1*	*2*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply the different linear data structures like stack and queue to various computing problems using C Programming*	-	*1*	*2*	-	*3*	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*implement different types of trees and apply them to problem solutions using C Programming*	-	*1*	*2*	-	*3*	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*discuss graph structure and understand various operations on graphs and their applicability using C Programming*	-	*1*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*analyse the various sorting and searching algorithms, hashing technique and hash functions using C Programming*	-	*1*	*2*	-	*3*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Using C programming ***12 Hour***

- *Construct stack of integers and to perform the various operations on stack*
- *Simulate the working of a queue of integers using an array*
- *Simulate the working of a Circular queue and Deque of integers using an array*
- *Construct a singly linked list and perform the various operations on it*

Unit-2 - Using C programming ***12 Hour***

- *Construct stack of integers and to perform the various operations on stack*
- *Simulate the working of a queue of integers using an array*
- *Simulate the working of a Circular queue and Deque of integers using an array.*

Unit-3 - Using C programming ***12 Hour***

- *Construct a binary search tree of integers.*
- *Traverse the tree using all the methods i.e., inorder, preorder and postorder.*
- *Display the elements in the tree*

Unit-4 - Using C programming **12 Hour**

- *Represent, implement and traverse graphs in data structure.*
- *Implement the adjacency list representation of a graph with m vertices and n edges*
- *Find the minimum spanning tree of an undirected Graph using greedy approach*

Unit-5 - Using C programming **12 Hour**

- *Implement linear search algorithm and binary search algorithm.*
- *Implement Selection sort algorithm, Insertion sort algorithm*
- *Implement Bubble sort algorithm, and Quick sort algorithm*

Learning Resources	*1 Mark Allen Weiss, ―Data Structures and Algorithm Analysis in C 2nd Edition, Pearson Education, 1997.*	*3 Thomas H. Cormen, Charles E. Leiserson, Ronald L.Rivest, Clifford Stein, Introduction to Algorithms", Second Edition, Mcgraw Hill, 2002.*
	2 Reema Thareja, ―Data Structures Using C, Second Edition , Oxford University Press, 2011	*4 Ellis Horowitz, Sartaj Sahni, Susan Anderson-Freed, ―Fundamentals of Data Structures in C, Second Edition, University Press, 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		CLA-1 Average of first cycle experiments (30%)		*CLA-2 Average of second cycle experiments (30%)*		*Practical Examination (40% weightage*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 2	*Understand*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 4	*Analyze*	-	*20%*	-	*20%*	-	*20%*	-	-
Level 5	*Evaluate*	-	*10%*	-	*10%*	-	*10%*	-	-
Level 6	*Create*	-	*10%*	-	*10%*	-	*10%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1 Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1 Dr. R. Venkatesan, Sr. Scientist, NIOT, Chennai*	*1 Dr.J. Subhashini, SRMIST*
2 Mr. Sai Vineeth, ML Silicon Architect, Google Cloud TPU, USA	*2 Dr. Meenakshi, Professor of ECE, CEG, Anna University*	

Course Code	21ECC312T	**Course Name**	HARDWARE INTERFACING AND NETWORKING	**Course Category**	C	PROFESSIONAL CORE		L	T	P	C
								3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*acquire knowledge of CAN standards, electrical requirements and signaling*
CLR-2:	*overview of CAN open protocol used in industrial controllers*
CLR-3:	*outline LIN bus, MODBUS, ProfiBus used for automotive networks*
CLR-4:	*organize the Flexray protocol standard for automotive control networks*
CLR-5:	*incorporate Automotive Ethernet in an automotive application*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the CAN electrical, mechanical standards and signaling methods*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze a typical application based on CAN open protocol*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*interpret the LINbus, MODBUS, and Profibus protocols for software interfacing*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*construct codes in C to interface software for Flexray protocol application*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*comprehend the case studies in the automotive environment*	-	-	*3*	*2*	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - CAN Bus Introduction ***9 Hour***

Introduction to CAN – Electrical properties – CAN signaling and data rates – CAN data frame format- Collision and arbitration- Design examples -Error handling – Error state diagram – CAN controller block diagram and working- Software for CAN controller interfacing- CAN development tools- Demonstration of a typical CAN connection definition.

Unit-2 - CAN and CAN Open ***9 Hour***

CAN open overview. - Communication requirements for embedded networking- The object dictionary concept- Communication entries- SDO and PDO- PDO linking- Identifying objects COB-ID -EDS and DCF, PDO communication -SDO communication- Network management and safety critical feature.

Unit-3 - Profibus, LIN Bus, MODBUS ***9 Hour***

Profibus, network topologies- Network Configuration-Active components – Passive components: connectors, cables, etc- Testing of profibus – LIN bus basics- LINbus protocol; master slave configuration – Basics of MODBUS – MODBUS protocol – MODBUS application

Unit-4 - Flexray Protocol ***9 Hour***

Introduction to Flexray- Bus architectures – Protocol operation control context- Operational overview- Protocol operation control process – Behaviour during normal operation- Coding and decoding-Flexray payload – Wakeup and startup- Clock synchronization – Controller host interface- System parameters.

Unit-5 Automotive Ethernet ***9 Hour***

Introduction to Automotive networking – Electrical requirements – Network layer protocols, TCP/IP, UDP – Ports and sockets – Audio, Video bridging- Audio/Video transport protocol – IEEE1722- Audio/Video transport protocol- Measurement, calibration, diagnostics.

Learning Resources	1. *Olaf Pfeiffer, Andrew Ayre and Christian Keydel, "Embedded networking with CAN and CANopen", Copper hill Technologies Corporation, 2008.* 2. *SGS-Thompson, "Lin Application note AN1278", SGS - Thompson Ltd. 2002.* 3. *Modbus-IDA, "MODBUS application protocol specification", Modbus-IDA, 2006. Siemens, "Profibus network manual", Siemens manual, 2009.*	4. *Xiu Ji, "Profibus in practice: System Architecture and Design", CRC press, 2015.* 5. *Domnique parot "Flexrayand its applications: Real time multiplexed network", Wiley online library, 2012.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	25%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	30%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. K. Vadivukkarasi, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECC313P	Course Name	EMBEDDED MICROCONTROLLERS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
CLR-1:	*apply the basic concept of digital fundamentals to Microprocessor based personal computer system*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-2:	*solve basic binary math operations using the microprocessor / Microcontroller*															
CLR-3:	*demonstrate programming proficiency using the various addressing modes of the target microprocessor / microcontroller*															
CLR-4:	*analyse the properties of Microprocessors & Microcontrollers*															
CLR-5:	*design and interface of various peripheral chips with 8051 and PIC microcontroller*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*illustrate the CAN electrical, mechanical standards and signaling methods*	-	-	3	-	2	-	-	-	1	-	-	-	3	-	-
CO-2:	*analyze a typical application based on CAN open protocol*	-	-	3	-	2	-	-	-	1	-	-	-	3	-	-
CO-3:	*interpret the LINbus, MODBUS, and Profibus protocols for software interfacing*	-	-	-	3	2	-	-	-	1	-	-	-	-	3	-
CO-4:	*construct codes in C to interface software for Flexray protocol application*	-	-	-	3	2	-	-	-	1	-	--	-	-	3	-
CO-5:	*comprehend the case studies in the automotive environment*	-	-	-	3	2	-	-	-	1	-	-	-	-	3	-

Unit-1 - Microprocessor	***12 Hour***
Basics of Microprocessor, 8086 registers and its functions, Instruction set of 8086 and simple Programs, Microprocessor bus, and signals, 8086 Hardware architecture, Min mode system configuration, arithmetic operation, shift operation, Max mode system configuration, Advanced instructions, Interrupt processing, HALT and WAIT for test states, DMA, ***Case studies**: 8086 to transfer data, do arithmetic and logical operations*	
Unit-2 - 8051 Peripherals	***12 Hour***
Comparisons between Microprocessors and microcontroller, 8051 architecture, Pin functions, Memory organization, Special Function Registers, Instruction set-classification, Instruction set-addressing modes, C Programming- I/O programming, Timer programming, 8051 interrupts Programming, ***Case studies:** 8051 to transfer data Serially, receive data Serially, timer and counter, serial communication using Interrupts.*	
Unit-3 - External Peripheral Interfacing	***12 Hour***
- LCD interfacing, Keyboard interfacing, Interfacing with external ROM, ADC interfacing, DAC interfacing, Sensor interfacing, Stepper motor interfacing, DC motor interfacing, DS12887 RTC interfacing, ***Case studies:** Interfacing LED / 7- segment / LCD displays/ keyboard, Interfacing DC motor / stepper motor / servo motor.*	
Unit-4 - PIC Microcontroller	***12 Hour***
PIC Architecture, Registers organization, Memory organization, addressing modes, Instruction set: classification, logical operation, Arithmetic operation, branching, time delay loop, arithmetic operation, CALL, Programming in assembly, Programming in Embedded C, ***Case Studies:** PIC microcontroller based embedded system for logical, arithmetic operation, CALL*	

Unit-5 - PIC Peripheral Interfacing	***12 Hour***
Timers, Interrupts, I/O ports, I2C bus, LCD Interfacing, CCP modules, Flash and EPROMS, ADC Interfacing, DAC Interfacing, PIC timer programming, serial port programming, interrupt programming, CCP programming, ***Case studies:*** *Interfacing LCD displays, Interfacing ADC / DAC, Timer, Serial, Interrupt, CCP.*	

Learning Resources	1. *Krishna Kant, "Microprocessor and Microcontrollers, Architecture, Programming and System Design 8085, 8086, 8051, 8096", PHI, 2013.* 2. *Muhammad Ali Mazidi and Janice Gillispie Mazidi, "The 8051 - Microcontroller and Embedded systems", 7th Edition, Pearson Education, 2011.* 3. *Anbazhagan K "Beginning 8051 Microcontroller Projects Handson", Independently Published, 2020*	4. *Subrataghoshal "8051 Microcontroller Internals Instructions, Programming and Interfacing",2nd edition Pearson 2010* 5. *Muhammad Ali Mazidi-Rolin-D-Muckinlay, Danny Caussey. "Pic Microcontroller And Embedded System Using Assembly And C For Pic 18" Pearson Education, 2021.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*5%*	-	-	*5%*	-	*5%*	-	-
Level 2	*Understand*	*5%*	-	-	*5%*	-	*5%*	-	-
Level 3	*Apply*	*25%*	-	-	*25%*	-	*20%*	-	-
Level 4	*Analyze*	*25%*	-	-	*20%*	-	*25%*	-	-
Level 5	*Evaluate*	*20%*	-	-	*20%*	-	*20%*	-	-
Level 6	*Create*	*20%*	-	-	*25%*	-	*25%*	-	-
	Total	*100 %*		*100 %*		*100 %*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr.S. Kayalvizhi, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECC314J	Course Name	EMBEDDED HARDWARE AND OPERATING SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*recognize the fundamentals of ARM instruction set architectures*
CLR-2:	*emphasize on ARM cortex microcontroller features*
CLR-3:	*realize the thread management and parallel programming in RTOS*
CLR-4:	*comprehend the scheduling process in RTOS*
CLR-5:	*study and implement the case study through sample use cases*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*write program with the ARM microprocessor instructions*	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	*interpret the architectural features of microcontrollers*	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the concepts of thread management in RTOS*	3	-	-	-	2	-	-	-	-	-	-	-	3	-	-
CO-4:	*explicate the scheduling and services of embedded operating systems*	3	-	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-5:	*analyze the features and RTOS services through related sample use cases*	3	-	-	2	-	-	-	-	-	-	-	-	3	-	-

Unit-1 - Microprocessor and Microcontroller ***12 Hour***

Cortex-M Processor architecture- ARM Cortex assembly language - Programming exercises -ARM Cortex microcontroller interface standards- IDE software tools- Embedded debugging tools in Keil IDE- Embedded debugging example with simulation- Memory management.

Practice*: ARM Cortex assembly language with simulator, C & assembly programming using Keil IDE and kit.* *12*

Unit-2 - Microcontroller Features ***12 Hour***

Parallel I/O programming- Sample programs- Interrupt processing basics- System tick; periodic interrupts- Conditional execution- UART programming- Digital signal time measurement- Use of timers and compare, capture registers - SSI interface- SSI programming with interrupt- Analog I/O; A/D converter interfacing- Programming example-
OS considerations of I/O devices

Practice*: Interrupts and timers in C and assembly, A/D interfacing, Debugging hardware with target board*

Unit-3 - Thread Management ***12 Hour***

Introduction to RTOS- Concurrent programming- Thread fundamentals- Shared resources and Critical sections- Consumer producer problem- Switching threads- Profiling the OS- Semaphores and implementation- Operations on semaphores- Resource sharing- Conditional variable- Thread communications- Process management- Dynamic linking and loading.

Practice*: Simple thread programming in RTOS, Multithreaded application in RTOS, Program profiling*

Unit-4 - RTOS Services ***12 Hour***

Spin-lock semaphore, Cooperative scheduler, Blocked state- Implementation- Thread rendezvous- Example- FIFO & Little's theorem- Three semaphore implementations- Kahn process networks- Thread sleeping- Deadlocks, monitors- Fixed scheduling.

Practice: *Two semaphore implementation, one semaphore implementation, Multithreaded application with communication, Priority based scheduling; threads and communications*

Unit-5 - Real-Time Embedded Systems	***12 Hour***
Real time systems: Data acquisition system- Approach- Performance Metrics-Examples- Multilevel feedback queue- priority scheduler- DMA / high speed interface- Solid state disk- Flash device driver- SD card interface- Communication systems with Ethernet- Application layer protocols for embedded systems- CoAP, MQTT ***Practice:*** *Priority based scheduling; threads and communications, Semaphore implementation experiment in RTOS, Application programs using RTOS*	

Learning Resources		
Learning Resources	1. *Jonathan Valvano, "Real time operating systems for ARM Cortex- Microcontrollers, Embedded systems - Volume 3", Jonathan Valvano, 2017.* 2. *Andrew Sloss ET all, "ARM system developer's guide", Elsevier, 2004.*	3. *Quing Li, "Real time techniques for embedded systems", CMP Books, 2003* 4. *K.C. Wang, "Embedded and Real time operating systems", Springer, 2017.* 5. *www.arm.com, for ARM cortex M references*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*15%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*30%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*5%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. P. Radhika, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECC315T	Course Name	DATABASE MANAGEMENT SYSTEMS	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamentals of Database Management Systems, Architecture and Languages*
CLR-2:	*conceive the database design process through ER Model and Relational Model*
CLR-3:	*design Logical Database Schema and mapping it to implementation level schema through Database Language Features*
CLR-4:	*understand the practical problems of concurrency control and gain knowledge about failures and recovery*
CLR-5:	*familiarize the basics of distributed database management systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*identify and define the information that is needed to design a database management system for a business information problem*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*create conceptual and logical database designs for a business information problem*	*2*	*3*	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*build a database management system that satisfies relational theory and provides users with business queries*	*3*	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*describe transaction processing and concurrency control concepts*	*2*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*understand distributed database systems architecture and design*	*2*	*1*	-	-	*3*	-	-	-	-	-	-	-	-	-	-

Unit-1 - Database Systems	***9 Hour***
Introduction to Databases and Transactions: database system, purpose of database system, view of data, relational databases, database architecture, transaction management Data Models: The importance of data models, Basic building blocks, Business rules, The evolution of data models, Degrees of data abstraction PL-SQL: Beginning with PL / SQL, Identifiers and Keywords, Operators, Expressions, Sequences, Control Structures, Cursors and Transaction, Collections and composite data types, Procedures and Functions, Exceptions Handling, Packages, With Clause and Hierarchical Retrieval, Triggers.	
Unit-2 - Database Design	***9 Hour***
Entity-Relationship model - E-R Diagrams - Enhanced-ER Model - ER-to-Relational Mapping - Functional Dependencies - Non-loss Decomposition - First, Second, Third Normal Forms, Dependency Preservation - Boyce/Codd Normal Form -Multi-valued Dependencies and Fourth Normal Form - Join Dependencies and Fifth Normal Form	
Unit-3 - Relational Algebra	***9 Hour***
Relational Algebra and Calculus: Relational algebra: introduction, Selection, and projection, set operations, renaming, Joins, Division, syntax, semantics. Operators, grouping and ungrouping, relational comparison. Calculus: Tuple relational calculus, Domain relational Calculus, calculus vs algebra, computational capabilities	
Unit-4 - Transaction Management	***9 Hour***
Transaction processing - Concurrency control - ACID property - Serializability of scheduling - Locking and timestamp-based schedulers - multi-version and optimistic Concurrency Control schemes -Database recovery- Case study	
Unit-5 - Distributed Database Management Systems	***9 Hour***
Distributed Databases: Architecture, – Client/Server, Peer to peer, MDBS Systems, Distributed Data Processing, -Promises of DDBSs, - Complicating factors- Design Alternatives- Fragmentation	

Learning Resources	1. *Data base Management Systems, Raghu Ramakrishnan, Johannes Gehrke, McGraw Hill Education (India) Private Limited, 3rd Edition, 2003* 2. *Fundamental of Database Systems, Ramez Elmasri, Shamkant B. Navathe, Pearson Education, 6th edition, 2011* 3. *Data base System Concepts, A. Silberschatz, and Henry. F. Korth, S. Sudarshan, McGraw Hill Education (India) Private Limited l, 6th edition, 2011*	4. *Database Systems Design, Implementation, and Management, Peter Rob & Carlos Coronel, 7th Ed., 2011.* 5. *Principles of Distributed Database Systems, Ozsu, Pearson Publication, 2011* 6. *Distributed Database Management Systems, Rahimi & Haug, Wiley, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	15%	-	15%	-
Level 2	*Understand*	25%	-	20%	-	25%	-
Level 3	*Apply*	30%	-	25%	-	30%	-
Level 4	*Analyze*	30%	-	25%	-	30%	-
Level 5	*Evaluate*	-	-	10%	-	-	-
Level 6	*Create*	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr.K. Kalimuthu, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECC317T	**Course Name**	DATA COMMUNICATION AND PLC	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain knowledge in Physical layer*
CLR-2:	*know the various data link layer protocols and multiple access schemes*
CLR-3:	*understand various network layer protocols*
CLR-4:	*describe the functionality of transport and application layer*
CLR-5:	*gain knowledge on programmable logic controllers*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply modulation, sampling multiplexing techniques for effective data communication*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*incorporate data link layer protocols to have error and flow control and multiple access schemes*	-	2	-	*3*	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*analyze various network layer protocols and multiple access schemes*	-	2	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*demonstrate the concepts of transportation and Application layer protocols*	-	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*implement Programmable logic controllers in suitable applications*	-	-	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - Physical Layer ***9 Hour***

Line coding, Modulation-Amplitude modulation, Over modulation and Distortion, Single-Sideband Suppressed-Carrier Amplitude Modulation, Frequency Modulation, Phase Modulation, Sampling Theorem- Analyzing Impulse Train Sampling, Reconstruction of the Continuous-Time Signal, Statement of the Sampling Theorem, Proof of the Sampling Theorem, Analog-to-Digital Conversion: From PAM to PCM-PCM, Quantization Noise, Basic digital modulation schemes- Amplitude-Shift Keying, Frequency-Shift Keying, Phase-Shift Keying, Media access sharing schemes- Frequency Division Multiplexing, Time Division Multiplexing, Synchronous Versus Asynchronous TDM, Modems, Transmission media -Twisted Pair, Coaxial Cable, Optical Fiber, Fiber Modes, Wireless medium, Channel impairments- Attenuation, Noise, Distortion, Equalization

Unit-2 - Data Link Layer Protocols and Multiple Access Schemes ***9 Hour***

Framing, Bit Stuffing, Flow Control-The Stop-and-Wait Protocol, Error Detection-Parity Checking, Two-Dimensional Parity, Cyclic Redundancy Checking, Error Control Protocols- Stop-and-Wait ARQ. Go-Back-N ARQ, Selective Repeat ARQ, Data Link Control Protocols-High-level Data Link Control, Point-to-Point Protocol, Multiple Access Schemes- Orthogonal Access Schemes, Controlled Access Schemes-Centralized Polling, Token Passing, Random Access Schemes, Aloha System, Slotted Aloha, CSMA, CSMA/CD, CSMA/CA

Unit-3 - Network Layer ***9 Hour***

IP Address, Maximum Transmission Unit, IP Version 4 Addressing, IP Subnetting, Variable Length Subnet Mask Networks,IPv6-IPv6 Header, Concept of Flexible Addressing in IPv6, Routing Algorithms-Static Versus Dynamic Routing, Link-State Versus Distance–Vector Routing, Flat Versus Hierarchical Routing, Host-Based Versus Router-Intelligent Routing, Centralized Versus Distributed Routing, Routing Metrics, Distance–Vector Routing Algorithms, Link-State Routing Algorithms, Open Shortest Path First Protocol, The Dijkstra's Algorithm

Unit-4 – Transport Layer and Application Layer ***9 Hour***

TCP Basics, TCP Ports, TCP Sockets, TCP Segment Format, TCP Connection Establishment, TCP Connection Release, TCP Connection Management, TCP Flow Control-Slow start, Congestion avoidance, Fast retransmit, Fast recovery, UDP, Application layer-Dynamic Host Configuration Protocol-DHCP Basics, Discovery Phase, Offer Phase, Request Phase, Acknowledgment Phase, DNS-Structure of the DNS, DNS Queries, Name-to-Address Resolution Process, DNS Zones, DNS Zone Updates, Dynamic Update

Unit-5 – Programmable Logic Controllers	***9 Hour***
controllers, programmable logic controllers, Hardware of PLC system, Internal architecture, Input devices- Temperature sensors, strain gauges, output devices-Relay, directional control valves, Examples of applications-A robot control system, Liquid level monitoring, Ladder and functional block programming-Ladder diagrams, PLC ladder programming, Latching, Multiple outputs, Entering programs- ladder symbols-program examples-location of stop switches-safe systems-PLC systems and safety.	

Learning Resources	*1. Oliver C. IBE, Fundamentals of Data Communication Networks, Wiley, 2018.* *2. Robert Techo,Data Communications-An introduction to concepts anddesign,Springer,2013*	*3. W.Bolton, Programmable logic controllers, Sixth edition, Newnes, 2015* *4. Frank D.Petruzella, Programmable logic controllers, Mc-Graw Hill Eucation,2016*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr.S. Krithiga, SRMIST*
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECC412J	**Course Name**	PROGRAMMING WITH PYTHON	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the basics of Python*
CLR-2:	*explore the advanced features like classes and modules*
CLR-3:	*define System Programming for optimization of codes*
CLR-4:	*implement the internet programming for different web page applications*
CLR-5:	*use Python Programming for automating the various tasks*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*write simple python programs using different data types and control statements*	-	*3*	-	-	*3*	-	-	-	*3*	-	-	-	*2*	-	-
CO-2:	*define own classes and functions to organize the code*	-	*3*	-	-	*3*	-	-	-	*3*	-	-	-	*2*	-	-
CO-3:	*optimize the applications using multithreading*	-	-	-	*2*	*3*	-	-	-	*3*	-	-	-	-	-	*2*
CO-4:	*perform data communication between websites and develop interactive web pages*	-	-	-	*3*	*3*	-	-	-	*3*	-	-	-	-	-	*3*
CO-5:	*automate the various tasks using Python Programs*	-	-	*3*	-	*3*	-	-	-	*3*	-	-	-	-	-	*3*

Unit-1 - Python Basics ***12 Hour***

Introduction to Python - Python Interpreter and its working - Syntax and Semantics - Data Types - Assignments and Expressions - Control Flow Statements - Sequences - Lists - Tuples - Dictionaries - Functions and lambda expressions

Practice: *Simple programs to compute mathematical Formulas, Programming on Functions, Programming on Lists, Tuples and Dictionaries*

Unit-2 - Advanced Python Features ***12 Hour***

Iterations and Comprehensions - Handling text files - Modules - Classes - OOPs - Exception Handling - Strings and Regular Expressions

Practice*: Programming on Class, String Manipulations, Reading and Writing Text Files*

Unit-3 - System Programming ***12 Hour***

System Tools: sys module - OS module - File Tools - Directory Tools - Parallel System Tools: Threads, Program Exits, multiprocessing module

Practice*: Programming using File Tools, Programming using Directory Tools,*

Unit-4 - Internet Programming ***12 Hour***

Network Scripting: Socket Programming, Handling Multiple Clients - Client-Side Scripting: FTP and SMTP - Server Side Scripting : CGI Scripts with User Interaction, Passing Parameters

Practice: *Socket Programming, Programming on FTP, Passing parameters in URLs*

Unit-5 - Automating Tasks Using Python ***12 Hour***

Patten Matching: Phone number detection, Strong Password detection, Organizing Files: Copying, Moving, Renaming and deleting of Files and File Folders, compressing files with the zip file module, Drawing shapes and text

Practice: *Verification of phone number, Detection of Strong Password, Drawing shapes and text*

Learning Resources	*1. "Learning Python" by Mark Lutz, 5th Edition, O'Reilly Media, June 2013* *2. "Programming Python" by Mark Lutz, 4th Edition, O'Reilly Media, 2010,*	*3. "Automate the Boring Stuff with Python" by Al Sweigart, 2015, William Pollock*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*15%*	-	-	*15%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*30%*	*30%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*30%*	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	-	-
Level 6	*Create*	*10%*	-	-	*10%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University, meena68@annauniv.edu*	*1. Dr. E. Chitra, SRMIST*
2. Ms. Roshni Rajan, SDE II, Amazon, US. *Mr. S. Ashish, Software Engineer, TCS – Digital, Chennai*	*2. Dr. Venkatesan, Sr. Scientist, NIOT, Chennai, venkat@niot.res.in*	

Course Code	21ECC413T	**Course Name**	FPGA BASED EMBEDDED SYSTEMS	**Course Category**	C	PROFESSIONAL CORE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*understand the basic concepts of FPGA architecture*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*employ VHDL as a design entry language for FPGA System design*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*design and construct simple system design using arithmetic and logic units*															
CLR-4:	*acquire the knowledge of embedded processor and hardware accelerated design*															
CLR-5:	*practice coding for various application using FPGA tools*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*acquire knowledge on FPGA architecture and practice on HDL language*	3	-	-	-	2	-	-	-	-	-	-	-	-	-	-
CO-2:	*design and implement the digital circuits using VHDL*	2	-	3	-	3	-	-	-	-	-	-	-	2	-	-
CO-3:	*construct various subsystems for FPGA system design*	2	-	3	-	3	-	-	-	-	-	-	-	-	-	-
CO-4:	*develop the embedded hardware accelerated design for real time applications*	-	-	3	-	2	-	-	-	-	-	-	-	3	-	-
CO-5:	*implement the various applications using SysGen and Vivado tool for practice*	-	-	3	-	3	-	-	-	-	-	-	-	3	-	-

Unit-1 – FPGA Architectures	***9 Hour***
FPGA Introduction- FPGA Internal architectures- Fine, medium, and coarse-grained architectures- CLBs, LABs &Slices-Logic Implementation using MUX and LUTs- Programmable Interconnections-Anti-fuse, SRAM-Fine, EEPROM-Embedded multipliers, Adders, MACs-Embedded processor cores-clock tree and clock manager-general purpose I/O, Hard IP, Soft IP and Firm IP-FPGA Implementation process for Digital logics	
Unit-2 – Digital Circuit Design with VHDL	***9 Hour***
Introduction-Code design structures-Data types and their conversions- Operators and Attributes-Concurrent code –Sequential code-Flip-Flops-Data shift registers-Multifrequency generator	
Unit-3 – Arithmetic, Logical Programming and Simple System Design	***9 Hour***
Introduction- Arithmetic Operations-Multiply –Accumulation Circuit-Arithmetic and Logic Unit-Rom design and Logic implementation-RAM design-Counter design and Interfacing-Digital clock design and Interfacing	
Unit-4 – Hardware Accelerated Designs	***9 Hour***
A simple embedded processor-soft core processor on an FPGA –Real time clock and Interface protocol Programming-Inter-Integrated circuit Interface Programming-UART- Serial peripheral interface programming	
Unit-5 – SysGen and Vivado Tool Practice	***9 Hour***
Use and Interfacing methods of some Blocksets-System design and Implementation using SysGen tool. Zynq 7 series architecture-Use Vivado design flow to build an Embedded System-Adding IP cores in PL.	

Learning Resources	*1. Raj, A. Arockia Bazil,” FPGA-Based Embedded System Developer’s Guide” Taylor & Francis, CRC Press, 2018* *2. Clive Maxfield,”FPGAs world class designs, Newnes 2009*	*3. https://www.xilinx.com/support/university.html* *4. Sass and Schmidt, "Embedded system design with Platform FPGAs", Morgan Kaufmann, 2010.* *5. www.arm.com for processor architecture*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	20%	-	20%	-	20%	-
Level 2	*Understand*	25%	-	25%	-	25%	-
Level 3	*Apply*	35%	-	35%	-	35%	-
Level 4	*Analyze*	20%	-	20%	-	20%	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Elango Sekar, Assistant Professor (Level -III), BIT Sathyamangalam, TN, India*	1. *Dr. P. Radhika, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21ECE210P	Course Name	IOT SYSTEM DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*classify the components and protocols required to build IoT network*
CLR-2:	*evaluate suitable protocols for the IoT network*
CLR-3:	*develop IOT system for various applications*
CLR-4:	*analyze the architecture of IoT communication layers*
CLR-5:	*demonstrate the techniques of Data Analytics and security for IoT networks*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*categorize the components and protocols required to build IoT network*	3	-	-	2	1	-	-	-	-	-	-	-	2	-	-
CO-2:	*appraise suitable protocols for the IoT network*	3	-	2	-	2	-	-	-	-	-	-	-	-	-	-
CO-3:	*evaluate IOT system for various applications*	3	-	2	-	2	-	-	-	-	-	-	3	3	-	2
CO-4:	*distinguish the architectures of IoT communication layers*	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*demonstrate the techniques of Data Analytics and security for IoT networks*	3	-	-	2	-	-	-	-	-	-	-	2	3	-	-

Unit-1 - IoT Technology	***9 Hour***
Sensors, Actuators and Smart Objects, Smart sensor object hardware and software, Energy management of nodes, Communication standard IEEE802.15.4, IoT Access Technologies IEEE 802.15.4g and 802.15.4e, IoT Access Technologies: LoRa WAN, Case Studies: Sensor measuring experiment using IoT node	
Unit-2 - IoT Communication	***9 Hour***
IEEE802.11 WiFi communication, Lightweight IP stack, IPv6 for smart object networks, RPL routing in smart objects, Case Studies: Communication through WiFi, Communication through Bluetooth	
Unit-3 - IoT Design Applications	***9 Hour***
Non-IP smart object technologies, Smart Grid, Smart Cities, Smart cities and Urban networks, home automation, building automation Case Studies: Configuration of Raspberry-Pi/ Beagle Board circuit with basic peripherals, IoT Data Logging using Beaglebone Black and Thingspeak	
Unit-4 - Protocols for IoT	***9 Hour***
Need for Optimization and Nodes, Networks, Optimizing IP For IoT, IoT Layers: : Physical And Controllers – Connectivity Edge Computing And Upper Layers, Core IoT Functional Stack: Sensors And Actuators Layer – Communication Network Layer – Access Network Layer – Gateways And Backhaul , Network Transport – Sublayer – IoT Network Management Sublayer – Applications And Analytics Layer, Data Versus Network Analytics- Smart Services IoT Data Management & Compute Stack , IoT Application Transport Methods And Protocols, Case Studies : IoT Gateway router, Cloud connectivity	
Unit-5 - Data Analytics and Security	***9 Hour***
IoT Data Analytics Overview & Challenges, Machine Learning Networks: Overview – Supervised & Unsupervised Learning – Neural Networks, Machine Learning Networks & Getting Intelligence from Bigdata – Predictive Analysis, Big Data Analytics Tools and Technology: Massively Parallel Processing Databases – NoSQL Databases., Big Data Analytics Tools And Technology: Hadoop And Ecosystem – Apache Kafka, Lambda Architecture, IoT Security, Case Studies: IoT Cloud data analysis, IoT Security	

Learning Resources		
Learning Resources	*1. James, A., Seth, A., Mukhopadhyay, S.C. IoT System Design—a Project Based approach. In: IoT System Design. Smart Sensors, Measurement and Instrumentation, vol 41. Springer, Cham, 2022.* *2. Hanes David, Salgueiro Gonzalo, Grossetete Patrick, "IoT fundamentals: Networking technologies, protocols and use cases for the Internet of Things", Cisco, Pearson India, 2015.* *3. Jean-Philippe Vasseur, Adam Dunkels, "Interconnecting Smart Objects with IP, The next Internet", Morgan Kofmann, 2010.*	*4. Arsheep Bahga, Vijay Madlseti, "Internet of Things: A hands-on approach",* *5. Elsevier, 2009.* *6. Adrin McEwan, Hakim Cassimally, "Designing for Internet of Things", John Wiley, 2014.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*						*Final Examination (0% weightage)*	
		Formative CLA-1 Average of unit test (20%)		*Project Based Learning CLA-2 (60%)*		*Report and Viva Voce (20%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*15%*	-	*20%*	-	-
Level 2	*Understand*	*20%*	-	-	*20%*	-	*20%*	-	-
Level 3	*Apply*	*30%*	-	-	*25%*	-	*30%*	-	-
Level 4	*Analyze*	*20%*	-	-	*25%*	-	*30%*	-	-
Level 5	*Evaluate*	*10%*	-	-	*10%*	-	-	-	-
Level 6	*Create*	-	-	-	*5%*	-	-	-	-
	Total	*100%*		*100%*		*100%*		-	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1 Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr.T. Deepa, SRMIST*
2. Mr. Saivineeth, ML Accelerator Architect @ Google	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE211T	**Course Name**	ELECTROMAGNETICS AND ANTENNA THEORY	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain knowledge on the basic concepts and insights of Electric field*
CLR-2:	*attain knowledge on the basic concepts and insights of Magnetic field with emphasis on the significance of Maxwell's equations*
CLR-3:	*acquire knowledge about the various antenna parameters*
CLR-4:	*analyze the various functions of special purpose antennas*
CLR-5:	*explain the mechanisms of planar antennas and radio wave propagation in the atmosphere*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts and knowledge to solve problems related to electric field*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*implement the concepts of Magnetic field and Maxwell's equations in the real-world application*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*familiarize the fundamental parameters of antenna and radiation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*analyze the performance various special purpose antennas*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*acquire the knowledge on planar antennas and radio wave propagation mechanism*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 – Electrostatics **9 Hour**

Introduction to electrostatics- Rectangular co-ordinate- Cylindrical & Spherical Co-ordinate- Review of vector calculus- Coulomb's Law and field intensity- Electric field due to continuous charge distribution-Concept-Derivation of E due Infinite Line charge, Sheet charge and volume Charge, Electric flux density, Gauss law application-point charge and line charge, Relation between E&V.

Unit-2 - Magnetostatics and Maxwells Equations **9 Hour**

Biot Savart law-Magnetic field intensity due to Infinite line charge- H- due finite and semi finite line charge- Ampere's circuital law& application: Infinite line current- Infinite Sheet current- Infinitely long coaxial Transmission line- Magnetic flux density, Maxwell's equation for static field, Faraday's law, Displacement current, Maxwell's equation in time varying field.

Unit-3 - Antenna Fundamentals and Radiations **9 Hour**

Basic Antenna parameters - Antenna field zones - Antenna Reciprocity Theorems - Friis transmission equation- Radiation Mechanism- Radiation: Retarded potential - Far Field due to an alternating current element - Power Radiated by a current element - Far field due to sinusoidal current distribution for half wave dipole and Quarter wave monopole.

Unit-4 - Antenna Types and its Applications **9 Hour**

Traveling wave antennas - Square Loop antenna and its Radiation Resistance - Folded dipole antenna - Horn antenna - Helical antenna design– Reflector Antennas - Yagi - Uda antenna - Log periodic antenna

Unit-5 - Planar Antennas **9 Hour**

Micro strip antenna design – Circular polarized Patch antennas - Arrays and Feed Networks – Planar Array - Antenna beamforming, Modes of radio wave propagation and wave characteristics- Case study on Smart antenna systems

Learning Resources	1. Matthew N. O. Sadiku., S. V. Kulkarni, Elements of Electromagnetics, 7th ed., Oxford university Press, 2018 2. Constantine Balanis. A, “Antenna Theory: Analysis and Design”, 4th Edition, Wiley, 2016. 3. K.D. Prasad, Satya Prakashan, “Antennas and Wave Propagation,” Tech. India Publications, New Delhi, 2001	4. John D Kraus , Ronald J Marhefka, Ahmed S Khan “Antenna and wave propagation” 5th Edition, McGraw Hill Education 2017 5. G. S. N. Raju, Electromagnetic Field Theory and Transmission Lines, Pearson Education, 2006

Learning Assessment

	Bloom’s Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. V. Sangeetha, Manger R&D (Networking and Communications), FLDEC Systems, Pvt Ltd., Chennai	1. Dr.B.Manimegalai, Professor, Thiagarajar college of Engineering, Madurai, Tamilnadu	1. Dr.S. Bashyam, SRMIST
2. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	2. Dr.S. Ram Prabhu, SSN College of Engineering, Kalavakkam, Tamilnadu.	2. Dr.M. Susila, SRMIST

Course Code	21ECE310J	Course Name	APPLIED DIGITAL SIGNAL PROCESSING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*21ECC204T*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the concept of analog to digital conversion*
CLR-2:	*understand the need for Multirate DSP and Poly Phase Decomposition*
CLR-3:	*study the architecture of TMS320C54x Processor*
CLR-4:	*study the architecture of TMS320C6748 Processor*
CLR-5:	*design DSP system for real time applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*acquire knowledge of sampling and quantization and understand the errors that arise due to quantization*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-2:	*explore the need for Multirate signal processing*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-3:	*implement DSP algorithms using TMS320C54x Processor*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*implement DSP algorithms using TMS320C6748 Processor*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*infer Knowledge on DSP system based design and applications*	-	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*1*

Unit-1 - *Digital Conversion of Analog Signals* ***12 Hour***

Basic Elements of DSP, Advantages and applications of DSP, Sampling of analog signals Sampling theorem, Aliasing and Quantization of continuous amplitude signal, Quantization noise, Errors due to truncation and Rounding off, Realization of digital filters - Direct form I realization, Canonical structure Realization, Parallel and Cascade Structures

Practice: *Generation of Continuous and discrete time fundamental signals, Study of sampling theorem and Aliasing Effects, Circular convolution of DT Signals*

Unit-2 - Multirate Signal Processing ***12 Hour***

Decimation of Signals, Interpolation of Signals, Sampling rate conversion by a rational factor I/D, Polyphase structure of decimator, Polyphase decimation using z transform, Polyphase structure of interpolator, Polyphase interpolation using z transform,

Practice: *Design of anti-aliasing filter, Effect of interpolation and decimation on signals, Design of anti-imaging filter*

Unit-3 - Architecture and Programming - TMS320C54x ***12 Hour***

DSP Systems – Introduction, Harvard Architecture and Von- Neuman Architecture, Texas Instruments TMS320 Family, TMS320C54x DSP Functional Block Diagram and Explanation, MAC Unit, Pipeline and Parallel Processing, Instruction Set of TMS320C54x, Addressing Modes of TMS320C, Introduction to code composer studio and Procedure to work on ccs using target.

Practice*: Arithmetic operations using processor (Addition, Subtraction, Multiplication) - Assembly and C language*

Unit-4 - Architecture and Programming - TMS320C6748 ***12 Hour***

Introduction to TMS320C6748, Advanced Features of C6748, Dual Core Architecture, RISC, Block Diagram and Explanation, Instruction Set of C6748 processor, Addressing Modes of C6748, Procedure to work with non-real time projects, Procedure for working with the real time projects using c6748

Practice: *Basic Programs and Random wave generation using processor*

Unit-5 - DSP Applications	***12 Hour***
Dual tone Multi-Frequency Signaling, Software Defined Radio, QAM Transmitter and QAM Receiver, u-Law for Speech Companding, Acoustic Direction Tracker, Multirate Filter, Neural Network for Signal Recognition, PID Controller, Four-Channel Multiplexer for Fast Data Acquisition, Video Line Rate Analysis, MP3 Player, DSP Automotive application. ***Practice:*** *Audio signal processing, PID Controller, Filtering Applications*	

Learning Resources		
Learning Resources	*1. John G. Proakis, Dimitris G. Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", Pearson Education, 4th edition, 2007* *2. Alan V. Oppenheim, Ronald W. Schafer, John R. Buck, "Discrete Time Signal Processing", Pearson Education, 8th edition, 2011*	*3. Sanjit Mitra, "Digital Signal Processing – A Computer Based Approach", McGraw Hill, India, 4th Edition, 2013.* *4. Ronald D.Crochier, Lawrence R.Rabiner, Multirate Digital Signal Processing, 1st edition, 1983 Prentice Hall series.* *5. TMS320C54x and TMS320C6748 - Lab Manual - Texas Instruments*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	-	15%	15%	-
Level 2	*Understand*	25%	-	-	15%	25%	-
Level 3	*Apply*	30%	-	-	30%	30%	-
Level 4	*Analyze*	30%	-	-	30%	30%	-
Level 5	*Evaluate*	-	-	-	5%	-	-
Level 6	*Create*	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Athif Shah, CTO, Abe Technologies, Chennai	*1. Dr.V.Masilamani, Associate Professor, Computational Engineering, IIIT DM, Kancheepuram*	*1. Dr. S. Dhanalakshmi, SRM IST*
2. Mr.A.Vishwanath, Research and Innovation Scientist, Genet.IO.Hyderabad	*2. Dr.V.Sathiesh Kumar, Assistant Professor,,Electronics Department, MIT, Chennai*	*2. Dr. S. Latha, SRMIST*

Course Code	21ECE311T	Course Name	DIGITAL COMMUNICATION SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*NIL*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*
CLR-1:	*understand the basics of digital modulation and detection techniques*
CLR-2:	*investigate different modulation schemes and analyze the probability of error*
CLR-3:	*identify the concepts of information theory and source coding*
CLR-4:	*interpret various error detection and correction codes in digital communication systems*
CLR-5:	*explore the principles of spread spectrum communication systems*

Course Outcomes (CO):	*At the end of this course, learners will be able to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*interpret the concepts of digital communication system*	2	2	-	-	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*analyze the mechanism of digital modulation schemes and data transmission*	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*illustrate the operation of information theory and error coding techniques in digital systems*	2	-	2	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*examine the fundamentals of channel coding*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	3
CO-5:	*review the data transmission using spread spectrum*	3	2	-	-	-	-	-	-	-	-	-	-	-	2	-

Unit-1 - Introduction to Digital Communication System ***9 Hour***

Elements of digital communication system, advantages and disadvantages, pulse code modulation (PCM) - sampling, quantization and coding, quantization error, companding in PCM systems, differential PCM, delta modulation, adaptive delta modulation

Unit-2 - Digital Modulation Techniques ***9 Hour***

Introduction, ASK modulator, coherent and non-coherent ASK detector, FSK modulator, spectrum of FSK, coherent reception, non-coherent detection of FSK, BPSK transmitter, coherent reception of BPSK, DPSK, QPSK, QAM Data transmission: Baseband signal receiver, probability of error, optimum filter, matched filter, probability of error of ASK, FSK, BPSK and QPSK

Unit-3 - Information Theory ***9 Hour***

Discrete messages, concept of amount of information and its properties, average information, entropy and its properties, information rate, mutual information, Source coding: Introduction, advantages, Shannon's theorem, bandwidth – S/N trade-off, Shannon-Fano coding, Huffman coding

Unit-4 - Linear Block Codes ***9 Hour***

Introduction, matrix description of linear block codes, error detection and error correction capabilities of linear block codes, hamming codes, cyclic codes - encoding, syndrome calculation, decoding, convolution codes - introduction, encoding and decoding

Unit-5 - Principles of Spread Spectrum ***9 Hour***

Model of a spread spectrum digital communication system, direct sequence spread spectrum, effect of de-spreading on a narrowband interference, generation of PN sequence, frequency hopped spread spectrum, CDMA based on IS-95, case study - Recent trends in diversity, case study - MIMO systems

Learning Resources	1. *Bernard Sklar and Ray, Digital Communications-Fundamentals and Applications, Pearson Education, 3rd Edition, 2014.* 2. *Herbert Taub and Donald L Schilling, Principles of Communication Systems, Tata McGraw-Hill, 3rd Edition, 2009.* 3. *B. P. Lathi and Zhi Ding, Modern Digital and Analog Communication Systems, Oxford University Press, 4th Edition, 2010.* 4. *Simon Haykin, Digital Communication Systems, John Wiley & Sons, 1st Edition, 2014.*	5. *John G Proakis and Masoud Salehi, Fundamentals of Communication Systems, 2014 Edition, Pearson Education.* 6. *Ian A Glover and Peter M Grant, Digital Communications, Pearson Education, 3rd Edition, 2010.* 7. *R. Bose, Information Theory, Coding and Cryptography, McGraw-Hill Education, 3rd Edition, 2016.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*35%*	-	*35%*	-	*35%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. Sachin Kumar, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE410T	Course Name	ASIC DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*prepare the student to be an entry-level industrial standard ASIC or FPGA designer*
CLR-2:	*understand the basic FPGA Architectures*
CLR-3:	*give the students an understanding of issues and tools related to ASIC design*
CLR-4:	*analyze the partition and placement issues*
CLR-5:	*understand the concept of clock planning in ASIC design*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understanding different FPGA Architecture and their interconnect mechanism*	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*familiarize the various programmable ASICs*	-	*3*	*3*	-	*2*	-	-	-	*2*	-	-	-	*3*	-	-
CO-3:	*summarize the optimization algorithms in ASIC and applying the concept of partitioning*	-	-	*3*	*2*	*2*	-	-	-	*2*	-	-	-	*3*	-	-
CO-4:	*illustrating floor planning and clock planning*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*analyzing the various routing algorithm*	*3*	*3*	*2*	*2*	-	-	-	-	*2*	-	-	-	*3*	-	*1*

Unit-1 - Introduction to ASIC ***9 Hour***

VLSI Design Flow-Types of ASIC-Programmable ASICs design type-Antifuse-SRAM-EPROM based ASICs-ASIC fusing based on EPROM-EEPROM based ASICs-FAMOS description-Programmable ASIC logic cells-ASIC I/O cells-Programmable interconnects – FPGA-Types of FPGA-Programmable FPGA-ASIC I/O Cells: DC Input- AC Input- ASIC I/O Cells-DC/AC output-Clock Input- Introduction to CPLD-CPLD architecture-Types of CPLD

Unit-2 - Programmable ASIC Logic Cells ***9 Hour***

Actel ACT Architecture-Actel Interconnect delay analysis-Xilinx LCA -Architecture-Xilinx LCA internal architecture- Lab 3:Generate RTL netlist for a digital circuit and analyze the performance.-Xilinx EPLD Architecture-Xilinx EPLD Internal Architecture-Xilinx LCA Interconnect-Xilinx EPLD Interconnect-Altera MAX 7000, - Architecture-Altera Max 9000 : Architecture-Altera Max 9000 : interconnect mechanism-Altera Interconnect features- Altera MAX 5000 : Interconnect Delay analysis- ALTERA's FLEX 8000/10000: Architecture-ASIC Design system: Introduction-Design Systems: Detailed analysis-Logic Synthesis-Half gate ASIC-Low level design language-PLA tools, EDIF-CFI design representation- Lab 4:Implementation of KL algorithm in EDA environment

Unit-3 - System Partitioning and Floor Planning ***9 Hour***

System Partitioning Objectives-System partitioning Procedure-Partitioning Methods-Measuring Connectivity-Problem on Constructive Partitioning-Constructive Partitioning-Iterative Partitioning Improvement-Problem on Iterative Partitioning Improvement-The Kernighan–Lin Algorithm-The Ratio-Cut Algorithm- ASIC floor planning-Channel Definition-I/O and Power Planning -Clock Planning-

Unit-4 - Placement and Routing ***9 Hour***

Placement-placement algorithms- Eigen value placement algorithm- Iterative placement improvement-Time driven placement methods-Introduction to Routing- single layer global routing-single layer detailed routing wire length- Global Routing Methods-Routing between blocks-inside flexible blocks-Detailed Routing- Algorithms-Left Edge algorithm-Area routing algorithm-Multilevel Routing-Timing driven detailed routing-Special routing

Unit-5 - Optimization Methods and ASIC Testing	***9 Hour***
I Trade off issues at System Level-Solutions to the issues at system level-Optimization with regard to speed-Optimization with regard to area- Optimization with regard to power-Optimization trade off factor-Asynchronous and low power system design- Boundary scan test – Faults – Fault simulation – Automatic test pattern generation algorithm: D-algorithm, PODEM – Built in self-test	

Learning Resources	1. *Smith, Michael. Application-Specific Integrated Circuits. United Kingdom, Addison Wesley Professional, 2008* 2. *Douglas J. Smith, Fundamentals of HDL Design: An Engineering Approach. India: Pearson Education, 2010.* 3. *Taraate, Vaibbhav. ASIC Design and Synthesis: RTL Design Using Verilog. Germany: Springer Singapore, 2021.*	4. *Golshan, Khosrow. Physical Design Essentials: An ASIC Design Implementation Perspective. Ukraine: Springer US, 2007.* 5. *Herwani, Naveed A. Sherwani, Naveed A. Algorithms for VLSI Physical Design Automation. United States: Springer US, 2013.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Saivineeth, ML Accelerator Architect @ Google	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr. K. Ferents Koni Jiavana, SRMIST*
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE411T	**Course Name**	EMBEDDED LINUX	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop the skill to use Linux operating system*
CLR-2:	*develop the skill to write programs in C and Scripting languages and interfacing with Git repository*
CLR-3:	*acquire knowledge on software development process for Embedded Linux*
CLR-4:	*become familiar with the methods of software design for Embedded Linux*
CLR-5:	*develop the skill of writing embedded applications, in Linux platform*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement the Linux operating system and the commands associated*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-2:	*create C programs and interface with GIT repository*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*analyze the GNU development tool chain with C and shell programming*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*develop a flash based embedded Linux device drivers*	-	-	*3*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*implement Embedded Linux based application programs*	-	-	-	*3*	*3*	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Linux Essentials ***9 Hour***

Introduction to Linux, Linux file system architecture, Linux commands: User level, Linux commands: System level (Superuser specific), "vi" text editor- commands, "gedit" text editor - commands, Introduction to "bash"; the Borne shell., Shell programming, Important system commands & its use, Linux shell programming

Unit-2 - Linux Programming Fundamentals ***9 Hour***

Revision on "C" w.r.t GNU C compiler, GNU Tool chain: introduction & installation, editing source code in C with "gedit" or IDE, Compiling and building executable, Introduction to "gdb", Running the program on terminal using gdb., Introduction to Git repository, Cloning files from Git Hub, Git essentials, Advanced Git features, Programming using Git hub

Unit-3 - Elements of Embedded Linux ***9 Hour***

Introduction to embedded Linux, Generic Architecture of an Embedded Linux System, Cross platform tools, Types of Host/Target Development Setups, Types of Host/Target Debug Setups, Sample programs for cross platform use, booting process and boot loader, Linux kernel; introduction, Porting and configuring the kernel, Simple typical kernel programming, building root file system, Selecting a build system; build process, Simple kernel programs,

Unit-4 - System Architectures and Design Choices ***9 Hour***

Embedded system storage; choosing the parameters, Flash memory and system memory operation, Access time considerations, Introduction to device drivers - identifying and using them, Internals and architecture of device drivers, Module utilities, writing sample device driver; char device, block device, Debugging the device driver, Making the "init", Kernel programming - Device Driver programming

Unit-5 - Embedded Applications ***9 Hour***

Process and threads, POSIX thread commands; syntax and use, Memory allocation and management; leak detection, GDB debugging revisited, Tracing and Profiling tools, FT- Trace utility and its use in debugging, Use of graphics plotting tools; Installing and using FT trace utilities, Debug/test data collection and profiling, Real time Linux,

Learning Resources	1. *Karim Yaghmore, Jon Masters, Gilad Ben Yosef, Phillepe Gerome, "Building Embedded Linux Systems, Oreilly Publications, Safari Books, 2nd Reprint, 2008.* 2. *Chris Simonds, "Mastering Embedded Linux Programming", Packt Publishing, Open source, 2015.* 3. *https://www2.packtpub.com/books/subscription/packtlib.*	4. *Richard Stones, Neil Mathew, "Begining Linux Programming", WileyPublications, 4th edition, 2008.* 5. *Willam Rothwell, "Jump start your Linux programming skills", Addison Wesley, 2017.* 6. *Christopher Hallinan, "Embedded Linux Primer", A practical real world approach", Prentice Hall, 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	20%	-
Level 3	Apply	30%	-	25%	-	20%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	10%	-
Level 6	Create	-	-	5%	-	5%	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Saivineeth, ML Accelerator Architect @ Google*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. V. Padmajothi, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT,Pallikkaranai*	

Course Code	21ECE412T	Course Name	ALGORITHMS FOR CRYPTOGRAPHY	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*utilize the classical and symmetric encryption standards*															
CLR-2:	*illustrate Public and Private key cryptography*															
CLR-3:	*analyze Key management, distribution and certification*															
CLR-4:	*describe the enhancements made to IPv4 by IPSec*															
CLR-5:	*analyze the various firewalls and web security*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*differentiate symmetric and asymmetric encryption systems and their applications*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*apply the concepts of Number theory*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*discuss about the importance and application of each of confidentiality, integrity, authentication and availability*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-4:	*explain the various aspects of IPsec*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-
CO-5:	*analyze various effects in system security*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	*2*	-	-

Unit-1 - Classical Encryption Techniques ***9 Hour***

Cryptography, Cryptanalysis and Brute-Force Attack. Cryptography Concepts and Techniques: Introduction, plain text and cipher text, Symmetric Cipher Model Substitution Techniques, Caesar Cipher, Monoalphabetic Cipher, Play fair Cipher, Hill Cipher, Polyalphabetic Cipher, One Time Pad. DES and the nature of the DES algorithm, timing attacks. Traditional block Cipher structure, stream Ciphers and block Ciphers. Block Cipher Modes of Operation.

Unit-2 - Cryptographic Algorithms and Public-Key Cryptography ***9 Hour***

Symmetric key Ciphers: AES, Blowfish, RC5, IDEA and CAST-128 Asymmetric key Ciphers: Principles of public key cryptosystems, Number Theory, RSA algorithm, Public Key Management, Public Key Certificate Generation and Verification, X. 509 Certificates and Diffie-Hellman Key Exchange.

Unit-3 – Cryptographic Hash Function ***9 Hour***

Message Authentication, MD5, SHA-1, Secure Hash Algorithm (SHA-512), Message authentication codes: Authentication requirements, HMAC, CMAC, Digital signatures. Key Management and Distribution: Symmetric Key Distribution Using Symmetric & Asymmetric Encryption, Distribution of Public Keys, Kerberos.

Unit-4 - IP Security ***9 Hour***

IP Security overview, applications of IPsec, benefits of IPsec, Routing applications, IPsec documents, IPsec services, transport and tunnel modes - combining security associations, authentication plus confidentiality, basic combinations of security associations, internet key exchange, key determinations protocol, header and payload formats, cryptographic suits. .IP Security policy, Security associations, Security associations database, Security policy database, IP traffic processing, Encapsulating Security payload, ESP format, encryption and authentication algorithms, Padding, Anti replay service.

Unit-5 - Web Security and Firewalls	***9 Hour***
Transport-level Security: Web security considerations, Secure Socket Layer and Transport Layer Security, HTTPS, Secure Shell (SSH), Wireless Network Security: Wireless Security, Mobile Device Security, IEEE 802.11 Wireless LAN, IEEE 802.11i Wireless LAN Security, Introduction to Firewall Types and Configurations, Trusted system.	

Learning Resources	*1. Stallings, William, "Cryptography and Network Security: Principles and Practice", 7th ed., Pearson Higher Education, 2016* *2. Bruce Schneider, Applied Cryptography, 2nd ed., 2015*	*3. Behrouz A.Forouzan, Debdeep Mukhopadhyay, Cryptography and Network Security, 2nd ed., Tata McGraw Hill, 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr.K. Vijayan, SRMIST*
2. Mr. Saivineeth, ML Accelerator Architect @ Google	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE231T	Course Name	PRINCIPLES OF CLOUD COMPUTING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental ideas behind Cloud Computing, as well as current and future challenges*
CLR-2:	*work effectively on the shared infrastructure*
CLR-3:	*explore cloud storage technologies and relevant distributed file systems*
CLR-4:	*get detailed understanding of various cloud-based platforms and simulators*
CLR-5:	*understand the cloud security threats and protective mechanism for cloud computing*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1 Engineering Knowledge	2 Problem Analysis	3 Design/development of solutions	4 Conduct investigations of complex problems	5 Modern Tool Usage	6 The engineer and society	7 Environment & Sustainability	8 Ethics	9 Individual & Team Work	10 Communication	11 Project Mgt. & Finance	12 Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply fundamental concepts in cloud infrastructure for cloud applications*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*explore the principles of virtualization and virtual machines*	*3*	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*illustrate the fundamental concepts of cloud storage and demonstrate their use in storage systems*	*3*	2	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*identify the security issues related to cloud computing to handle the security threats and provide solutions*	*3*	2	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyze cloud programming models and apply them to solve problems on the cloud using cloud simulators*	-	*3*	-	2	2	-	-	-	-	-	-	-	-	2	-

Unit-1 - Cloud Introduction and Cloud Infrastructure ***9 Hour***

Cloud Computing: Benefits and applications, Grid computing and Utility computing Vs Cloud Computing, Cloud delivery models and services, Cloud deployment models, Ethical issues and major challenges, Cloud infrastructure: Amazon Web Services, Google cloud, Microsoft Azure, Energy use and ecological impact of large-scale data centers, Service- and compliance-level agreements, Case Study: Open-source software platforms for private clouds: Eucalyptus, OpenNebula

Unit-2 - Cloud Resource Virtualization ***9 Hour***

Virtualization, Layering and Virtualization, Virtual Machine Monitors, Virtual Machines, Performance isolation, Full virtualization and para-Virtualization, Hardware Support for virtualization

Unit-3 - Cloud Storage Systems ***9 Hour***

Storage models, file systems, and databases, Distributed File systems, Google File system, Apache Hadoop, Online Transaction Processing, NoSQL Database, Cloud Databases (HBase, MongoDB Cassandra, CongoDB)

Unit-4 - Cloud Security ***9 Hour***

Cloud Security risks, Threat Agents, Cloud Security Threats, Cloud Security Mechanisms, Identity and Access Management, Single Sign-On: Kerberos authentication, One time Password, VMM and VM based threats, Security of Virtualization, Trusted VMM

Unit-5 - Cloud Applications and Cloud Simulators ***9 Hour***

Cloud Applications: Processing Pipelines, batch Processing Systems and Web Applications, Architectural Styles, MapReduce Programming model, Cloud simulator: Introduction, understanding CloudSim simulator, CloudSim Architecture (User code, CloudSim, GridSim, SimJava) Understanding Working platform for CloudSim, Introduction to GreenCloud

Learning Resources	1. *Dan C. Marinescu," Cloud Computing Theory and Practice", Second Edition Copyright © 2018 Elsevier Inc.* 2. *Rajkumar Buyya, James Broberg, AndrzejGoscinski, Cloud Computing Principles and Paradigms, Wiley Publications, 2017.* 3. *Thomas Erl, ZaighamMahmood, and RichardoPuttini, "Cloud Computing: Concepts, Technology & Architecture", Prentice Hall/PearsonPTR, Fourth Printing, 2014, ISBN: 978013338752.*	4. *K. Chandrasekaran, "Essentials of Cloud Computing", Chapman and Hall/CRC Press, 2014, ISBN 9781482205435* 5. *Arshdeep Bahga, Vijay Madisetti, "Cloud Computing: A Hands-On Approach", University Press, 2016, ISBN-13: 978-0996025508.*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr.M.S. Vasanthi, SRMIST*
2. *Mr. Saivineeth, ML Accelerator Architect @ Google*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE232T	**Course Name**	DATA ANALYSIS AND VISUALIZATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn to handle data and the various statistical techniques in data handling*
CLR-2:	*know the various regression and classification techniques*
CLR-3:	*identify various data sources and dealing with messy date*
CLR-4:	*gain insight about visualizations*
CLR-5:	*appreciate the various visual effects*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*handle data and statistical distributions*	*3*	*2*	-	-	-	-	-	-	-	*3*	-	-	-	-	-
CO-2:	*classify regression models*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*deal data from various sources and messy data*	-	*3*	-	*3*	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*choose right data visualization technique*	-	*3*	-	-	*3*	-	-	-	-	-	-	*3*	-	-	-
CO-5:	*add appropriate visual effects*	-	-	-	-	-	*2*	-	-	-	*2*	-	-	-	-	-

Unit-1 - Shape of Data ***9 Hour***

Univariate data, Frequency distributions - Measures of central tendency, Spread, Population, sampling, and estimation - Probability distributions, Multivariate data: Relationships between single categorical and single continuous variable - Relationships between two categorical variables - Relationship between two continuous variables – Covariance, Correlation coefficients - Comparing multiple correlations, Probability: Basics - A tale of two interpretations. Sampling from distributions - Binomial distribution, Problems in binomial distribution -Normal distribution, Problems in normal distribution - Three sigma rule and using z tables

Unit-2 - Predicting Continuous Variables ***9 Hour***

linear models- Linear regression, Multiple regression - Regression with a non-binary predictor, Kitchen sink regression - The bias variance trade off: Cross validation, Striking a balance - Linear regression diagnostics, Second, third and fourth anscombe relationship - Advancements, Predicting categorical variables: k nearest neighbors - Confusion matrix , Logistic regression - Role of sigmoid function, Decision trees Random forests, Choosing a classifier: vertical and diagonal boundary - Choosing a classifier: crescent and circular boundary

Unit-3 - Data Sources ***9 Hour***

Relational databases, SQL - JSON, XML - Other data formats, Handling data from online repositories - Dealing messy data - Analysis with messy data Types, Unsophisticated methods for dealing missing data: Complete case analysis, Pairwise deletion, Unsophisticated methods for dealing missing data: Mean substitution, Hot deck imputation - Unsophisticated methods for dealing missing data: Regression imputation, Stochastic regression imputation, Multiple imputation - Analysis with sanitized data, checking for out of bounds and data type - Checking for unexpected categories, outliers, typographical errors Checking unlikely data - Other messiness

Unit-4 - Classification of Visualization	***9 Hour***
Complexity - Infographics vs data visualization, Exploration vs explanation - Information vs persuasive vs visual art, looking data as designer - Role of designer, Looking data as reader - Creation of visualization for other people, Contextual considerations Context of use, the goal and supporting data - Knowledge before structure, choosing appropriate visual encodings: natural order, distinct values, redundant encoding, Defaults vs innovative formats - Readers context - Compatibility with reality - Patterns and consistency, Selecting structures: Comparisons, bad structures - Abused structure and simplicity in designing	
Unit-5 - Positioning	***9 Hour***
Layout - Positioning: axes, Placement and proximity Semantic distance and relative proximity, absolute placement, Representation of physical space - Logical and physical relationships - Patterns and grouped objects, Patterns of organizations: Graphs, layouts - Axis styles Using circles and circular layouts - Applying encodings: Color, Leverage Common color - Cognitive interference and Stroop test. Color theory sizes: Conveying size, Size: Comparing size -Text and typography, Shapes and lines - Keys Vs direct labeling of data points	

Learning Resources	*1. Tony Fischetti, Data Analysis with R, Packt publishing, 2015.* *2. Noab Iliinsky, Julie Steele, Designing data visualizations, O' Reilly publishers, 2011.*	*3. Trevor Hastie, Robery Tibshirani, Jerome Friesman, The Elements of Statistical Learning, Data mining, Inference and prediction, 2nd Edition, Springer, 2010.* *4. Charles D. Hansen and Chris R. Johnson, Visualization Handbook, Academic Press, 2004*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	*20%*	-	*20%*	-
Level 2	*Understand*	*20%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr. Diwakar R Marur, SRMIST*
2. Mr. Saivineeth, ML Accelerator Architect @ Google	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai Industry:*	

Course Code	21ECE330T	**Course Name**	FULL STACK DEVELOPMENT	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
CLR-1:	*introduce full stack development and Java*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*gain knowledge in JAVA programming*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*acquire knowledge on database management and internationalization using JAVA*															
CLR-4:	*understand servlets and communication*															
CLR-5:	*explore the Java Server Pages*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*apply Java programming structures for full stack development*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*develop programming skills in JAVA*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*explore Java for web development*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*analyze the servlets and inter servlet communication*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyze JSP for web development*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Full Stack Web Development and JAVA	***9 Hour***
Introduction to Full Stack Development, Introduction to JAVA, JAVA programming environment, Programming structures in JAVA - Data types, Variables, operators, strings, input and output, Control flow, Arrays	
Unit-2 - Programming Using JAVA	***9 Hour***
Objects and classes - Introduction to Object Oriented Programming, classes, objects, defining class, Inheritance - classes, super class, sub class, interfaces, Lambda Expressions, Inner classes, Exceptions, Assertions, and Logging, Collections, Concurrency	
Unit-3 - JAVA Web Development	***9 Hour***
Database management, ODBC API, JDBC API, establishing connection with database, JDBC URL, Localization, Constructors and methods of Locale and Resource bundle class, Developing I18N-based application, Internationalization	
Unit-4 - Servlets, Working with Servlets, and Inter Servlet Communication	***9 Hour***
Webserver, Servlets and their characteristics, Working of Servlet, Lifecycle of Servlet, servlet interface, HTTP Servlet, HTTP Request and Response, The GET and POST methods, HTTP Servlet Request Interface, Session tracking and techniques for session tracking, HTTP Session interface, Request Dispatcher, Servlet Context, Implementing Inter servlet communication via a problem statement	
Unit-5 - Java Server Pages (JSP)	***9 Hour***
Need for JSP, Life cycle of JSP: Example, Structure of JSP, JSP Elements, Scripting Elements, Implicit Objects, Types of Directives, JSP directives, Implicit Objects, Buffer, Include and Taglib directive, JSP Action Elements, Custom Tags, Expression Language, Model view controller (MVC), example in JSP	

Learning Resources	*1. Cay Horstmann, Core Java Volume I--Fundamentals: 1, Pearson; 11th edition, 2020.* *2. Herbert Schildt, Java: The Complete Reference, McGraw Hill; 12th edition, 2021.*	*3. Sarika Agarwal and Vivek Gupta, Java for Web Development, BPB Publications, 2022.* *4. Chris Northwood, The Full Stack Developer: Your Essential Guide to the Everyday Skills Expected of a Modern Full Stack Web Developer, APRESS; 1st edition, 2018.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr. Sudhanya P, SRMIST*
2. Mr. Saivineeth, ML Accelerator Architect @ Google	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT,Pallikkaranai*	

Course Code	21ECE331T	**Course Name**	DATA MINING AND ANALYTICS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the basic terminologies used in data mining*
CLR-2:	*study the association and rules used in data mining*
CLR-3:	*acquire knowledge on various classification algorithms*
CLR-4:	*ability to analyze clusters*
CLR-5:	*familiarize with outlier analysis and applications*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*develop necessary insights to carry out data mining process*	*3*	*1*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*analyze association and rules in data mining*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply different types of classification algorithms*	*3*	-	-	-	*2*	-	-	-	-	-	-	-	-	-	*1*
CO-4:	*evaluate various kinds of cluster analysis techniques*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*1*
CO-5:	*implement outlier analysis for various data mining applications*	*3*	-	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Data Mining Overview

9 Hour

Data mining introduction, Kinds of data and patterns suited for mining, Applications suitable for data mining, Issues in Data mining, Data objects and Attribute types, Statistical descriptions of data, Need for data preprocessing and data, Data cleaning, Data integration, Data reduction, Data transformation, Data cube and its usage.

Unit-2 - Association Rule Mining

9 Hour

Mining frequent patterns: Basic concepts, Market basket analysis, Frequent item sets, Closed item sets, Decision tree induction, Association rules- Introduction, Apriori algorithm - theoretical approach, Apply Apriori algorithm on different datasets, Generating association rules from frequent item sets, Improving efficiency of Apriori, Pattern growth approach, Mining frequent item sets using vertical data format, Strong rules vs. weak rules, Association analysis to correlation analysis, Comparison of pattern evaluation measures.

Unit-3 - Classification Algorithms

9 Hour

Classification: Basic concepts, General approach to classification, Decision tree induction, Algorithm for decision tree induction, Numerical example for decision tree induction, Attribute selection measure, Tree pruning, Scalability and decision tree induction, Bayes' theorem, Naïve Bayesian classification, IF-THEN rules for classification, Rule extraction from a decision tree, Metrics for evaluating classifier performance, Cross validation, Bootstrap, Ensemble methods: introduction, Bagging and boosting, Overview of random forests

Unit-4 - Cluster Analysis

9 Hour

Cluster Analysis: introduction, Requirements and overview of different categories, Partitioning method: introduction, k-means, k-medoids, Hierarchical method: introduction, Agglomerative vs. divisive method, Distance measures in algorithmic methods, BIRCH technique, DBSCAN technique, STING technique, CLIQUE technique, Evaluation of clustering techniques

Unit-5 - Outlier Analysis and Applications

9 Hour

Outliers: introduction, Challenges of outlier detection, Outlier detection methods: introduction, Supervised and semi-supervised methods, Unsupervised methods, Statistical and proximity-based methods, Statistical approaches, Statistical data mining, Data mining and recommender systems, Data mining for financial data analysis, Data mining for intrusion detection

Learning Resources	1. *Jiawei Han and Micheline Kamber, Data Mining: Concepts and Techniques", 3rd Edition, Morgan Kauffman Publishers, 2011* 2. *Kris Jamsa, Introduction to Data Mining and Analytics, First Edition, Jones & Barlett Learning, 2021.*	3. *Mohammed J. Zaki, Wagner Meira, Jr., Wagner Meira, Data Mining and Analysis: Fundamental Concepts and Algorithms, Cambridge University Press, 2014.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. Diwakar R. Marur, SRMIST*
2. *Mr. Saivineeth, ML Accelerator Architect @ Google*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE332J	**Course Name**	MULTI-CORE ARCHITECTURE AND PROGRAMMING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand muti-core processors and architecture*
CLR-2:	*learn parallel and multi thread programming*
CLR-3:	*study various parallel programming concepts*
CLR-4:	*exploit loop level parallelism approach*
CLR-5:	*study the need for synchronization in parallel programs*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*evaluate the characteristics of multi-core processors*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*compile parallel program paradigms*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*apply shared memory programming with open MP*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*express parallel execution in open MP*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*analyze synchronization in shared memory parallel programs*	-	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-

Unit-1 - Multi-Core Processor Architect ***12 Hour***

Introduction to multi-core architecture, SIMD and MIMD, Interconnection networks, distributed shared memory architectures, Cache coherence, Parallel program design.

Practice: *Programs on parallel programming in multi core architecture.*

Unit-2 - Parallel Program Paradigms ***12 Hour***

Performance, Scalability, Synchronization, Data sharing, Data races, Synchronization, Mutex, Locks, Semaphores, Dead locks and live locks, Thread communication, Message queues, Pipes

Practice: *Programs on semaphores, mutex, message queues*

Unit-3 - Open MP ***12 Hour***

Performance with open MP, Parallel computer structure, Communication, and data environment, Run time execution model of open MP, Communication and data scoping, Synchronization in the simple loop, Explicit synchronization, Reduction clause.

Practice: *Programs on a simple loop, Parallelized open MP*

Unit-4 - Loop Level Parallelism ***12 Hour***

Usage of parallel do directive, controlling data sharing, Shared clause, Private clause, Default variable scopes, Private variable initialization and finalization,removing data dependences, Scheduling loops to balance the load, Static and dynamic scheduling, Comparison of run time scheduling behavior.

Practice*: Program on Loops and subroutine calls, Parallelization of loop nest*

Unit-5 - Synchronization ***12 Hour***

Need for synchronization, Synchronization mechanism in open MP, Mutual exclusion synchronization, Critical section, atomic directive, Event synchronization, Custom synchronization.

Practice*: Program on Data race, Critical section*

Learning Resources	1. *Peter S. Pacheco, —An Introduction to Parallel Programming, Morgan-Kauffman/Elsevier, 2011.* 2. *Chandra, Rohit, et al. Parallel programming in OpenMP. Morgan Kaufmann, 2001.* 3. *Darryl Gove, —Multicore Application Programming for Windows, Linux, and Oracle Solaris‖, Pearson, 2011*	4. *Kuhn, Robert, and David Padua. "Parallel Processing, 1980 to 2020." Synthesis Lectures on Computer Architecture 15.4 (2020): i-166.* 5. *Trobec, Roman, et al. Introduction to parallel computing: from algorithms to programming on state-of-the-art platforms. 2020*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. N.R. Shanker Managing Director Chase Research and Development Centre, Chennai.*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. M.K. Srilekha, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT,*	

Course Code	21ECE333T	**Course Name**	HARDWARE SOFTWARE CO-DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*study the design of embedded computing system*
CLR-2:	*understand the concept of system partitioning and interfacing in real time systems*
CLR-3:	*analze the concept of design technologies in digital signal processing*
CLR-4:	*learn hardware/software co-simulation emulation*
CLR-5:	*design and implement hardware software framework*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*compile the characteristics of digital system and real time embedded system*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*apply interfacing of real time multitasking system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-3:	*implement embedded software in real time digital signal processing system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-4:	*incorporate the framework for simulating heterogenous system*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*design embedded system application*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	*2*	-	-

Unit-1 – Co-Synthesis of Embedded Computing System	***9 Hour***
Architecture of hardware software partitioning, Hardware software co-synthesis for digital system, Constraint analysis, System partitioning, Synthesis of real time embedded system, Hardware software co-synthesis for microcontrollers, Software oriented co-synthesis approach, Microcontroller system modeling, Cosyma system	
Unit-2 - System Level Partitioning, Synthesis, and Interfacing	***9 Hour***
Hardware/software mapping and scheduling, Specific heterogenous multiprocessor system, Co-synthesis algorithm for distributed embedded computing system, Interface co-synthesis technique for embedded system, Interface generation for hardware software codesign, Real time multi tasking in software synthesis.	
Unit-3 - Implementation Generation in Real Time Digital Signal Processing System.	***9 Hour***
Design of real time digital signal processing system, Data flow in multi rate signal processing algorithm, Memory management in embedded network application, Latency of VLIW ASIP data path, Constraint in DSP code generation, Compilation of digital signal processor.	
Unit-4 – Co-Simulation and Emulation	***9 Hour***
Framework for simulating heterogenous system, Synthesis and simulation of digital system interfacing, Hardware software codesign for DSP application, Co-simulator for embedded system design and debugging, Co-synthesis of mixed hardware software system	
Unit-5 - Embedded System Design and Application	***9 Hour***
Electronic Design for HP Ink Jet Plotter, Design of Robot Control System, Hardware Software Rapid Prototyping Framework, Portable Device For Wireless Information Access, Processor-Coprocessor Architecture For High End Video Application	

Learning Resources	1. DeMicheli, Giovanni, and M. G. Sami, eds. Hardware/software Co-design. Vol. 310. Springer Science & Business Media, 2013. 2. De Micheli, Giovanni, et al. Readings in hardware/software co- design. Morgan Kaufmann, 2002.	3. Florea, Adrian, and Teodora Vasilas. "Optimizing the integration area and performance of VLIW architectures by hardware/software co- design." International Conference on Modelling and Development of Intelligent Systems. Springer, Cham, 2021. 4. Ghaffari, Sina, et al. "A novel hardware–software co-design and implementation of the HOG algorithm." Sensors 20.19 (2020): 5655.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	15%	-	15%	-
Level 2	Understand	25%	-	20%	-	25%	-
Level 3	Apply	30%	-	25%	-	30%	-
Level 4	Analyze	30%	-	25%	-	30%	-
Level 5	Evaluate	-	-	10%	-	-	-
Level 6	Create	-	-	5%	-	-	-
	Total	100%		100%		100%	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Dr. N.R. Shanker Managing Director Chase Research and development centre	1. Dr. Meenakshi, Professor of ECE, CEG, Anna University	1. Dr. M.K. Srilekha, SRMIST
2. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd	2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai	

Course Code	21ECE430T	Course Name	INTRODUCTION TO VIRTUAL COMPUTING	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain expertise on the concept of virtualization and types of virtualizations*
CLR-2:	*familiarize with the server virtualization, virtual machines and hypervisors*
CLR-3:	*emphasize virtualization infrastructure and application that is fundamental to cloud computing*
CLR-4:	*deploy practical virtualization solutions and expertise solutions*
CLR-5:	*gain knowledge on cloud platform architecture*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*categorize storage virtualization, network virtualization and its management*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*perform server virtualization*	3	-	2	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*apply the concept of virtualization in cloud computing*	3	2	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*deploy and optimize virtualization solutions*	3	-	-	-	-	2	-	-	-	-	-	-	-	-	-
CO-5:	*identify the architecture, infrastructure and delivery models of cloud computing*	3	-	-	-	-	1	-	-	-	-	-	2	-	1	-

Unit-1 - Virtualization	***9 Hour***
Basics of virtual machines, Process Virtual Machine, System Virtual Machine, Emulation, Interpretation, Binary Translation, Taxonomy of Virtual Machines. Virtualization- Management Virtualization, Hardware Maximization, Architectures- Virtualization Management, Storage Virtualization, Network Virtualization.	
Unit-2 - Hypervisors and Virtual Machines	***9 Hour***
Server Virtualization: Understanding Server Virtualization, Types of server virtualization, virtual machine basics, types of virtual machine, hypervisor concepts and types.	
Unit-3 - Virtualization Infrastructure	***9 Hour***
Comprehensive Analysis – Resource Pool – Testing Environment – Virtual Workloads – Provision Virtual Machines – Desktop Virtualization – Application Virtualization - Implementation levels of virtualization – virtualization structure – virtualization of CPU, Memory and I/O devices – virtual clusters and Resource Management – Virtualization for data center automation	
Unit-4 - Virtualization Solutions	***9 Hour***
Understanding Microsoft's Virtualization solutions: Microsoft's Infrastructure Optimization Model, Virtualization and the Infrastructure Optimization Model Benefits of Virtualization, Achieving the Benefits of Datacenter Virtualization, Achieving the Benefits of Client Virtualization, Achieving the Benefits of Cloud Virtualization	
Unit-5 - Introduction to Cloud Architecture	***9 Hour***
Migrating into a Cloud- Challenges while migrating to Cloud - Migration Risks and Mitigation, Introduction to cloud delivery model Architecture, Infrastructure / Hardware as a Service, Platform as a Service, Software as a Service, Types of Clouds, Public Clouds, Private Clouds, Hybrid Clouds, Community Clouds, Economics of the Cloud, Open Challenges, Cloud Interoperability and Standards, Scalability and Fault Tolerance.	

Learning Resources	1. *Distributed and Cloud Computing, Kaittwang Geoffrey C.Fox and Jack J Dongrra, Elsevier India 2012* 2. *Mastering Cloud Computing- Raj Kumar Buyya, Christian Vecchiola and S.TanuraiSelvi, TMH, 2012.* 3. *Cloud Computing (Principles and Paradigms), Edited by Rajkumar Buyya, James Broberg, Andrzej Goscinski, John Wiley & Sons, Inc. 2011*	4. *Cloud computing a practical approach - Anthony T.Velte , Toby J. Velte Robert Elsenpeter, TATA McGraw- Hill , New Delhi – 2010* 5. *David Marshall, Wade A. Reynolds, Advanced Server Virtualization: VMware and Microsoft Platform in the Virtual Data Center, Auerbach* 6. *Cloud Computing: Web-Based Applications That Change the Way You Work and Collaborate Online - Michael Miller - Que 2008*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	*30%*	-	*30%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*25%*	-	*25%*	-	*25%*	-
Level 4	*Analyze*	*20%*	-	*20%*	-	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr B Priyalakshmi, SRMIST*
2. *Mr. Saivineeth, ML Accelerator Architect @*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT,*	

Course Code	21ECE431T	**Course Name**	MOBILE COMPUTING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*impart basic understanding of the concepts of mobile computing*
CLR-2:	*familiar with the network protocol stack*
CLR-3:	*investigate the working model of mobile telecommunication system*
CLR-4:	*exposed to the concept of Ad-hoc networks*
CLR-5:	*gain knowledge about different mobile platforms and application development*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*categorize different mobile platforms and application development*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*analyze different Services and Architecture of Mobile Telecommunication system*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-3:	*infer the various protocol architecture of WLAN technology*	-	-	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-
CO-4:	*perceive the concepts of Mobile Ad-hoc Networks*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*apply the knowledge in various Mobile Computing application, services and architecture*	-	*3*	-	-	-	-	-	-	*3*	-	-	-	-	-	-

Unit-1 - Introduction to Mobile Computing	***9 Hour***
Applications of Mobile Computing- Internet-Ubiquitous networks, Architecture and three-tier architecture for Mobile Computing, Design consideration for Mobile Computing. Generations of Mobile Communication Technologies- Multiplexing — Spread spectrum -MAC Protocols — SDMA- TDMA- FDMA- CDMA ***Case Study****: SWOT analysis of Mobile Computing*	
Unit-2 - Mobile Telecommunication System	***9 Hour***
Introduction to Cellular Systems-Global System for Mobile Communication (GSM) – General Packet Radio Service (GPRS) – Universal Mobile Telecommunication System UMTS) –LTE-5G- Services & Architecture — Protocols — Connection Establishment — Frequency Allocation — Routing — Mobility Management— Handover — Security. ***Case Study****: Explore the possible opportunities and future extension problems of Mobile Cloud after the Evolution of 5G Technology.*	
Unit-3 - Mobile Internet Protocol and Transport Layer	***9 Hour***
Overview of Mobile IP – Features of Mobile IP – Key Mechanism in Mobile IP – route Optimization. Overview of TCP/IP – Architecture of TCP/IP- Adaptation of TCP Window– Improvement in TCP Performance.	
Unit-4 - Mobile Ad-Hoc Networks	***9 Hour***
Ad-hoc Basic Concepts – Characteristics – Applications – Design Issues – Routing – Essential of Traditional Routing Protocols –Popular Routing Protocols – Vehicular Ad Hoc networks (VANET) –MANET Vs VANET –Security. ***Case Study****: Location aware/Location sensitivity*	

Unit-5 - Mobile Platforms and Applications	***9 Hour***
Mobile Device Operating Systems — Special Constraints & Requirements — Commercial Mobile Operating Systems — Software Development Kit:iOS, Android, BlackBerry, Windows Phone — MCommerce — Structure — Pros & Cons — Mobile Payment System — Security Issues. ***Case Study****: Power Management -System level energy saving techniques*	

Learning Resources	*1. Prasant Kumar Pattnaik, Rajib Mall, "Fundamentals of Mobile Computing", PHI Learning Pvt. Ltd, New Delhi – 2012.* *2. Raj Kamal, "Mobile Computing", Oxford University Press, 2007, ISBN: 0195686772* *3. Asoke K. Talukder, Hasan Ahmad, Mobile Computing Technology- Application and Service Creation, 2nd Edition, McGraw Hill Education.* *4. Jochen Schiller, Mobile Communications, Pearson Education Asia, 2008.*	*5. Jonathan Rodriguez, Fundamentals of 5G Mobile Networks,, Wiley Publishers, 2015* *6. Android Developers: http://developer.android.com/index.html* *7. Apple Developer: https://developer.apple.com/* *8. Windows Phone Dev Center: http://developer.windowsphone.com* *9. BlackBerry Developer: http://developer.blackberry.com*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*30%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*30%*	-	*30%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.	*1. Dr. Meenakshi, Professor of ECE, CEG, Anna University*	*1. Dr.C. T. Manimegalai, SRMIST*
2. Mr. Raji Kumar, Sr. Manager Core Corporation (Airtel)	*2. Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE432T	**Course Name**	QUANTUM COMPUTING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn about fundamentals of quantum mechanics*
CLR-2:	*become familiar with the fundamental concepts of quantum circuits and postulates*
CLR-3:	*learn the different insights behind basic quantum algorithms,*
CLR-4:	*become acquainted with quantum cryptography and the supremacy of quantum computing*
CLR-5:	*acquire knowledge on programming for quantum computers*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the use of linear algebra in quantum computing*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*construe quantum computing Postulates and quantum circuits*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*examine quantum computer algorithms*	-	-	*3*	*2*	-	-	-	-	-	-	-	*1*	-	-	-
CO-4:	*investigate cryptography in quantum computing*	-	*2*	-	*3*	-	-	-	-	-	-	-	*1*	-	-	-
CO-5:	*understand, Design and Test quantum circuits on IBMQ*	-	-	*3*	-	*2*	-	-	-	-	-	-	*1*	-	-	-

Unit-1 - Quantum Mechanics-Fundamentals ***9 Hour***

Linear algebra basics, Vector Spaces, Tensor products, inner and outer product, Hilbert space, N dimensional inner product, Infinite dimensional inner product, Schwarz's Inequality, Hilbert space examples, Probabilities and Measurements, Spectral decomposition, Quantum entanglement, Spectral decomposition, Bell's inequalities, Density operators

Unit-2 - Quantum Circuits and Postulates ***9 Hour***

Quantum Computing and its advantage, Postulates of Quantum mechanics, Qubits and Dirac notation, Bloch sphere, Quantum Gates-Single and Multi-qubit, Quantum circuits-basic

Unit-3 - Quantum Algorithms ***9 Hour***

No-Cloning Theorem, Deutsch-algorithm, Deutsch-Jozsa algorithm, Grover's Search algorithm, Quantum Fourier Transform, Shor's factoring algorithm, Variational quantum algorithms such as QAOA, VQE

Unit-4 - Quantum Cryptography ***9 Hour***

Quantum cryptography-Introduction, Quantum Key Distribution, BB84 Protocol, B92 Protocol, EPR Protocol, Quantum Teleportation

Unit-5 - Programming Quantum Computer ***9 Hour***

The IBMQ, Bell test, GHZ state, W state, Quantum circuits for specific application-Design, graphically building quantum circuits, Dynamic circuit design using Qiskit

Learning Resources	1. *Michael A. Nielsen and Issac L. Chuang, "Quantum Computation and Information, Cambridge (2002).* 2. *Quantum Computing, A Gentle Introduction, Eleanor G. Rieffel, and Wolfgang H. Polak MIT press (2014)* 3. *David McMahon-Quantum Computing Explained-Wiley- Interscience, IEEE Computer Society (2008)* 4. *N. S. Yanofsky and M. A. Mannucci, Quantum Computing for Computer Scientists. Cambridge, England: Cambridge University Press, 2022.*	5. *A. Ozaeta, W. van Dam, and P. L. McMahon, “Expectation values from the single-layer Quantum Approximate Optimization Algorithm on Ising problems,” Quantum Sci. Technol., 2022.* 6. *A. Peruzzo et al., “A variational eigenvalue solver on a photonic quantum processor,” Nat. Commun., vol. 5, no. 1, p. 4213, 2014.* 7. *www.quantum-computing.ibm.com*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*20%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*5%*	-	*5%*	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. Arun Sehrawat, Director of Quantum Theoritical Research, QpiAi, Bangalore*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr.R. Kumar, SRMIST*
2. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software’s Pvt Ltd*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE433T	**Course Name**	DEEP LEARNING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*know the basic mathematical tools for machine learning ML and its Concepts*
CLR-2:	*understand various techniques for better performance of ML algorithms*
CLR-3:	*describe the Convolutional Neural Network and its blocks*
CLR-4:	*study the DNN Models for computer vision, time series, auto encoders and transfer learning method*
CLR-5:	*acquire skill in the usage of libraries and tools for development of DL models through case studies*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the linear algebra to machine learning and machine learning concepts*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*apply improvement techniques for enhanced ML algorithms performance*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*apply the concept of convolution operation in building CNN model and its blocks*	-	-	*3*	-	-	-	-	-	-	-	-	*3*	*2*	-	-
CO-4:	*understand advanced architectures of deep learning - LeNET, VGGNet, GoogleNet / InceptionNet, MobileNetV1, ResNet, RNN, LSTM and autoencoders*	-	-	-	*3*	-	-	-	-	-	-	-	*3*	*1*	-	-
CO-5:	*develop DL models for the case studies using the libraries*	-	-	*3*	-	*3*	-	-	-	-	-	-	*3*	*3*	-	*3*

Unit-1 - Linear Algebra for ML and its Basics ***9 Hour***

Matrices and Tensors, Identity and inverse Matrices, Linear Dependence and Span, Norms, Special Kinds of Matrices and Vectors, Eigen decomposition and problem solving, Singular Value Decomposition and problem solving, The Trace Operator, Principal Components Analysis with problem solving, perceptron learning algorithm, linear separability, multilayer perceptron, back propagation

Unit-2 - Techniques for Improved Performance ***9 Hour***

Regularization for Deep Learning: Parameter Norm Penalties, Norm Penalties as Constrained Optimization, Regularization and Under-Constrained Problems, Early Stopping, Parameter Tying and Parameter Sharing, Dropout. Optimization for Training Deep Models: Challenges in Neural Network Optimization, Basic Algorithms, Parameter Initialization Strategies, Algorithms with Adaptive Learning Rates

Unit-3 - Deep Neural Network ***9 Hour***

Deep Feed forward network, Convolutional Networks: Convolution Operation, basic components of CNN and unique properties of CNN, architectures of CNN, Variants of the Basic Convolution Function

Unit-4 - Advanced Deep Learning Models ***9 Hour***

LeNet, AlexNet, GoogleNet, VGGNet, ResNet, Architectures, sequential models: RNN, bi-directional RNN, Challenge of Long-Term Dependencies, LSTM, autoencoders, its types and applications, transfer learning

Unit-5 - Applications of Deep Learning Through Case Studies and Tools ***9 Hour***

Introduction to Keras, Classifying movie reviews: a binary classification, multiclass classification, Deep learning for computer vision, Deep learning for text and sequences

Learning Resources	*1. IanGoodfellow, YoshuaBengio, AaronCourville, ―DeepLearning, MITPress, 2016.* *2. KevinP.Murphy, ―MachineLearning: AProbabilisticPerspective, MITPress,2012* *3. Francois Chollet, - Deep Learning with Python, Manning Publications Co., ISBN 9781617294433*	*4. Navin Kumar Manaswi, -Deep Learning with Applications Using Python, Apress, ISBN-13 (pbk): 978-1-4842-3515-7* *5. Daniel Graupe- Deep Learning Neural Networks- Design and case studies, World Scientific, ISBN 978-0-00-098854-6(pbk)*

Learning Assessment							
	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*20%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*20%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	*10%*	-
Level 6	*Create*	-	-	*5%*	-	*5%*	-
	Total	*100%*		*100%*		*100%*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr.S. Malarvizhi, SRMIST*
2. *Mr. Saivineeth, ML Accelerator Architect @ Google*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

Course Code	21ECE434T	**Course Name**	WEB OF THINGS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*obtain knowledge about Web of Things*
CLR-2:	*learn the communication protocols and testbed*
CLR-3:	*identify various patterns and discovering things*
CLR-4:	*create insights about integration of devices from various platforms*
CLR-5:	*identify the security mechanisms and various health and social impact of WoT*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*gain knowledge about WoT*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	-
CO-2:	*develop knowledge of various protocols and testbed*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*distinguish and appreciate various patterns*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-4:	*organize the devices working on heterogeneous platform*	*3*	*2*	-	-	*2*	-	-	-	-	-	-	-	-	-	-
CO-5:	*gain insight about the security and authentication aspects of WoT and its social effects*	*3*	-	-	-	-	*3*	*3*	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to the Web of Things	***9 Hour***
Introduction to the concept and history of the Internet of Things (IoT), Purpose of IoT, Limitations of traditional approaches to the IoT, Significance of Web of Things (WoT), Applications, Features and Shortcomings of WoT, Ontology of WoT, Embedded devices, Introduction to Raspberry Pi, Node.js on Raspberry Pi, Connecting sensors and actuators on Pi, Modeling RESTful services, Mashup tools, Model driven engineering for WoT, Comparing mashup and model driven tools, Modeling of RESTful services, Modeling WoT system with generic RESTful operations	
Unit-2 - Networking for Things	***9 Hour***
Building network of things: Topologies, Classification models, Network protocols for things: spatial considerations, Internet protocols and IoT, IoT Personal Area Networks, IoT Wide Area Networks, Application protocol for things: Zigbee, Bluetooth application stack, Application protocol for things: Apple home kit, Google weave, Message Queuing Telemetry Transport (MQTT), Constraint application protocol, WoT architecture: Access, Find, WoT architecture: Share, Compose, Building IoT with Avatars: Avatar based IoT Platform, Disruption tolerant communication, Context modeling and management, Social vision of WoT, Challenges of WoT, Testbeds of WoT and IoT, Hardware of a WoT testbed, Software of WoT testbed	
Unit-3 - Integration in WOT	***9 Hour***
Web API's for things: Devices, Resources Things, Principles for web API's, Publish subscribe model, Web hooks, Comes and web sockets, Implementing web things, Connecting devices to the web, Direct integration pattern, REST on devices, Gateway integration pattern, CoAP, Cloud integration pattern, MQTT communication, Findability problem, Discovering	
Unit-4 - Representation and Storage	***9 Hour***
Automatic integration and querying of semantic rich heterogeneous data: introduction, Semantic WoT (SWoT), Semantic web as enabler of SWoT, Case study: smart application, Building entity graphs for WoT, Background and methodology, DisCor-T: classification, DisCor-T: recommendation, Interoperability and cross domain Applications, Trends and evolution, Challenges in interoperability, Contributions, M3 framework, Data storage in WoT: framework, Methods and challenges, Data storage in cloud platform, Tendency for data storage technology, Future directions	

Unit-5 - Security in WOT and Social and Health Impacts F WOT	***9 Hour***
Securing things, Open issues and challenges, Web of Topics (WoX) model, Design and implementation, Security from IoT to WoT, Existing models, Security in WoT: Encryption 101, TLS, Enabling HTTPS and WSS with TLS on Pi, Authentication and access control with REST and API tokens, OAuth, Social WoT authentication proxy, Implementing a social WoT authentication, Social impact and vulnerable populations, WoT and health, Potential positive implications for health, Challenges from health perspective, Unintended consequences for social health, Implications	

Learning Resources	1. *Dominique Guinard and Vlad Trifa, Building the Web of Things: With examples in Node.js and Raspberry Pi, Manning Publishers, 2016.* 2. *Michael Sheng, Yongrui Qin, Lina Yao, Boualem Benatallah (Editors), managing the Web of Things Linking the Real World to the Web, Morgan Kaufmann publishers, 1st edition, 2017.* 3. *Shikha Mehta, Sanju Tiari, Patrick Siarry, M A Jabbar, (Editors), Tools, Languages, Methodologies for Representing Semantics on the Web of Things, ISTE Ltd publishers, 1st edition, 2022.*	4. *Ning Zhong, Jianhua Ma, Jiming Liu, Runhe Huang, Xiaohui Tao, Wisdom Web of Things, Springer; 1st ed. 2016.* 5. *Aarti Jain, Rubén González Crespo and Manju Khari (Editors), Smart Innovation of Web of Things, CRC Press Publishers, 1st edition, 2020.* 6. *https://www.w3.org/TR/2023/CR-wot-thing-description11-20230119/* 7. *https://www.w3.org/WoT/* 8. *https://webofthings.org/*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100%*		*100%*		*100%*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Anuj Kumar, Program Delivery Manager, Nagarro Software's Pvt Ltd.*	1. *Dr. Meenakshi, Professor of ECE, CEG, Anna University*	1. *Dr. Sudhanya P, SRMIST*
2. *Mr. Saivineeth, ML Accelerator Architect @ Google*	2. *Dr. Venkatesan, Sr. Scientist (Rtd.), NIOT, Pallikkaranai*	

ACADEMIC CURRICULA

UNDERGRADUATE/ INTEGRATED POST GRADUATE DEGREE PROGRAMMES

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(Choice Based Flexible Credit System)

Regulations 2021

Volume – 14F

(Syllabi for Electronics and Communication Engineering w/s in Microelectronics System Design Programme Courses)

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu, India

ACADEMIC CURRICULA

Professional Core Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21ECC561P	Course Name	ANALOG AND MIXED SIGNAL IC DESIGN	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	1	0	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*utilize basics of IC Biasing techniques and analysis of the characteristic parameters of single stage amplifiers*
CLR-2:	*characterize the basics of differential amplifier and knowledge of various operational amplifiers*
CLR-3:	*understand and analyse different oscillator circuits and PLL*
CLR-4:	*illustrate the basic architectures of Sampling and Quantization process and the Construction of the different types of filters*
CLR-5:	*create insights into the operation of different types of D/A and A/D converters*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*analyse IC Biasing techniques and the characteristic parameters of CMOS single stage amplifiers*	*3*	*3*	*-*	*1*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*1*	*-*
CO-2:	*demonstrate the concepts of Differential Amplifiers and Op-amp circuits*	*2*	*-*	*3*	*1*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*1*	*-*
CO-3:	*construct various oscillators and switched capacitors circuits*	*2*	*-*	*3*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*1*	*-*
CO-4:	*illustrate comparator design, various sampling architectures and different types of analog Filters and SC amplifiers*	*2*	*-*	*3*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*1*	*-*
CO-5:	*describe the different types of digital to analog converters and Analog to digital converters*	*2*	*-*	*3*	*-*	*3*	*-*	*-*	*-*	*-*	*-*	*-*	*-*	*2*	*1*	*-*

Unit-1 - IC Biasing and Single Stage Amplifiers — *12 Hour*

Basic Current mirror, Matching considerations in current mirrors, Cascode current mirrors, Cascode Current mirror and Voltage Reference Circuits Reference circuits: Performance Parameters. Voltage reference circuits using Resistor, BJT, MOS transistor, Zener diode, Band gap reference circuits, Supply Independent Biasing, Temperature independent Reference circuit, Constant –Gm biasing, Analog Design Process flow, Analog Design Octagon, Performance parameters, Common source Amplifier: Resistive load, Diode connected load, Current-source load, triode load, Common source amplifier with source degeneration, Source Follower, Common Gate amplifier, Cascode Amplifier, Foldedcascode amplifier, Frequency response of CS, CD,CG, Cascode amplifier, Noise in amplifiers.

Case Study*: Design of an amplifier with active load, operates for a frequency range 3-10GHz.*

Unit-2 - Differential Amplifiers and Operational Amplifiers — *12 Hour*

Basic differential pair, Qualitative analysis of differential amplifier, Quantitative analysis, Common-mode response, CMRR – Derivation, Differential pair with MOS loads, Frequency response of Differential amplifier, Analysis of Resistively loaded differential amplifier, Active- loaded MOS amplifier, Noise in differential amplifier ,Performance parameters of op-amp, Block Diagram of Op-amp, one stage op-amp, Telescopic op-amp, Two Stage op-amp, Gain Boosting techniques, Folded Cascode CMOS op-amp, Frequency response of op-amp, Noise in Op-amps.

Case Study: *Design and Analysis the performance parameters for two stage op-amp linear and non-linear applications*

Unit-3 - Oscillators and PLL — *12 Hour*

Ring oscillator, Two stage and three stage ring oscillator ,LC oscillators: Colpitt, Cross coupled oscillator ,Voltage controlled oscillators, Tuning range of VCOs, Phase Locked Loop: Basic PLL topology & Characteristic parameters ,Phase detector, Charge Pump PLL, Problem of lock acquisition, Non ideal effects in PLL: PFD/CP, Jitter in PLLs, Transient response of PLL in the locked state, Delay Locked Loops, Delay Locked Loops-Continuation, Applications of PLL : Frequency multiplication, Skew reduction and jitter reduction.

Case Study*: Design of PLL for frequency multiplication and analyse its performance parameters*

Unit-4 - Comparator, Sampling Architectures and Analog Filters	**12 Hour**
Comparator Design, Basic building blocks, Pre-amplifier design, Post distortion amplifier design, Comparator analysis, Sampling theorem, Nyquist criteria, Aliasing Quantization Process, Quantization noise, multi-bit quantizers, Sampling Architectures: Characteristic parameters & Types, Unity gain sampler. Open loop architecture, closed loop architecture, Design of switched capacitor circuits, Ideal effects of SC circuits, Non-ideal effects in SC circuits, Switched Capacitor filter, Active RC Integrator, MOSFET-C Integrator, Transconductance- C integrator. ***Case Study:*** *Design a Dynamic comparator for DAC.*	
Unit-5 - Data Converters	**12 Hour**
Mixed Signal IC Performance metrics of D/A converter, D/A converter in terms of voltage division multiplication, Current division multiplication, Charge division multiplication, Resistor-Ladder architectures, Current mode R-2R DAC, Voltage mode R-2R DAC, Performance metrics of A/D converter, Successive approximation converters, Flash ADC, Two-step A/D converters, Interpolating A/D converters, Pipelined A/D converters, Time-Interleaved converters, Cyclic ADC. ***Case Study****: Demonstration of a project on design and verification of Analog and mixed signal circuit in any of the applications in IOT, Signal conditioning and Communication using EDA tools.*	

Learning Resources	*1. Allen, Holberg, "CMOS analog circuit design", 3rd Edition, Oxford University Press, 2004.* *2. Behzad Razavi, "Design of analog CMOS integrated circuits", 2nd Edition, McGraw Hill, 2017.* *3. Gray, Meyer, Lewis, Hurst, "Analysis and design of Analog Integrated Circuits", 5th Edition, Willey International, 2009.* *4. Adel S. Sedra, Kenneth C. Smith, "Microelectronic Circuits" 7th Edition, Oxford University Press,2015*	*5. Jacob Baker, "CMOS Mixed-Signal circuit design", IEEE Press, 2009.* *6. Razavi, "Principles of data conversion system design", Wiley IEEE Press, 1st Edition, 1994* *7. Baker, Li, Boyce, "CMOS: Circuit Design, layout and Simulation", PHI, 2000.* *8. Jacob Baker, "CMOS circuit design simulation Layout,", IEEE press, 3rd Edition 2010*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)						Final Examination (0% weightage)	
		Formative CLA-1 Average of unit test (20%)		Project Based Learning CLA-2 (60%)		Report and Viva Voce (20%)			
		Theory	Practice	Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	10%	-	--	10%	-	10%	-	-
Level 2	Understand	15%	-	-	15%	-	15%	-	-
Level 3	Apply	20%	-	-	20%	-	20%	-	-
Level 4	Analyze	25%	-	-	25%	-	25%	-	-
Level 5	Evaluate	10%	-	-	10%	-	10%	-	-
Level 6	Create	5%	-	-	5%	-	5%	-	-
	Total	100 %		100 %		100 %		-	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Amrendra Kumar, Keysight Technologies. Email id: amrendra.kumar@keysight.com Mobile: 73378 96220	*1. Dr. Guru Prasad Subas Chandra Mishra, Associate professor, NIT Raipur. Email id: gpscmishra.etc@nitrr.ac.in, Mobile: 9437306597,*	*1. Dr.J.Manjula, SRMIST*

Course Code	21ECC562J	Course Name	CHIP DESIGN VERIFICATION	Course Category	C	PROFESSIONAL CORE	L	T	P	C
							3	0	2	4

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce chip design flow process*
CLR-2:	*explains chip design concepts*
CLR-3:	*system Verilog programming features*
CLR-4:	*fundamentals on chip Verification*
CLR-5:	*introduce chip Verification methodology*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*learning Verilog programming concepts and system Verilog for the chip design*	*3*	*1*	-	-	*2*	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*implement SOC design concepts*	-	*3*	*1*	-	*2*	-	-	-	-	-	-	-	-	*3*	-
CO-3:	*apply the concepts of system Verilog for advanced learning*	-	*3*	*2*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*evaluate the Verification methodology*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*analyse the significance of chip verification domain*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Chip Design Flow ***15 Hour***

Types of Modeling – Gate Level Modeling, Dataflow Modeling, Behavioral Modeling, Test bench code simulation and synthesis, Introduction to System Verilog- basic concepts

Practice: *Test bench code generation and synthesis using Verilog HDL*

Unit-2 - Chip Primer ***15 Hour***

Chip introduction, chip characteristics, chip interfaces, control status registers, Example SOC design

Practice*: SOC programming using cypress semiconductors*

Unit-3 - System Verilog ***15 Hour***

Data types, Arrays, Procedural Statements and flow control, Processes, Task and Function, Classes, Randomization & Constraints, IPC, Assertions and Coverage.

Practice: *System Verilog programming, test bench development using sv, mailbox connections between components like generator and driver in sv, Checking Assertions*

Unit-4 - Design Verification ***15 Hour***

Testing in chip making process, checking involved in the chip making flow, functional verification, high level description of functional verification, verification planning, testbench development, simulation, regression, debug, coverage closure, Test plan.

Practice: *synthesis of the design using chip vault*

Unit-5 - Chip Verification ***15 Hour***

Design Verification techniques based on simulation, analytical and formal approaches, Functional verification, Timing verification, Formal verification, Basics of equivalence checking and model checking, Hardware emulation.

Practice: *Design verification using cypress and chip vault*

Learning Resources		
Learning Resources	1. Samir palnitkar,"Verilog HDL", Pearson education, Second Edition, 2003. 2. System Verilog For Verification: A Guide to Learning the Test bench Language Features by Chris Spear & Greg Tumbush (3rd Edition) 3. System Verilog 3.1a –Language Reference Manual (Accellera Extensions to Verilog 2001), 2004.	4. A Practical Guide to Adopting Universal Verification Methodology (UVM) by Sharon Rosenberg & Kathleen A Meade (2nd Edition), 2013. 5. https://www.infineon.com/cms/en/design-support/tools/sdk/psoc-software/manual. 6. Ray Salemi," UVM Primer: A Step-by-Step Introduction to the Universal Verification Methodology", second edition, October 2013.

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (45%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (15%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	15%	-	-	15%	15%	-
Level 2	Understand	25%	-	-	20%	25%	-
Level 3	Apply	30%	-	-	25%	30%	-
Level 4	Analyze	30%	-	-	25%	30%	-
Level 5	Evaluate	-	-	-	10%	-	-
Level 6	Create	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Raja K -Tech Lead (Verification Engineer) – L&T Technology Services	1. Dr.J. Ramesh - Professor- ECE-PSG College of Technology, peelamedu Coimbatore.	1. Dr.K. Suganthi, SRMIST
2. Govindan R – Design Verification Engineer – L&T Technology Services		2. Dr.J. Selvakumar, SRMIST

ACADEMIC CURRICULA

Professional Elective Courses

Regulations 2021

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India

Course Code	21ECE560T	Course Name	TESTING AND DIAGNOSIS OF VLSI CIRCUITS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*introduce the concepts of testing and its methods*
CLR-2:	*illustrate the concepts of combinational circuit testing*
CLR-3:	*analyze sequential circuit testing and their testability measures*
CLR-4:	*explain the concepts behind Memory and Fault testing*
CLR-5:	*introduce the concepts of Built-In-Self-Test*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*introduce the concepts in testing for a better yield in IC design*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*apply the algorithms for test pattern generation of combinational circuits*	*1*	*3*	-	-	-	-	-	-	-	-	-	-	*3*		-
CO-3:	*analyse the design of sequential circuits testing*	*1*	*3*	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*interpret the design of Memory and Fault testing*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*utilize the concepts of BIST for test pattern generation*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Basics of Testing and Fault	***9 Hour***
Introduction – Principle of testing – types of testing – DC and AC parametric tests- fault modelling-Stuck-at-fault- fault equivalence-fault collapsing-fault dominance-fault simulation	
Unit-2 - Testability of Combinational Circuits	***9 Hour***
Test generation basics- test generation algorithms-path sensitization-Boolean difference-D-algorithm-PODEM overview	
Unit-3 - Testing of Sequential Circuits and Testability Measures	***9 Hour***
State table verification-test generation based on circuit structure-Design of testable sequential circuits- SCOAP Controllability and Observability, High Level Testability Measures Digital DFT and Scan Design:	
Unit-4 - Memory and Delay Fault Testing	***9 Hour***
Testable memory design-RAM fault models-test algorithms for RAMs- Delay Faults-Delay test	
Unit-5 - Built-In-Self-Test (BIST)	***9 Hour***
BIST architectures –Test pattern generation- Logical Level Diagnosis – Diagnosis by UUT reduction– Self-checking design – System Level Diagnosis.	

Learning Resources		
	1. *M. L. Bushnell and V.D. Agrawal, “Essentials of Electronic Testing for Digital Memory and Mixed-Signal VLSI Circuits”, Kluwar Academic publishers, Springer, 2005.* 2. *P.k. Lala, “Digital Circuit Testing and Testability”, Academic Press, 2002.* 3. *M. Abramovici, M. A. Breuer and A.D. Friedman, “Digital systems and Testable Design”, Jaico Publishing House, 2002.*	4. *H. Fujiwara, Logic Testing and Design for Testability, MIT Press, 1985.* 5. *Fabrizio Lombardi and Mariagiovanna Sami, “Testing and diagnosis of VLSI and ULSI”, Kluwer Academic publishers, Dordrecht, Springer 2004*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*20%*	-	*25%*	-
Level 3	*Apply*	*30%*	-	*25%*	-	*30%*	-
Level 4	*Analyze*	*30%*	-	*25%*	-	*30%*	-
Level 5	*Evaluate*	-	-	*10%*	-	-	-
Level 6	*Create*	-	-	*5%*	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Nitin, Design Engineer, QualCom,*	1. *Dr. Guru Prasad Subas Chandra Mishra, Associate professor, NIT Raipur, gpscmishra.etc@nitrr.ac.in,*	1. *Dr.K. Suganthi, SRMIST*
2. *Mr. Vinoth Design Engineer, QualCom,*		2. *Dr.J. Selvakumar SRMIST*

Course Code	21ECE561J	**Course Name**	HARDWARE DESIGN FOR MACHINE LEARNING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basics of deep learning, deep learning frameworks*
CLR-2:	*discussion on various aspects of hardware for machine learning,*
CLR-3:	*basic knowledge on systolic array and FPGA Accelerator*
CLR-4:	*introduction to co-optimization of algorithms and hardware, training and inferenc*
CLR-5:	*fundamental of Quantum computing and software 2.0*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*basics of deep learning, deep learning frameworks, support for state-of-the-art deep learning networks*	-	2	3	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*designed to help students come up to speed on various aspects of hardware for machine learning,*	-	3	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-3:	*impart knowledge on FPGA Accelerator and systolic array*	-	2	3	-	-	-	-	-	-	-	-	-	-	2	-
CO-4:	*introduction to hardware accelerators, co-optimization of algorithms and hardware, training and inference*	-	3	1	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*basics of Quantum computing and knowledge on software 2.0*	-	2	2	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Introduction to Deep Neural Network –DNN ***12 Hour***

Introduction to DNNs - Quantization slides recording - Integer-Arithmetic-Only Inference-Kernel Computation slides recording -Dataflow slides recording - Accelerator slides recording - The current state of Neural Network Quantization –Chipyard / FireSim Overview and Setup.

Practice*: DNN Algorithm*

Unit-2 - Introduction to Systolic Array and Tensorization ***12 Hour***

Systolic arrays and MIMDs, CGRAs -Introduction to Spatial: Analyzing Performance and Energy with Spatial - Evaluating Performance, Energy efficiency, Parallelism, Locality -Memory hierarchy, Roofline model - Luigi Nardi: Design Space Optimization with Spatial Key Components of a Deep-Learning Accelerator -Mapping slides recording - Data Orchestration slides recording - Sparsity slides recording - Co-Design slides recording Configurable Cloud-Scale Real-Time Deep Learning, Other Operators & Near-Data slides recording- Accelerating Software 2.0, Accelerator-Level Parallelism slides -Science to Fuel Neural Nets and TPU Design.

Practice: *Benchmark: LeNet, Cifar-10 Full; Dataset: MNIST, Cifar-10, ILSVRC 2012 : Description : Hand-written Digit Recognition, Object Recognition, Network-in-Network(NiN) using DNNWeaver 1.0*

Unit-3 - FPGA Based Acceleration and AI Compute ***12 Hour***

Systolic Arrays-Architectures for ML in the cloud and at the edge-Memory systems for ML-In-memory or near-memory computing for ML-Temporal and spatial parallelism for machine learning-Energy aware architectures for ML-ASIC design for machine learning-GPU based acceleration for ML-FPGA based acceleration for ML-Hardware-software co-optimization for machine learning-Energy, area, delay trade-offs-Case study of ML chips: Google TPU, MIT Eyeriss, emerging AI chips-ML benchmarking (MLPerf)-HW/SW Co-design of AI Compute Systems.

Practice: *FPGA Machine Learning Algorithm using open source software/Xilinx vivado*

Unit-4 - Introduction- Software 2.0	***12 Hour***
Introduction- Software 2.0 -Role of hardware accelerators in post Dennard and Moore era - Linear algebra fundamentals and accelerating linear algebra -BLAS operations - -Boris Ginsburg: Generalization and Regularization of Training Fast Implementation of Deep Learning Kernels-GPU Design Tradeoffs for Deep learning and MLPerf -Accelerating Natural Language Processing - Sparsity in Deep Learning-Machine Learning Systems and Software Stack- Basics of Machine Learning and Neural Networks-Computing need for machine learning- Overview of hardware platforms for training and inference (CPU, GPU, GPU+DSP, FPGAs, ASIC) ***Practice:*** *DNN/ML algorithm in sparsity.*	
Unit-5 - Accelerator and Quantum Computing	***12 Hour***
Domain-Specific Computing- Vector Architectures, GPU Architectures, and Benchmarking Metrics - FPGA Accelerator Novel Post-Moore Computing Accelerators for ML - In-Memory Computing Accelerator Design - Hyperdimensional Computing Accelerators- ML Accelerators in Quantum Computing - Single and multi-Qubit System - Quantum Data Preparation & Processing – Quantum NAS ***Practice****: Implementation of Gates, Combination Logic using quantum computing using open source software*	

Learning Resources	*1. Deep Learning (Adaptive Computation and Machine Learning series) - Aaron Courville (Author), Ian Goodfellow (Author), YoshuaBengio,2016* *2. Hardware resources : : Jetson Nano- Coral Edge TPU- XilinxPYNQ-Z1- Chipyard, 2019*	*3. H. T. Kung, C. E. Leiserson: Algorithms for VLSI processor arrays; in: C. Mead, L. Conway (eds.): Introduction to VLSI Systems; Addison-Wesley, 2008* *4. N. Petkov: Systolic Parallel Processing; North Holland Publishing Co, 2008* *5. Quantum Computing - A Gentle Introduction - Leanor Rieffel and WolfgangPolak, MIT Press, Cambridge,2011*

Learning Assessment

		Continuous Learning Assessment (CLA)				*Summative Final Examination (40% weightage)*	
	Bloom's Level of Thinking	*Formative CLA-1 Average of unit test (45%)*		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Leela Krishna Thota, Sr. Solution engineer,Synopsys.	*1. Dr.S. Meenakshi, Professor, AnnaUniversity*	*1. Dr.J. Selvakumar, SRMIST.*

Course Code	21ECE562J	**Course Name**	MODERN ASIC DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*gain Knowledge on entry-level industrial standard ASIC or FPGA designer*
CLR-2:	*understand the basic FPGA Architectures*
CLR-3:	*familiarize issues and tools related to ASIC design*
CLR-4:	*analyze the partition and placement issues*
CLR-5:	*understand the concept of clock planning in ASIC design*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand different FPGA Architecture and their interconnect mechanism*	*3*	-	-	-	2	-	-	-	-	-	-	-	*3*	-	-
CO-2:	*familiarize the various programmable ASICs*	*3*	-	-	-		-	-	-	-	-	-	-	*3*	-	-
CO-3:	*summarize the optimization algorithms in ASIC and applying the concept of portioning*	-	-	*3*	*2*		-	-	-	-	-	-	-	*3*	-	-
CO-4:	*illustrate floor planning and clock planning*	*3*	2	-	-	-	-	-	-	-	-	-	-	-	-	*2*
CO-5:	*analyze the various routing algorithm*	-	*3*	-	-	-	-	-	-	2	-	-	-	*3*	-	-

Unit-1 - Introduction To ASIC ***12 Hour***

VLSI Design Flow-Types of ASIC-Programmable ASICs design type-Antifuse-.SRAM-EPROM based ASICs-ASIC fusing based on EPROM-EEPROM based ASICs-FAMOS description-Programmable ASIC logic cells-ASIC I/O cells-Programmable interconnects – FPGA-Types of FPGA-Programmable FPGA-ASIC I/O Cells: DC Input- AC Input- ASIC I/O Cells-DC/AC output-Clock Input-Introduction to CPLD-CPLD architecture-Types of CPLD

Practice: *Functional verification of a combinational circuit using GPDK library, Functional verification of a sequential circuit using GPDK library.*

Unit-2 - Programmable ASIC Logic Cells ***12 Hour***

Actel ACT Architecture-Actel Interconnect delay analysis-Xilinx LCA -Architecture-Xilinx LCA internal architecture- -Xilinx EPLD Architecture-Xilinx EPLD Internal Architecture-Xilinx LCA Interconnect-Xilinx EPLD Interconnect-Altera MAX 7000, - Architecture-Altera Max 9000 : Architecture-Altera Max 9000 : interconnect mechanism-Altera Interconnect features-Altera MAX 5000 : Interconnect Delay analysis- ALTERA's FLEX 8000/10000: Architecture..

Practice*: Generate RTL netlist for a digital circuit and analyze the performance, Implementation of KL algorithm in EDA environment*

Unit-3 - Optimization Methods and System Partitioning ***12 Hour***

Trade off issues at System Level-Solutions to the issues at system level-Optimization with regard to speed-Optimization with regard to area-Optimization with regard to power-Optimization trade off factor-ASIC physical design issues- Power Dissipation: Introduction-Problem - Derivation on power dissipation -System Partitioning Objectives-System partitioning Procedure-Partitioning methods-Measuring Connectivity-Problem on Constructive Partitioning-Constructive Partitioning-Iterative Partitioning Improvement-Problem on Iterative Partitioning Improvement-The Kernighan–Lin Algorithm

Practice*: Placement of Standard cells and timing report generation, Implementation of Non-slicing (B tree) floorplan in EDA environment*

Unit-4 - Floor planning ***12 Hour***

ASIC floor planning-Measurement of Delay in Floor Planning-Channel Definition-I/O and Power Planning - Clock Planning-Placement-placement algorithms- Eigenvalue placement algorithm- Iterative placement improvement-Time driven placement methods- Problems on LEF algorithm

Practice: *Implementation of Non-slicing O-tree floorplan in EDA environment, IR drop analysis in pre-placement stage.*

Unit-5 - Routing	***12 Hour***
Introduction to Routing-single layer global routing-single layer detailed routing wire length- Global Routing Methods-Routing between blocks-inside flexible blocks-Timing driven methods- Detailed Routing- Algorithms-Left Edge algorithm-Area routing algorithm-Multilevel Routing-Timing driven detailed routing-Special routing. ***Practice:*** *IR drop analysis in post-placement stage, Generation of Clock tree for a target skew*	

Learning Resources		
Learning Resources	*1. Smith, Michael. Application-Specific Integrated Circuits. United Kingdom, Addison Wesley Professional, 2008* *2. Douglas J. Smith, Fundamentals of HDL Design: An Engineering Approach. India: Pearson Education, 2010.* *3. Taraate, Vaibhav. Asic Design and Synthesis: Rtl Design Using Verilog. Germany: Springer Singapore, 2021.*	*4. Golshan, Khosrow. Physical Design Essentials: An Asic Design Implementation Perspective. Ukraine: Springer Us, 2007.* *5. Sherwani, Naveed A. Sherwani, Naveed A. Algorithms for VLSI Physical Design Automation. United States: Springer Us, 2013.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	-	15%	15%	-
Level 2	*Understand*	25%	-	-	20%	25%	-
Level 3	*Apply*	30%	-	-	25%	30%	-
Level 4	*Analyze*	30%	-	-	25%	30%	-
Level 5	*Evaluate*	-	-	-	10%	-	-
Level 6	*Create*	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Leela Krishna Thota, Sr.Solution Engineer, Synopsys	*1. Dr.S.Meenakshi, Professor, Anna University*	*1. Dr. K. Ferents Koni Jiavana, SRMIST*

Course Code	21ECE563T	Course Name	LOW POWER CMOS VLSI DESIGN	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***	Program Outcomes (PO)												Program Specific Outcomes		
CLR-1:	*learn the Low Power VLSI concepts*	1	2	3	4	5	6	7	8	9	10	11	12			
CLR-2:	*gain Knowledge on the Device modelling*	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-3:	*design of low power VLSI CMOS Circuits*															
CLR-4:	*understand the concept Low power Techniques and Memories*															
CLR-5:	*cmos Circuits.in VLSI applications*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*manifest the Knowledge of Low power VLSI*	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*design and Model Low Voltage Device*	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*apply the Low Power techniques in CMOS circuits*	3	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*relate the low power concepts and Memories*	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*estimate Power and its impact on CMOS Circuits*	-	3	-	-	-	-	-	-	-	-	-	-	2	-	-

Unit-1 - Low-Power VLSI Design: An Overview	***9 Hour***
Low-Power Applications, Low-Power Design Methodology, Low-Voltage Process Technology, CMOS Process Technology, Bipolar Process Technology, CMOS and Bipolar Processes, Convergence, BiCMOS Technology, Complementary BiCMOS Technology, BiCMOS Design Rules, Silicon on Insulator	
Unit-2 - Low-Voltage Device Modeling	***9 Hour***
MOSFET Structure and Operation, SPICE Models of the MOS Transistor, CMOS Low-Voltage Analytical Model, CMOS Power Supply and Voltage Scaling, Modeling of the Bipolar Transistor	
Unit-3 - Low-Voltage Low-Power VLSI CMOS Circuit Design	***9 Hour***
CMOS Inverter: Switching Characteristics, Power Dissipation, Capacitance Estimation, CMOS static Logic Design, Clocking Low-Power Circuit Techniques, Adiabatic Computing	
Unit-4 - Low-Power CMOS Random Access Memory Circuits	***9 Hour***
Low-Power Techniques, Low-Voltage SRAM Operation and Circuitry, Low-Voltage DRAM Operation and Circuitry, Dynamic RAM	
Unit-5 - Low-Power VLSI Design Methodology	***9 Hour***
Low Power Physical Design, Low Power Gate-Level Design, Low Power Architecture-Level Design, Algorithmic-Level Power Reduction, Power Estimation Techniques	

Learning Resources	1. *Roy, Kaushik, and Sharat C. Prasad. Low-power CMOS VLSI circuit design. John Wiley & Sons, 2009* 2. *Yeap, Gary K. Practical low power digital VLSI design. Springer Science & Business Media, 2012.*	3. *Piguet, Christian. Low-power CMOS circuits: technology, logic design and CAD tools. CRC press, 2018.* 4. *Chandrakasan, Anantha P., and Robert W. Brodersen, eds. Low-power CMOS design. New York: IEEE press, 1998*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	20%	-	20%	-	20%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	30%	-	30%	-	30%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
1. Mr.Leela Krishna Thota, Sr.Solution Engineer, Synopsys	1. Dr.S. Meenakshi, Professor, Anna University	1. Dr. P. Aruna Priya, SRMIST

Course Code	21ECE564J	Course Name	RECONFIGURABLE SYSTEMS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the fundamentals of Reconfigurable computing*
CLR-2:	*demonstrate the types of placement algorithms for Reconfigurable computing*
CLR-3:	*introduce the mapping methods for placement process*
CLR-4:	*explain the working of sorting and searching algorithms for Reconfigurable computing*
CLR-5:	*introduce the concepts of scalability and run time reconfiguration*

		Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the concepts of various reconfigurable computing architectures*	-	2	3	2	-	-	-	-	-	-	-	-	3	-	-
CO-2:	*demonstrate the fundamentals of reconfiguration management*	-	-	3	-	1	-	-	-	-	-	-	-	-	-	-
CO-3:	*acquire knowledge on different types of reconfiguration placement methods*	-	2	2	2	-	2	-	-	-	-	-	-	-	-	2
CO-4:	*express the types of selection and sorting procedures for reconfigurable computing*	-	-	2	-	2	-	-	-	-	-	-	-	-	-	-
CO-5:	*utilize the concepts of reconfigurable logic for hardware development*	-	-	2	-	3	-	-	-	-	-	-	-	-	-	-

Unit-1 - Introduction to Reconfigurable Computing ***12 Hour***

Introduction to Reconfigurable computing - Reconfigurable Fabric – Coarse grained and fine grain architectures - Independent Reconfigurable architectures- RaPID structure RPF integration with traditional PE architecture – Loosely coupled and tightly coupled system design –- operating system support for reconfigurable computing- Context based FPGA design – Single Context and Multi context FPGA systems – Reconfiguration – Types – Static and Dynamic Reconfiguration –- Partial Reconfiguration – Evolution – Artificial Evolution – Evolvable digital platforms.

Practice *- Basic study of Xilinx Vertex board architectures, Exploring EDK tools on sample programs and Programs based on arithmetic operations with Xilinx target boards*

Unit-2 - Fundamentals of Reconfiguration Management ***12 Hour***

Pipeline and block based architectures –Reconfiguration management – Configuration grouping – Configuration Caching – Configuration Scheduling – Software based relocation and defragmentation - Context switching - Basic data models – sequential, data parallel – data centric – multi threaded – System architectures – streaming - sequential –bulk synchronous parallelism, data parallel – cellular automata and multithreaded architectures

Practice *- Design synthesis using Vivado, Analysing and implementing the design using vivado design flow, Implementing a design floorplan for reconfiguration*

Unit-3 - Reconfiguration Mapping ***12 Hour***

Mapping designs into reconfigurable platform– Structural – Area oriented – Performance driven - Power aware and integrated mapping methods - Mapping algorithms for heterogeneous structures - Mapping to complex logic blocks – Mapping to Embedded memory blocks – Macro cell mapping – Generic FPGA Placement – Clustering – Simulated annealing – VPR annealing.

Practice *- Implementation of a static design using Xilinx boards Mapping types and implementing the static design / configuration one to the target board*

Unit-4 - Reconfiguration Algorithms ***12 Hour***

Reconfiguration algorithms – Sorting algorithms –- optimal, sub optimal and constant time sorting – tradeoffs. - sorting three-dimensional R mesh Basics on the indexing and selection on an R mesh algorithm- - Graph algorithms – Euler tour- Minimum spanning tree -Algebraic path problem – Acyclic graphs – Efficient list ranking Deterministic and Randomized approach - Limitations

Practice - *Synthesis of Reconfigurable logic or configuration two on the target board, Mapping and swapping procedures on the desired floorplan*

Unit-5 - Reconfiguration Scaling	***12 Hour***
Scaling simulation on a small model instance –- Scaling HVR- LR – FR – R mesh instances – Degrees of scalability – Case study - Matrix multiplication – Matrix vector multiplication – Equivalence of one-dimensional models ***Practice*** *- Analysis and testing of the implemented configuration one and two using standard procedures, Case study- Relating PR and LR mesh- Run time reconfigurability*	

Learning Resources	*1. Ramachandran Vaidhyanathan and Jerry. L. Trahan “Dynamic Reconfiguration: Architectures and Algorithms”, Kluwer Academic publishers, 2003.* *2. Clive Maxfield, “The Design Warrior’s Guide to FPGAs Devices,Tools, and Flows”, Elsevier Publications, 2004.*	*3. Scott Hauck and Andre` DeHon, “Reconfigurable Computing: The Theory and Practice of FPGA-Based Computation”, Morgan Kaufmann, 2008* *4. Pao-Ann Hsuing, Macro D.Santambrogio, Chun -Hsian Huang, "Reconfigurable System Design and Verification”, CRC press, 2018.*

Learning Assessment

	Bloom’s Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	-	*15%*	*15%*	-
Level 2	*Understand*	*25%*	-	-	*20%*	*25%*	-
Level 3	*Apply*	*30%*	-	-	*25%*	*30%*	-
Level 4	*Analyze*	*30%*	-	-	*25%*	*30%*	-
Level 5	*Evaluate*	-	-	-	*10%*	-	-
Level 6	*Create*	-	-	-	*5%*	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishna Thota, Sr. Solution Engineer,Synopsys.	*1. Dr.S. Meenakshi, Professor, AnnaUniversity*	*1. Dr.A. Ruhan Bevi, SRMIST.*

Course Code	21ECE566J	**Course Name**	PROCESS AND DEVICE MODELING USING CAD	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*develop a firm foundation in the use of Computer-Assisted techniques for IC device and process Design (CAD)*
CLR-2:	*determine key indicators of device performance by linking process simulation to device simulation*
CLR-3:	*generate two-dimensional (2D) or three-dimensional (3D) structures including doping profiles and electrical contacts*
CLR-4:	*simulate numerically the electrical behavior of a single semiconductor device in isolation or several physical devices combined in a circuit*
CLR-5:	*understand the physics-based analytical modeling approach to predict device operation at specific conditions, environment and physical characteristics*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*understand the physics-based modelling of semiconductor devices and their fabrication process*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*design, analyze and optimize semiconductor technologies and devices with fundamental and accurate models*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*create a two-dimensional (2D) or three-dimensional (3D) device with multiple regions using geometric operations*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*compute terminal currents, voltages, and charges based on a set of physical device equations that describes the carrier distribution and conduction mechanisms*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*apply numerical models in virtual environment for device optimization*	*3*	-	-	-	*3*	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Technology- Oriented CAD ***12 Hour***

Process simulation flow, Conventional role of TCAD in IC processing, Process steps involved in the manufacturing of an IC, Steps involved in devicesimulation, History of process simulation, Evolution of TCAD, TCAD-based electrical characterization, Process synthesis, TCAD and compact model, Parameter extraction, TCAD for Nano electronic, Materials used in integrated circuits

Practice: *TCAD Tools, 2D Boundaries, 2D Structures*

Unit-2 - IC technology and TCAD Tools ***12 Hour***

Process simulation: Oxidation, Ion implantation, Diffusion, Lithography, Etching, Metallization, Synopsys TCAD Tools, Process-to-device simulation: Device generation, Device simulation

Practice*: Doping and Meshing, 3D Structure, Process simulation*

Unit-3 - Generating Geometric Structures ***12 Hour***

Introduction to Sentaurus Structure Editor, Modeling Unit and Modeling Range, Creating a New Structure, Basic 2D Shapes, Editing 2D Shapes, Simplifying 2D Structures, Electrical and Thermal Contacts, Defining Areas for Mesh Refinement or Doping, Mesh Refinement Definition, Defining Doping Profiles: Constant Doping Profiles, Analytic Doping Profiles, External 2D and 3D Doping Profiles, Particle Doping Profile

Practice*: 2D PN-Junction Structure, Sentaurus Workbench and Device Physics, Characteristics of PN Junction*

Unit-4 - Creating and Meshing Device Structure ***12 Hour***

Typical tool flow with device simulation using Sentaurus Device, Command File, Electrode Section, Physics Section, Plot Section, Math Section, Solve Section, Parameter File, and Example: Simulation of PN Junction diode and MOSFET, Abrupt and Graded Heterojunctions, Physical Models and the Hierarchy of Their Specifications - Region-specific and Material-specific Models, Interface-specific Models, Electrode-specific Models, Parameters for Composition-dependent Materials.

Practice: *2D MOSFET Structure, DC and AC Characteristics of MOSFET, 2D N-Type lightly doped drain (LDD) MOSFET*

Unit-5 - Physics in Sentaurus Device ***12 Hour***

Electrostatic Potential, Equilibrium Solution, Quasi-Fermi Potential with Boltzmann Statistics, Fermi Statistics, Carrier Transport Models, Numeric Parameters for Continuity Equation, Current Potential, Semiconductor Band Structure -Selecting the Bandgap Model, Effective Masses and Effective Density-of-States, Overview of Sentaurus Workbench, Mixed-Mode CMOS Inverter Simulation

Practice: *DC and AC Characteristics of N-Type lightly doped drain (LDD) MOSFET, 3D MOSFET Structure, DC and AC Characteristics of 3D MOSFET*

Learning Resources	*1. G.A. Armstrong, C.K. Maiti, "TCAD for Si, SiGe and GaAs Integrated Circuits", Published by The Institution ofEngineering and Technology, London, United Kingdom, 2007.* *2. Robert W.Dutton, Zhiping Yu, "Technology CAD Computer Simulation of Processes and Devices", Kluwer Academic Publishers, 1993.* *3. Yung-Chun Wu • Yi-Ruei Jhan, "3D TCAD Simulation for CMOS Nanoeletronic Devices", Springer Nature Singapore Pte Ltd. 2018*	*4. Yogesh Singh Chauhan, Darsen Duane Lu, Vanugopalan Sriramkumar, Sourabh Khandelwal, Juan Pablo Duarte, Navid Payvadosi, Ai Niknejad, Chenming Hu , "FinFET Modeling for IC 'Simulation and Design: Using the BSIM-CMG Standard", AcademicPress - Elsevier ,2015.* *5. Synopsys Sentaurus TCAD Manual.*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*20%*	-	-	*20%*	*20%*	-
Level 2	*Understand*	*20%*	-	-	*20%*	*20%*	-
Level 3	*Apply*	*40%*	-	-	*40%*	*40%*	-
Level 4	*Analyze*	*20%*	-	-	*20%*	*20%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishna Thota, Sr.Solution Engineer,Synopsys.	*1. Dr.S.Meenakshi, Professor, AnnaUniversity*	*1. Dr. Maria Jossy A, SRMIST*

Course Code	21ECE567J	**Course Name**	QUANTUM TECHNOLOGIES AND APPLICATIONS	**Course Category**	E	PROFESSIONAL ELECTIVE	L 2	T 0	P 2	C 3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*learn about fundamentals of quantum mechanics*
CLR-2:	*become familiar with the fundamental concepts of quantum circuits and postulates*
CLR-3:	*learn the different insights behind basic quantum algorithms,*
CLR-4:	*become acquainted with quantum cryptography and the supremacy of quantum computing*
CLR-5:	*acquire knowledge on programming for quantum computers*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*define the use of linear algebra in quantum computing*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*2*	-	-
CO-2:	*construe quantum computing Postulates and quantum circuits*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*examine quantum computer algorithms*	-	-	*3*	*2*	-	-	-	-	-	-	-	*1*	*2*	-	-
CO-4:	*investigate cryptography in quantum computing*	-	*2*	-	*3*	-	-	-	-	-	-	-	*1*	*1*	-	-
CO-5:	*understand, Design and Test quantum circuits on IBMQ*	-	-	*3*	-	*2*	-	-	-	-	-	-	*1*	*1*	-	-

Unit-1 - Quantum Mechanics-Fundamentals ***12 Hour***

Linear algebra basics, Vector Spaces, Tensor products, inner and outer product, Hilbert space, N dimensional inner product, Infinite dimensional inner product, Schwarz's Inequality, Hilbert space examples, Probabilities and Measurements, Spectral decomposition, Quantum entanglement, Spectral decomposition, Bell's inequalities, Density operators Practice: bell states, mixed states,

Unit-2 - Quantum Circuits and Postulates ***12 Hour***

Quantum Computing and its advantage, Postulates of Quantum mechanics, Qubits and Dirac notation, Bloch sphere, Quantum Gates-Single and Multi- qubit, Quantum circuits-basic
Practice: Single and multi qubits quantum gates, basic quantum circuit designs

Unit-3 - Quantum Algorithms ***12 Hour***

No-Cloning Theorem, Deutsch-algorithm, Deutsch-Jozsa algorithm, Grover's Search algorithm, Quantum Fourier Transform, Shor's factoring algorithm, Variational quantum algorithms such as QAOA, VQE
Practice: Deutsch-algorithm, Deutsch-Jozsa algorithm, Grover's Search algorithm, Quantum Fourier Transform

Unit-4 - Quantum Cryptography ***12 Hour***

Quantum cryptography-Introduction, Quantum Key Distribution, BB84 Protocol, B92 Protocol, EPR Protocol, Quantum Teleportation
Practice: Quantum Key Distribution, Quantum Teleportation

Unit-5 - Entropy and Quantum information theory ***12 Hour***

Shannon entropy, properties of entropy, Von-Neumann entropy, quantum relative entropy, basic properties of Von Neumann entropy, measurements Practice: Measurements of entropy

Learning Resources	*1. Michael A. Nielsen and Issac L. Chuang, "Quantum Computation and Information, Cambridge (2002).* *2. Quantum Computing, A Gentle Introduction, Eleanor G. Rieffeland Wolfgang H. Polak MIT press (2014)* *3. David McMahon-Quantum Computing Explained-Wiley-Interscience , IEEE Computer Society (2008)* *4. N. S. Yanofsky and M. A. Mannucci, Quantum Computing for Computer Scientists. Cambridge, England: Cambridge UniversityPress, 2022.*	*5. Ozaeta, W. van Dam, and P. L. McMahon, "Expectation values fromthe single-layer Quantum Approximate Optimization Algorithm on Ising problems," Quantum Sci. Technol., 2022.* *6. Peruzzo et al., "A variational eigenvalue solver on a photonic quantum processor," Nat. Commun., vol. 5, no. 1, p. 4213, 2014.* *7. www.quantum-computing.ibm.com*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*30%*	-	-	*30%*	*30%*	-
Level 2	*Understand*	*30%*	-	-	*30%*	*30%*	-
Level 3	*Apply*	*40%*	-	-	*20%*	*40%*	-
Level 4	*Analyze*	-	-	-	*20%*	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Dr. Arun Sehrawat, Director of Quantum Theoritical Research, QpiAi, Bangalore	*1. Dr.S. Meenakshi, Professor, AnnaUniversity*	*1. Dr. Soumyaranjan Routray, SRMIST*
		2. Mrs. Gayathri S. S, SRMIST

Course Code	21ECE568J	**Course Name**	RF SYSTEM DESIGN	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*discuss the high-frequency behavior of common circuit components*
CLR-2:	*list and identify the challenges in using high frequency devices in Circuit design*
CLR-3:	*understand the design issues in RF amplifiers, filters and Oscillators*
CLR-4:	*analyze the stability considerations and interference issues in RF design*
CLR-5:	*learn RF circuit fundamentals for designing various circuit building blocks in a typical RF transceiver*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*calculate basic radio specifications in terms of, gain, noise, signal-to-noise ratio, power*	*3*	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-
CO-2:	*apply mathematical skills and software skills to design and simulate RF filters and matching circuits*	2	-	*3*	-	*3*	-	-	-	-	-	-	-	*3*	-	-
CO-3:	*identify and learn the working principle and characteristics of Radio frequency devices*	*3*	2	-	-	-	-	-	-	-	-	-	-	*3*	-	-
CO-4:	*perform stability analysis on RF amplifier designs*	-	-	*3*	*3*	2	-	-	-	-	-	-	-	*3*	-	-
CO-5:	*design RF oscillators and mixers*	-	*3*	*3*	-	2	-	-	-	-	-	-	-	*3*	-	-

Unit-1 - Introduction to Radio Frequency Design ***12 Hour***

Introduction to passive components at RF, Definitions – RF Units, RF parameters Parallel and series connection of networks - ABCD and scattering parameters, Smith chart and its applications, Noise in RF systems – Noise figure computations - Electromagnetic Interference in RF circuits: Sources of EMI, Elements of EMI

***Practice**: Smith chart, Noise figure calculations in a cascaded system, Testing for EMI*

Unit-2 - RF Filters and Matching Circuits ***12 Hour***

Filter configurations- LPF, HPF, BPF, BSF, Special filter realizations - Low pass prototype, filter implementation – Richards Transformation, Kuroda Identity, Impedance matching using discrete components, microstrip line matching networks.

***Practice:** Design and simulation of LPP microwave filter, Design and simulation of impedance matching circuits using lumped elements*

Unit-3 - Radio Frequency Devices ***12 Hour***

RF diodes: Schottky, PIN, IMPATT, GUNN - RF BJT, RF MESFET-High Electron Mobility Transistors- Transistor Models-Scattering parameter device characterization,

***Practice:** V-I characteristics of GUNN diode, Schottky diode, RF BJT / MESFET*

Unit-4 - RF Amplifiers ***12 Hour***

Amplifier classes of operation, Characteristics of amplifiers, amplifier power relations, stability circle and conditional stability, stability testing of RF amplifiers, broadband amplifiers. High power amplifiers: Gain compression, Intermodulation distortion

***Practice**: Design an RF amplifier, Stability testing of RF Amplifiers,*

Unit-5 - Radio Frequency Generation & Mixer ***12 Hour***

One-port and two-port microwave oscillator design, Crystal Oscillator, YIG tuned Oscillator, Analysis of phase noise in oscillators. Mixers: Characteristics, Various types of Mixers: FET mixers, Balanced mixers, Image reject mixers

***Practice:** Design One port and two port RF oscillator, Analyze Oscillator phase noise*

Learning Resources	1. *David M. Pozar, "Microwave Engineering - Theory and Practice",Wiley India Pvt Ltd, 2020* 2. *Reinhold Ludwig, "RF circuit design, theory and applications" PavelBretchko, "Pearson Asia Education", 2ed, 2009* 3. *Behzad Razavi, " RF Microelectronics", 2nd edition Pearson Prentice Hall,2013*	4. *William F Egan, "Practical RF System Design", Wiley - IEEE Press, 1ed,2003* 5. *W. Prasad Kodali, Engineering Electromagnetic Compatibility: Principles, Measurements, Technologies, and Computer Models, Wiley-IEEE Press, 2ndEdition, 2001*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA) Formative CLA-1 Average of unit test (45%)		Continuous Learning Assessment (CLA) Life-Long Learning CLA-2 (15%)		Summative Final Examination (40% weightage)	
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	15%	-	-	15%	15%	-
Level 2	*Understand*	25%	-	-	20%	25%	-
Level 3	*Apply*	30%	-	-	25%	30%	-
Level 4	*Analyze*	30%	-	-	25%	30%	-
Level 5	*Evaluate*	-	-	-	10%	-	-
Level 6	*Create*	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr.Leela Krishna Thota, Sr.Solution Engineer,Synopsys.*	1. *Dr,S.Meenakshi, Professor, AnnaUniversity*	1. *Dr.M.S. Vasanthi, SRMIST*

Course Code	21ECE569T	**Course Name**	VLSI SIGNAL PROCESSING TECHNIQUES	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the fundamental lower bound on the sample period and the techniques used for high-speed and low-power applications*
CLR-2:	*analyze retiming and unfolding techniques to increase the throughput of the circuit*
CLR-3:	*explore reduction in hardware complexity by use of substrate sharing technique*
CLR-4:	*demonstrate application of systolic architecture in VLSI Design*
CLR-5:	*emphasis on architecture design based on design methodologies for mapping algorithms to arithmetic architectures at bit-level*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*compute the iteration bound using DSP algorithm and illustration of low-power design using pipelining and parallel processing techniques*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-2:	*apply retiming algorithm to reduce the critical path delay and unfolding algorithm to improve the throughput of the circuit*	*2*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-3:	*examine algorithmic strength reduction transformation to design fast parallel FIR filters, DCTs, and parallel rank-order filters*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*
CO-4:	*design regular iterative algorithm using linear mapping techniques*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	*3*
CO-5:	*implement bit-level arithmetic architectures and bit-parallel multipliers*	*3*	-	-	*2*	-	-	-	-	-	-	-	-	-	-	*3*

Unit-1 - Iteration Bound, Pipelining and Parallel Processing ***9 Hour***

Iteration Bound, data flow graph representations, loop bound, Iteration bound. Problems on iteration bound techniques. Various mechanism for iteration bound computation, longest path matrix algorithm, Problems on LPM techniques. Pipelining and parallel processing – Introduction, Pipelining of FIR digital filters, parallel processing, Parallel processing of FIR Filter. Pipelining processing for low power, Parallel processing for low power, Problems on low power pipelined and parallel systems.

Unit-2 - Retiming and Unfolding ***9 Hour***

Introduction to Retiming – Retiming Properties, Retiming for clock period minimization, Problems on Retiming mechanism, Unfolding – Introduction, An algorithm for unfolding, Properties of unfolding, application of Unfolding - sample period reduction and Parallel Processing

Unit-3 - Algorithmic Strength Reduction in Filters and Transforms ***9 Hour***

Algorithmic strength reduction – Introduction, Parallel FIR Filters using Polyphase Decomposition, Discrete Cosine Transform (DCT) and Inverse DCT, Algorithm – Architecture Transformation, Numerical problems in N-point DCT, Fast Convolution – Introduction, Cook – Toom algorithm, modified Introduction, Cook –Toom algorithm.

Unit-4 - Systolic Architecture ***9 Hour***

Introduction to systolic architectures, Systolic array design methodology, Systolic arrays for FIR digital filters, Selection of Scheduling Vector, Problem related to systolic array design, Matrix Multiplication and 2D Systolic Array Design, Systolic Design for space representations containing delays.

Unit-5 - Bit-Level Arithmetic Architecture ***9 Hour***

Bit-level architecture – Introduction, Parallel Multipliers, Parallel Multiplication with sign extension, Parallel Carry-ripple Array Multipliers, Parallel Carry-Save Array Multipliers, Baugh-Wooley Multipliers, Parallel Multipliers with Modified Booth Recoding, Interleaved Floorplan and Bit-plane based Digital Filters, Design of Bit-Serial Multipliers using Systolic Mappings

Learning Resources	1. Keshab K.Parhi, "VLSI Digital Signal Processing systems, Design and implementation", Wiley, Inter Science, 1999. 2. Gary Yeap, “Practical Low Power Digital VLSI Design”, Kluwer Academic Publishers, 1998. 3. Mohammed Ismail and Terri Fiez, "Analog VLSI Signal and Information Processing", Mc Graw-Hill, 1994.	4. S.Y. Kung, H.J. White House, T. Kailath, "VLSI and Modern SignalProcessing", Prentice Hall, 1985. 5. Jose E. France, Yannis Tsividis, "Design of Analog & Digital VLSI Circuits for Telecommunication and Signal Processing ", Prentice Hall, 1994

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	-	*15%*	-	*15%*	-
Level 2	*Understand*	*25%*	-	*25%*	-	*25%*	-
Level 3	*Apply*	*35%*	-	*35%*	-	*35%*	-
Level 4	*Analyze*	*25%*	-	*25%*	-	*25%*	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Leela Krishna Thota, Sr.Solution Engineer,Synopsys.	*1. Dr.S. Meenakshi, Professor, AnnaUniversity*	*1. Dr. Maria Jossy A, SRMIST*

Course Code	21ECE570T	**Course Name**	CAD FOR HIGH-SPEED CHIP PACKAGE SYSTEMS	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*21ECC205T*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*outline the use of CADs for high speed chip packaging*
CLR-2:	*elaborate different electrical challenges in packaging*
CLR-3:	*explore the basics of transmission lines and their types*
CLR-4:	*develop different AC and DC models for the simulations of interconnects and power distribution network*
CLR-5:	*deduce fundamental numerical models using partial element equivalent circuit for electrical characterization*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*illustrate the use of CADs and different parameters for high speed chip packaging*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*identify electrical challenges encountered during high speed packaging*	*2*	-	*1*	-	*2*	-	-	-	-	-	-	*2*	*2*	-	-
CO-3:	*correlate different transmission lines, time and frequency domain analysis*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-4:	*develop AC and DC model for 2.5D electrical characterization*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-5:	*apply partial element equivalent circuit concept to model 3D electrical characterization*	*2*	*2*	*2*	-	-	-	-	-	-	-	-	-	*1*	-	-

Unit-1 - CAD for High-Speed Chip-Package-Systems: An Overview	***9 Hour***
Function of packages: power and signal distribution, heat dissipation, mechanical stability, types of packages and PCBs, desired package properties: electrical performance, power distribution with low R and low L, thermal performance, mechanical performance, past trends, 3D integration today	
Unit-2 - Electrical Challenges	***9 Hour***
Review of electromagnetic and circuit basics, on-chip signal integrity, noise and timing analysis, high frequency aspect, skin effect, power integrity, simultaneous switching noise, A.C. power integrity, importance of inductance, electromagnetic interference and electromagnetic compatibility, review of SPICE basics, lumped models, distributed RLGC, S/Y/Z parameters	
Unit-3 - 2D Electrical Characterization	***9 Hour***
Transmission line basics, TEM mode and its properties, Stokes' and Gauss's theorem, Maxwell's equations, two conductor transmission line and per unit length parameters, cylindrical wires of different radii, wire on ground plane, co-axial cable, two conductor transmission line frequency domain analysis, losses, A, B, C, D,Z, Y parameters, 2D Analysis: multiconductor transmission lines (MTL) extraction, 2D analysis: MTL frequency and time domain analysis, 2D analysis: MTL channel simulation	
Unit-4 - 2.5D Electrical Characterization	***9 Hour***
Power delivery, power distribution network (PDN) modeling: DC and AC analysis, DC internal resistance (DCIR) drop solver, multigrid based solvers: algebraic multigrid (AMG), 2.5D analysis: multilayered finite-difference method (M-FDM), 2.5D analysis: gap and fringe correction, decoupling capacitor placement, simultaneous switching noise (SSN)	
Unit-5 - 3D Electrical Characterization	***9 Hour***
Partial element equivalent circuit (PEEC) method: quasistatic conductor, full-wave conductor, dielectric, non-orthogonal, surface, and fast compressed PEEC, advantages of PEEC, frequency dependence in PEEC, near and far field radiation, comparison of 2D, 2.5D, 3D, through-silicon-via modeling	

Learning	*1. Stephen H. Hall and Howard. L. Heck, Advanced Signal Integrity for High Speed Digital*	*3. Eric Bogatin, Signal and Power Integrity-Simplified, Second Edition, Prentice Hall, 2010*

Resources	Designs, IEEE Computer Society Press, 2009 2. Howard W. Johnson and Martin Graham, High Speed SignalPropagation: Advanced Black Magic, Prentice Hall, 2003	4. Madhavan Swaminathan and Ege Engin, Power Integrity Modelling and Design for Semiconductors and Systems, First Edition, Prentice Hall, 2007 5. HSPICE, Signal Integrity User Guide, Version A-2007.12, December 2007,Synopsys

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	Remember	20%	-	20%	-	20%	-
Level 2	Understand	30%	-	30%	-	30%	-
Level 3	Apply	30%	-	30%	-	30%	-
Level 4	Analyze	20%	-	20%	-	20%	-
Level 5	Evaluate	-	-	-	-	-	-
Level 6	Create	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Leela Krishna Thota, Sr, Solution Engineer,Synopsys.	1. Dr.S.Meenakshi, Professor, Anna University.	1. Dr. Aditya Nath Bhatt, SRMIST
		2. Dr. Rajesh Agarwal, SRMIST

Course Code	21ECE571T	**Course Name**	HARDWARE ACCELERATION AND OPTIMIZATION	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	1	0	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*to study mm-wave device modeling*
CLR-2:	*understands mm-Wave Device Optimization*
CLR-3:	*analyze mm-Wave CMOS Noise Analysis*
CLR-4:	*observe Unilateralization*
CLR-5:	*understand Terahertz CMOS Devices, Circuits, and Systems*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	**Program Outcomes (PO)**												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*infer mm-Wave Device Modelling*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-	-
CO-2:	*predict mm-Wave Device Optimization*	*1*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-3:	*estimate mm-Wave CMOS Noise Analysis*	*1*	*3*	-	*2*	-	-	-	-	-	-	-	-	-	-	*1*
CO-4:	*examine Unilateralization Techniques*	-	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	-
CO-5:	*explain Terahertz CMOS Devices, Circuits, and Systems*	*1*	*2*	*3*	-	-	-	-	-	-	-	-	-	-	-	*2*

Unit-1 - MM-Wave Device Modelling	***9 Hour***
The Terahertz Gap-Shift of Paradigm in the IC Design-The Importanceof Modelling in mm-Wave-High Frequency Modeling Procedure-Measurement and De-embedding.	
Unit-2 – MM wave Device Optimization	***9 Hour***
Device Performance Metrics-Layout Effect on Device Performance- Round-Table Structure-mm-Wave Power Device Optimization	
Unit-3 - MM Wave CMOS Noise Analysis	***9 Hour***
Two Port Noise Models-CMOS Noise Model-mm-Wave Noise Model- Noise Sensitivity Analysis to Parasitics.	
Unit-4 - Unilaterization	***9 Hour***
Theory of Unilateralization-Mason Gain as a Maximum Gain-2-Port Unilateralization Techniques-N-Port Unilateralization-Single Transistor Unilateralization-Simulated Results and Implementation.	
Unit-5 - Terahertz CMOS Devices, Circuits and Systems	***9 Hour***
Ultra-High Speed CMOS Devices-Ultra-High Speed CMOS Circuits- Ultra-High-Speed Systems.	

Learning Resources	*1. Sam Gharavi, Babak Heydari, “Ultra-High-Speed CMOS CircuitsBeyond 100 GHz”, Springer-Verlag New York, 2012.* *2. Dwight G Nishimura, “Principles of Magnetic ResonanceImaging”, 2010.* *3. Kerry Bernstein, Keith M. Carrig, “High-Speed CMOS Design Styles”, Kluwer Academic Publishers, 2002.*	*4. Evan Sutherland, Bob Stroll, David Harris,” Logical Efforts, Designing Fast CMOS Circuits”, Kluwer Academic Publishers, 1999.* *5. David Harris, “Skew Tolerant Domino Design”, IEEE Journal of Solid-State Circuits, 2001.*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (50%)		Life-Long Learning CLA-2 (10%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	35%	-	35%	-	25%	-
Level 2	*Understand*	35%	-	30%	-	35%	-
Level 3	*Apply*	30%	-	35%	-	40%	-
Level 4	*Analyze*	-	-	-	-	-	-
Level 5	*Evaluate*	-	-	-	-	-	-
Level 6	*Create*	-	-	-	-	-	-
	Total	100 %		100 %		100 %	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr.Leela Krishan Thota, Sr.Solution Engineer,Synopsys.	1. Dr.S. Meenaskshi, Professor, AnnaUniversity	1. Dr.S. Yuvaraj, SRMIST

Course Code	21ECE572T	Course Name	HARDWARE AND SOFTWARE CODESIGN WITH FPGAs	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							3	0	0	3

Pre-requisite Courses	*Nil*	Co- requisite Courses	*Nil*	Progressive Courses	*Nil*
Course Offering Department	*ECE*	Data Book / Codes / Standards	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*understand the basic concepts hardware software and dataflow modeling*
CLR-2:	*study FPGA hardware synthesis tools and SoC tool flows that integrate custom hardware*
CLR-3:	*highlight the characteristics of system models and representation*
CLR-4:	*study the performance of real time embedded system*
CLR-5:	*design FPGA with self-replicating properties*

Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*implement data flow in hardware software*	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-2:	*integrate SoC tools on custom hardware*	*3*	*2*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-3:	*apply the concepts of modeling in system design*	-	*3*	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-4:	*analyze the performance of embedded software system*	*3*	-	-	-	-	-	-	-	-	-	-	-	2	-	-
CO-5:	*analyze reconfigurable computing platforms using FPGA*	-	*3*	*2*	-	-	-	-	-	-	-	-	2	2	-	-

Unit-1 - Hardware Software Basic Concepts	***9 Hour***
Nature of hardware software, Hardware software code sign, Energy efficiency, Relative performance, Hardware software code sign space, Dualism of hardware and Software design, Modeling, concurrency and parallelism, Data flow modeling and transformation, Dataflow implementation in hardware software.	
Unit-2 - Design Space of Custom Architecture	***9 Hour***
Finite state machine with data path, Cycle based bit parallel and hardware, wires and registers, precision and sign, Hardware mapping of expression, Hardware modules, and Finite state machines with data path, Micro programmed architecture, and General-purpose embedded core.	
Unit-3 - Modeling and Hardware Description	***9 Hour***
Data flow process network, formal models, Validation, Synthesis, Paradigm for hardware software system design, VHDL generation from SDL specification, Development of complex reactive systems, Synchronous approach to reactive and real-time systems.	
Unit-4 - Analysis and Estimation of Hardware Software System	***9 Hour***
Performance of embedded software with instruction cache modeling, Scheduling algorithm for multi programming hard real time system, Performance estimation of real time embedded distributed system, Rate analysis for embedded system, Power analysis for embedded software, Design for system level power management, Power estimation for embedded system	
Unit-5 - Reconfigurable Computing Platforms	***9 Hour***
Programmable active memories, reconfigurable systems, Logic emulation with virtual wires, Embryonics, Design field programmable gate arrays with self-repair and self-replicating properties	

Learning Resources	1. *A Practical Introduction to Hardware/Software Codesign", Patrick Schaumont, Springer, 2010, ISBN 978-1-4614-3736-9* 2. *De Micheli, Giovanni, et al. Readings in hardware/software co-design. MorganKaufmann publisher, 2002.*	3. *Handbook of hardware/software codesign, Jürgen Teich, Soonhoi Ha, Springer Netherlands, 2017* 4. *The Codesign of embedded systems, James H. Aylor, Barry W. Johnson, WM A Wulf, Kluweracademic publishers, 1995*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (50%)		*Life-Long Learning CLA-2 (10%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*15%*	*-*	*15%*	*-*	*15%*	*-*
Level 2	*Understand*	*25%*	*-*	*20%*	*-*	*25%*	*-*
Level 3	*Apply*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 4	*Analyze*	*30%*	*-*	*25%*	*-*	*30%*	*-*
Level 5	*Evaluate*	*-*	*-*	*10%*	*-*	*-*	*-*
Level 6	*Create*	*-*	*-*	*5%*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Dr. N.R. Shanker Managing Director Chase Research and development Centre, Chennai*	1. *Dr.S. Meenakshi, Professor, Anna University*	1. *Dr. M.K. Srilekha, SRMIST*

Course Code	21ECE573J	Course Name	BOARD DESIGN PRACTICE PART-I: ELECTRONICS SYSTEM DESIGN AND ANALYSIS	Course Category	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	Nil	Co- requisite Courses	Nil	Progressive Courses	Nil
Course Offering Department	ECE	Data Book / Codes / Standards	Nil		

Course Learning Rationale (CLR):	*The purpose of learning this course is to:*	Program Outcomes (PO)												Program Specific Outcomes		
		1	2	3	4	5	6	7	8	9	10	11	12			
		Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CLR-1:	*utilize basics models of the devices- diodes, BJT and MOSFET and analysis its characteristic parameters*															
CLR-2:	*characterize the basics of operational amplifiers and its applications*															
CLR-3:	*understand and analyze the types of feedback and its application circuits*															
CLR-4:	*illustrate the concepts of digital subsystem and its functional elements*															
CLR-5:	*create insights into the operation of different types of D/A and A/D converters and electronics subsystem design*															
Course Outcomes (CO):	***At the end of this course, learners will be able to:***															
CO-1:	*analyze the characteristic parameters of diodes, BJT and MOSFET*	3	-	2	-	3	-	-	-	-	-	-	-	-	2	-
CO-2:	*demonstrate the concepts of Op-amp circuits*	3	-	2	-	3	-	-	-	-	-	-	-	-	2	-
CO-3:	*illustrate the various circuits using different feedback concepts*	3	-	2	-	3	-	-	-	-	-	-	-	-	2	-
CO-4:	*construct various digital subsystem and its functional elements*	3	-	2	-	3	-	-	-	-	-	-	-	-	2	-
CO-5:	*describe the different types of digital to analog converters and Analog to digital converters*	3	-	2	-	3	-	-	-	-	-	-	-	-	2	-

Unit-1 - Device Models — *12 Hour*

Overview; PN Junction as a Diode, Diode Models and Circuits;: Half and Full Wave Rectifiers with C/ LC/ Pi Filters, Voltage Regulation, Limiting Circuits, Diodes, Level Shifters and Switches, Diode as a switch, Diode Switching Time Parameters, Interpreting diode data sheets. Bipolar Junction Transistor Review and BJT Amplifiers: BJT I - V Characteristics - CB, CE and CC Configurations and Device Ratings of Interest; BJT Amplifiers, Biasing Techniques, Bias Stability, BJT Small Signal DC and AC Models, CE Amplifier with an Emitter Degenerate Resistor, Frequency Response, Input/ Output Impedances, The Emitter Follower, and the CB Amplifier; BJT as a switch - Switching time parameters, Interpreting the BJT datasheets, MOSFET Review and Discrete MOSFET Amplifiers: MOSFET Device Principle of Operation and I - V Characteristics Review; MOSFET Discrete Amplifiers -CS, CG and the Source Follower, Biasing Techniques and Circuits, MOSFET Small Signal DC and AC Models, Frequency Response Analysis Review; Current Mirrors and The Differential Amplifier

***Practice** on Design and verification of Diode application circuits: Rectifiers, voltage regulators, Level shifting circuits, Design and analysis of CE,CB and CC configurations of BJT amplifiers , Design and analysis of CS, CD and CG configurations of MOSFET amplifiers*

Unit-2 - Op-Amp Circuits — *12 Hour*

OPAMP Review - OPAMP Linear and Nonlinear Application Circuits: The Ideal OPAMP, Practical OPAMP Characteristics (OPAMP 741 as example): Large Signal Gain, Input Bias Current, Input Offset Voltage, CMRR, PSRR, Common Mode and Differential Input Resistances, Interpretation of the datasheet, OPAMP Large Signal and Small Signal Linear Model; OPAMP Linear Applications: Virtual Short and Virtual Ground Concept, Inverting, Non-Inverting Amplifiers, I2V/ V2I converters, Summing Amplifier, Instrumentation Amplifier, OPAMP Integrator and Differentiator - Gain and BW limitations; OPAMP Nonlinear Applications: Analog Comparator, ZCD, the Schmitt Trigger, Comparator Applications – ZCD, Phase Meter, Window Comparator, Comparator Wired OR function, Precision Diode and Rectifier Circuits, OPAMP Log and Antilog Amplifiers

***Practice** on Verification of OP-AMP operation and characteristics, Design and Analysis of Summer, Integrator and Differentiator using op-amp , Design and Analysis of comparator and Schmitt trigger using op-amp*

Unit-3 - Feedback Circuits — *12 Hour*

Feedback Concepts, FB Amplifiers and Waveform Generators - Review and Circuits: Basic Amplifier Topologies, Concept of FB and Basic FB Topologies – Review; FB Amplifier Analysis and Design - Frequency Response and Stability; Frequency Compensation Techniques; OPAMP Filters – Butterworth, Chebyshev Polynomials, Sallen – Key Filters, Oscillators and Multivibrators - Review, OPAMP RC and Wein Bridge

Oscillator Design, Hartley and Colpitts Oscillators, Automatic Gain Control, OPAMP Astable Multivibrator and VCO.

***Practice** on Design and analysis of Feedback amplifiers: voltage series, voltage shunt, Current series and current shunt amplifiers, Design and analysis of Butterworth and Chebyshev filters using op-amp, Design and analysis of RC and LC oscillators*

Unit-4 - Digital Subsystem Design** — **12 Hour

Digital Subsystem Design: Review of Digital Logic Functions and Combinational Circuits, Interpreting Datasheets; Logic Synthesis of Combinational Functional Blocks – Arithmetic Functions - FA, 4 Bit Parallel Adder/ Subtractor, Adder topologies – CLA, Carry Skip Adders, Multiplier topologies – Wallace Tree and Booth Multipliers, MUX, Decoders and Demux, Encoders, Parity Check and Generation; Sequential Digital Functional Elements - D Latch and D Flop, Applications - Switch Debounce Circuit; Design and Logic Synthesis of Binary and Non-Binary Synchronous Counters, FSM – Introduction; Memory types and Memory Interface – Review

***Practice** on Design of Combinational circuits: Adders, Subtractors, Multipliers, Parity generators and Synchronous counters*

Unit-5 – Data Converters** — **12 Hour

Data Converter Topologies: The Sample and Hold – Topologies, Key Specifications, the Sampling Theorem, Effect of Aliasing, Digital – to - Analog Converters – Principle, DAC topologies – R – 2R, Current Steering, Charge Sharing DAC, DAC Key Specifications; Analog – to – Digital Converter topologies – Counting Type, Dual Slope, SAR ADC, Oversampling, Sigma – Delta ADC, Pipeline ADC, Key Performance Specifications – Resolution, ENOB, SNR, SNDR, Conversion Time Electronic Subsystem Design : Linear Voltage Regulators and LDO Topologies; Key Specifications; The PLL and DLL – Clock recovery circuits, the Data Acquisition Signal Chain – Design of a 4-1/2 Digit Auto Ranging Digital Multi Meter with AC/ DC I/ V measurements, Temperature, Humidity sensor interfaces and LCD display, Design of a Complete Audio Signal Chain – Microphone to Speaker involving, data acquisition, DSP, and the speaker amplifier, Signal Interface Protocols – SPI, I2C

***Practice** on Simulation of R-2R DAC circuit*

Learning Resources	*1. Ronals A. Reis, 'Electronics Project Design and Fabrication' 4th Edition, Pearson, 1998.* *2. Walter C Bosshart, Printed Circuit Boards: Design and Technology, McGraw Hill Education, 1983.* *3. R. Khandpur, 'Printed Circuit Boards: Design, Fabrication, and Assembly', McGraw-Hill Electronic Engineering, 2005* *4. Allen, Holberg, "CMOS analog circuit design", 3rd Edition, Oxford University Press, 2004.* *5. Behzad Razavi, "Design of analog CMOS integrated circuits", 2nd Edition, McGraw Hill, 2017.*	*6. Adel S. Sedra, Kenneth C. Smith, "Microelectronic Circuits" 7th Edition, Oxford University Press,2015* *7. Jacob Baker, "CMOS Mixed-Signal circuit design", IEEE Press, 2009.* *8. Razavi, "Principles of data conversion system design", Wiley IEEE Press, 1st Edition, 1994* *9. Baker, Li, Boyce, "CMOS: Circuit Design, layout and Simulation", PHI, 2000.* *10. Jacob Baker, "CMOS circuit design simulation Layout,", IEEE press, 3rd Edition 2010*

Learning Assessment

	Bloom's Level of Thinking	*Continuous Learning Assessment (CLA)*				*Summative Final Examination (40% weightage)*	
		Formative CLA-1 Average of unit test (45%)		*Life-Long Learning CLA-2 (15%)*			
		Theory	*Practice*	*Theory*	*Practice*	*Theory*	*Practice*
Level 1	*Remember*	*25%*	*-*	*-*	*25%*	*25%*	*-*
Level 2	*Understand*	*30%*	*-*	*-*	*25%*	*30%*	*-*
Level 3	*Apply*	*30%*	*-*	*-*	*30%*	*30%*	*-*
Level 4	*Analyze*	*15%*	*-*	*-*	*15%*	*15%*	*-*
Level 5	*Evaluate*	*-*	*-*	*-*	*5%*	*-*	*-*
Level 6	*Create*	*-*	*-*	*-*	*-*	*-*	*-*
	Total	*100 %*		*100 %*		*100 %*	

Course Designers

Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. Mr. Venugopal D Kulkarni, Consultant, Entuple Technologies Mail ID: vdk@entuple.com	*1. Dr.S. Meenakshi, Professor, Anna University*	*1. Dr.J. Manjula, SRMIST*

Course Code	21ECE574J	**Course Name**	BOARD DESIGN PRACTICE PART-II: PCB DESIGN, FABRICATION AND TESTING	**Course Category**	E	PROFESSIONAL ELECTIVE	L	T	P	C
							2	0	2	3

Pre-requisite Courses	*Nil*	**Co- requisite Courses**	*Nil*	**Progressive Courses**	*Nil*
Course Offering Department	*ECE*	**Data Book / Codes / Standards**	*Nil*		

Course Learning Rationale (CLR):	***The purpose of learning this course is to:***
CLR-1:	*apply the design and other consideration involved in PCB design*
CLR-2:	*understand the design of Flexible PCB design consideration*
CLR-3:	*explore various PCB manufacturing techniques*
CLR-4:	*understand the testing and quality control of PCB*
CLR-5:	*address the pollution control and recycling in PCB Fabrication*

		Program Outcomes (PO)												**Program Specific Outcomes**		
		1	2	3	4	5	6	7	8	9	10	11	12			
Course Outcomes (CO):	***At the end of this course, learners will be able to:***	Engineering Knowledge	Problem Analysis	Design/development of solutions	Conduct investigations of complex problems	Modern Tool Usage	The engineer and society	Environment & Sustainability	Ethics	Individual & Team Work	Communication	Project Mgt. & Finance	Life Long Learning	PSO-1	PSO-2	PSO-3
CO-1:	*apply the design rules in designing PCB*	*2*	-	*3*	-	-	-	-	-	-	-	-	-	*1*	-	-
CO-2:	*explore the required PCB Fabrication Process and technology*	*1*	-	-	-	*3*	-	-	-	-	-	-	-	*1*	-	-
CO-3:	*identify the construction and advantages of Flexible PCBs*	*2*	-	*2*	-	-	-	-	-	-	-	-	-	-	-	-
CO-4:	*explore the required testing, Quality control and Recycling in PCB Design*	*2*	-	-	-	-	-	*2*	-	-	-	-	-	-	-	-
CO-5:	*develop a PCB layout using modern CAD tool*	*2*	*2*	-	-	*3*	-	-	-	-	-	-	-	-	*2*	-

Unit-1 - Layout Planning and Design — 12 Hour

General PCB Design Considerations: Important design elements and performance parameters, Fabrication and Assembly Considerations, Environment Factors: Thermal consideration, contamination and shock and vibrations, Cooling Requirements: Heat sink and packaging Density, Layout Design Rules:Grid system, Layout Scale, Sketch/Design, Layout consideration, materials and aids, Land requirements, Layout methodology, Layout Design Checklist, Documentations, Useful Standards, ***Practice:*** *Schematic and Layout Design of Combinational and sequential Circuit*

Unit-2 - Etching Techniques — 12 Hour

Etching solutions and Chemistry, etching arrangements: Simple batch production etching, continuous feed etching, open loop and close loop regeneration, Etching Parameters, etching equipment and Techniques: immersion etching, Bubble etching, Splash etching, Spray etching, Etching Equipment selections, Optimizing Etching Economy, Problems in Etching, Facilities for Etching Areas, Electrochemical etching, Mechanical Etching, ***Practice****: Etching process in the PCB design and Fabrication*

Unit-3 - Flexible Printed Circuit Boards — 12 Hour

Flexible Printed Circuit Boards, Construction of Flexible Printed Circuit Boards: Films, Foils and Adhesives, Design Considerations in Flexible Circuits and step by step Approach to design Flex circuit, Manufacturing of Flexible Circuits, Rigid Flex Printed Circuit Boards, Designing for flexibility and Reliability Terminations, Advantages of Flexible Circuits, Special Applications of Flexible Circuits, Useful Standards
Practice: *Schematic and Layout Design of Combinational and sequential Circuit using PCB Design Tool*

Unit-4 - Quality Reliability and Acceptability Aspects — 12 Hour

Quality Assurance: classifications of defects and defectives, Acceptability Quality Level, Quality control program, Testing for Quality Control, Designing of QA methods, Incoming QA, Traceability, Quality Control Methods, Testing of Printed Circuit Boards, Testing of Assembled board, Reliability Testing, Applicability of PCBs: Acceptance criteria, Inception of assembled PCB, Inception techniques, Acceptability criteria, Useful Standards, ***Practice****: Schematic and Layout Design of Combinational and sequential Circuit using PCB Design Tool*

Unit-5 - Environment concerns in the PCB Industry	***12 Hour***
Pollution Control in PCB Industry, Polluting agents, Recycling of Water, Recovery Techniques, Air pollutions, Recycling of Printed Circuit Boards: Present approach to PCB scrap disposal, characteristics of PCB scraps, Dis-assembly of equipment, Technologies of recycling of PCBs, Environmental Standards, Safety Precautions for the Personnel, Toxic Chemicals in Printed Circuit Board Fabrication, Useful Standards ***Practice**: Schematic and Layout Design of Combinational and sequential Circuit using PCB Design Tool*	

Learning Resources	1. *R. S. Khandpur, Printed Circuit Boards: Design, Fabrication, Assembly and Testing, 0-07-146420-4, McGraw-Hill, 2006.* 2. *Charles A. Harpe, "High Performance Printed Circuit Boards", McGraw Hill Professional, 2000.* 3. *9Bruce R. Archambeault, James Drewniak, "PCB Design for Real-World EMI Control", Volume 696 of The Springer International Series in Engineering and Computer Science,* 4. *Springer Science & Business Media, 2013.*	5. *Mark I. Montrose "Printed Circuit Board Design Techniques for EMCCompliance: A handbook for designers" Wiley, 2 Edition, 2015.* 6. *Esim open-source tool: http://esim.fossee.in/* 7. *TINA/Orcad User manual*

Learning Assessment

	Bloom's Level of Thinking	Continuous Learning Assessment (CLA)				Summative Final Examination (40% weightage)	
		Formative CLA-1 Average of unit test (45%)		Life-Long Learning CLA-2 (15%)			
		Theory	Practice	Theory	Practice	Theory	Practice
Level 1	*Remember*	30%	-	-	15%	15%	-
Level 2	*Understand*	30%	-	-	20%	25%	-
Level 3	*Apply*	20%	-	-	25%	30%	-
Level 4	*Analyze*	10%	-	-	25%	30%	-
Level 5	*Evaluate*	-	-	-	10%	-	-
Level 6	*Create*	-	-	-	5%	-	-
	Total	100 %		100 %		100 %	

Course Designers		
Experts from Industry	**Experts from Higher Technical Institutions**	**Internal Experts**
1. *Mr. Vikas Verma, Physical design Engineer,Mediatek, vikas.verma@mediatek.com*	1. *Dr. G. P.S. Mishra, Associate Professor,NIT Raipur, Chhattisgarh*	1. *Dr. Manish Verma, SRMIST*
2. *Mr. Mahesh Malewale Tanaji, Physical DesignEngineer, mahesh.tanaji.malewale@intel.com*	2. *Dr. Shivendra Yadav, Assistant Professor,SVNIT, Surat, Gujrat*	2. *Dr. P. Eswaran, SRMIST*

SRM INSTITUTE OF SCIENCE AND TECHNOLOGY

(Deemed to be University u/s 3 of UGC Act, 1956)

Kattankulathur, Chengalpattu District 603203, Tamil Nadu,
India