

**SCHEME & SYLLABUS**  
**OF**  
**V TO VI SEMESTERS B.E.**  
**ELECTRONICS AND COMMUNICATION**  
**ENGINEERING**  
**AY: 2025-26**  
**(Applicable to 2023-24 Batch)**

**Vision**

To be a center of excellence in education and research creating professionally competent and socially sensitive Electronics and Communication engineers capable of working in multicultural global environment.

**Mission**

- To provide quality education relevant to the current and future needs of the society ensuring experiential learning in Electronics and Communication engineers.
- To create state of the art infrastructure and research facility for learning-teaching-learning process and quality research.
- To imbibe professional ethics, human values and competency in students enabling them to work individually, and as a member or leader in multicultural global environment.

**Programme Educational Objectives:**

The graduates of Electronics and Communication engineering programme will

- a) Be able to design and build systems for providing solutions to real life problems in the area of Electronics and Communication.
- b) Be a successful entrepreneur, build careers in Industry, government, public sector undertakings, pursue higher education and research.
- c) Work individually, within multidisciplinary teams and lead the team following sound professional and ethical practices.

**Knowledge and Attitude Profile (WK)**

- WK1:** A systematic, theory-based understanding of the natural sciences applicable to the discipline and awareness of relevant social sciences.
- WK2:** Conceptually-based mathematics, numerical analysis, data analysis, statistics and formal aspects of computer and information science to support detailed analysis and modelling applicable to the discipline.
- WK3:** A systematic, theory-based formulation of engineering fundamentals required in the engineering discipline.
- WK4:** Engineering specialist knowledge that provides theoretical frameworks and bodies of knowledge for the accepted practice areas in the engineering discipline; much is at the forefront of the discipline.
- WK5:** Knowledge, including efficient resource use, environmental impacts, whole-life cost, re-use of resources, net zero carbon, and similar concepts, that supports engineering design and operations in a practice area.
- WK6:** Knowledge of engineering practice (technology) in the practice areas in the engineering discipline.
- WK7:** Knowledge of the role of engineering in society and identified issues in engineering practice in the discipline, such as the professional responsibility of an engineer to public safety and sustainable development.
- WK8:** Engagement with selected knowledge in the current research literature of the discipline, awareness of the power of critical thinking and creative approaches to evaluate emerging issues.
- WK9:** Ethics, inclusive behavior and conduct. Knowledge of professional ethics, responsibilities, and norms of engineering practice. Awareness of the need for diversity by reason of ethnicity, gender, age, physical ability etc. with mutual understanding and respect, and of inclusive attitudes.

**Graduate attributes: Program Outcomes (POs)**

- PO1: Engineering Knowledge:** Apply knowledge of mathematics, natural science, computing, engineering fundamentals and an engineering specialization as specified in WK1 to WK4 respectively to develop to the solution of complex engineering problems.
- PO2: Problem Analysis:** Identify, formulate, review research literature and analyse complex engineering problems reaching substantiated conclusions with consideration for sustainable development. (WK1 to WK4)
- PO3: Design/Development of Solutions:** Design creative solutions for complex engineering problems and design/develop systems/components/processes to meet identified needs with consideration for the public health and safety, whole-life cost, net zero carbon, culture, society and environment as required. (WK5)
- PO4: Conduct Investigations of Complex Problems:** Conduct investigations of complex engineering problems using research-based knowledge including design of experiments, modelling, analysis & interpretation of data to provide valid conclusions. (WK8).
- PO5: Engineering Tool Usage:** Create, select and apply appropriate techniques, resources and modern engineering & IT tools, including prediction and modelling recognizing their limitations to solve complex engineering problems. (WK2 and WK6)
- PO6: The Engineer and The World:** Analyze and evaluate societal and environmental aspects while solving complex engineering problems for its impact on sustainability with reference to economy, health, safety, legal framework, culture and environment. (WK1, WK5, and WK7).
- PO7: Ethics:** Apply ethical principles and commit to professional ethics, human values, diversity and inclusion; adhere to national & international laws. (WK9)

**PO8: Individual and Collaborative Team work:** Function effectively as an individual, and as a member or leader in diverse/multi-disciplinary teams.

**PO9: Communication:** Communicate effectively and inclusively within the engineering community and society at large, such as being able to comprehend and write effective reports and design documentation, make effective presentations considering cultural, language, and learning differences.

**PO10: Project Management and Finance:** Apply knowledge and understanding of engineering management principles and economic decision-making and apply these to one's own work, as a member and leader in a team, and to manage projects and in multidisciplinary environments.

**PO11: Life-Long Learning:** Recognize the need for, and have the preparation and ability for i) independent and life-long learning ii) adaptability to new and emerging technologies and iii) critical thinking in the broadest context of technological change. (WK8)

### **Program Specific Outcomes (PSOs)**

A graduate of the Electronics and Communication Engineering Program will demonstrate

1. The ability to analyse and design systems in the areas related to microelectronics, Communication, Signal Processing and embedded systems for solving real world problems (Professional Skills).
2. The ability to identify problems in the areas of communication and embedded systems and provide efficient solutions using modern tools/algorithm individually or working in a team (Problem solving Skills).

**SCHEME OF TEACHING AND EXAMINATION FOR 160 CREDITS SCHEME  
(EFFECTIVE FROM THE ACADEMIC YEAR 2022-23)**

**I Semester (Chemistry Cycle)**

**Electrical & Electronics Engg. Stream (EE, EC, EI, ET)**

Sl. No.	Course Category and Course Code	Course Title	Teaching Dept.	Teaching hrs/week					Examination			Credits
				Lecture		Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
				L	T							
1	ASC(IQ)	MATE1	Maths	2	2	2	0	3	50	50	100	4
2	ASC(IQ)	CHEE	Chem	3	0	2	0	3	50	50	100	4
3	ESC	ESCF1	ME	2	0	2	0	3	50	50	100	3
4	ESC2	ESCOx	ABE	3	0	0	0	3	50	50	100	3
5	PLC	PLCx	ABE	2	0	2	0	3	50	50	100	3
6	AEC	CC01	T&P	1	0	0	0	1:30	50	50	100	1
7	HSMC	CC05	HS	1	0	0	0	1:30	50	50	100	1
8	AEC/SDC	CC07	Any Dept.	1	0	0	0	1:30	50	50	100	1
				40 hours of work to be documented and produced for the examination at 8 <sup>th</sup> Semester					400	400	800	20
<b>Total</b>												

**Note:** 1) Students have to choose any one course out of five options available in Engineering Science Courses (Optional).

2) Students have to choose any one course out of five options available in Programming Language Courses

Code	Engineering Science Courses (Optional)			Programming Language Courses			L	T	P	Cr
	L	T	P	Code	Code	Code				
ESC01	3	0	0	PLC1	Introduction to Web Programming	2	0	2	3	
ESC02	3	0	0	PLC2	Introduction to Python Programming	2	0	2	3	
ESC03	3	0	0	PLC3	Basics of JAVA programming	2	0	2	3	
ESC04	3	0	0	PLC4	Introduction to C++ Programming	2	0	2	3	
ESC05	2	0	2							

ASQ(IC)	Applied Science Course (Integrated Course)	HSMC	Humanities, Social Science and Management Course
ESC	Engineering Science Course	AEC	Ability Enhancement Course
ETC	Emerging Technology Course	SDC	Skill Development Course
PLC	Programming Language Course	ABE	Appropriate Branch of Engineering

**SCHEME OF TEACHING AND EXAMINATION FOR 160 CREDITS SCHEME  
(EFFECTIVE FROM THE ACADEMIC YEAR 2022-23)**

**II Semester (Physics Cycle)**

**Electrical & Electronics Engg. Stream (EE, EC, EI, ET)**

Sl. No.	Course Category and Course Code	Course Title	Teaching Dept.	Teaching hrs/week					Examination				Credits
				Lecture	Tutorial	Practical/ Drawing	Self-Study Component		Duration in hrs.	CIE Marks	SEE Marks	Total Marks	
							T	P					
1	ASC(IC) MATE2	Mathematics - II for EEE Stream	Maths	2	2	2	0	0	3	50	50	100	4
2	ASC(IC) PHYE	Physics for EEE Stream	Phy	3	0	2	0	0	3	50	50	100	4
3	ESC	Elements of Electrical Engg. (For EE)	EE	2	2	0	0	0	3	50	50	100	3
				3	0	0	0						
4	ESC1	Basic Electronics (for EC, EI, ET)	EC	3	0	0	0	0	3	50	50	100	3
5	ETC	Engineering Science Course-II	ABE	3	0	0	0	0	3	50	50	100	3
6	AEC	Emerging Technology Course	ABE	3	0	0	0	0	3	50	50	100	3
7	HSMC	Professional Writing Skills in English	T&P	1	0	0	0	0	1:30	50	50	100	1
				1	0	0	0						
				1	0	0	0						
8	AEC/SDC	Innovation and Design Thinking	HS	1	0	0	0	0	1:30	50	50	100	1
	AAP	Innovation and Design Thinking	Any Dept.	1	0	0	0	0	1:30	50	50	100	1
		AICTE Activity Points	40 hours of work to be documented and produced for the examination at 8 <sup>th</sup> Semester							400	400	800	20
		<b>Total</b>											

**Note:** 1) Students have to choose any one course out of five options available in Engineering Science Courses (Optional) excluding Engineering Science Course studied in I Semester.

2) Students have to choose any one course out of four options available in Emerging Technology Courses

Code	Engineering Science Courses (Optional)				Emerging Technology Courses				L	T	P	Gr
	L	T	P	Gr	Code	Emerging Technology Courses	L	T				
ESC01	3	0	0	3	ETC01	Smart Materials and Systems	3	0	0	3		
ESC02	3	0	0	3	ETC02	Green Buildings	3	0	0	3		
ESC03	3	0	0	3	ETC03	Operation and Maintenance of Solar Electric Systems	3	0	0	3		
ESC04	3	0	0	3	ETC04	Introduction to Embedded System	3	0	0	3		
ESC05	2	0	2	3	ETC05	Introduction to Nanotechnology	3	0	0	3		
					ETC06	Introduction to Drone Technology	3	0	0	3		
					ETC07	Introduction to Sustainable Engineering	3	0	0	3		
					ETC08	Renewable Energy Sources	3	0	0	3		
					ETC09	Waste Management	3	0	0	3		
					ETC10	Emerging Applications of Biosensors	3	0	0	3		
					ETC11	Introduction to Internet of Things (IoT)	3	0	0	3		
					ETC12	Introduction to Cyber Security	3	0	0	3		

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**B.E. in Electronics and Communication Engineering**  
**SCHEME OF TEACHING AND EXAMINATION (2023 Scheme) (w.e.f. 2024-25)**

**III Semester**

Sl. No.	Course and Course Code	Course Title	Teaching / Paper setting Dept.	Teaching hrs.				Examination			Credits		
				Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks	SEE Marks		Total Marks	
													L
1.	IPCC S3EC01	Mathematics for Signal Processing	ECE	42	-	28	50	3	50	50	100	4	
2.	POC S3EC05	Random Process	ECE	42	-	-	48	3	50	50	100	3	
3.	IPCC S3CES1	Digital Electronic Circuits with Verilog <sup>s</sup>	ECE	42	-	28	50	3	50	50	100	4	
4.	PCC S3CES2	Analog Electronic Circuits <sup>s</sup>	ECE	42	-	-	48	3	50	50	100	3	
5.	PCCL S3ECL01	Analog Electronic Circuits Lab	ECE	-	-	28	02	3	50	50	100	1	
6.	ESC S3ECXX	ESC/ETC/PLC	ECE	42	-	-	48	3	50	50	100	3	
7.	UHV SHS01	Social Connect and Responsibility	ME	-	-	28	02	-	50	-	50	1	
8.	AEC/ SEC S3ECAXX	Ability Enhancement Course/ Skill Enhancement Course - III	ECE	If offered as Theory Course				1½	50	50	100	1	
				If offered as Integrated Course									
9.	NCMC	SMC01 SMC02 SMC03 SMC04	NSS CO PED PED	-				28	02	100	-	100	0
				National Service Scheme (NSS)									
				Physical Education (PE) (Sports and Athletics)									
				Yoga NCC									
		Total							550	350	900	20	
	AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)											

40 hours community service to be documented and produced for the examination

**Note:** PCC: Professional Core Course, IPCC: Integrated Professional Core Course, PCCL: Professional Core Course Laboratory, UHV: Universal Human Value Course, NCMC: Non Credit Mandatory Course, AEC: Ability Enhancement Course, SEC: Skill Enhancement Course, ESC: Engineering Science Course, ETC: Emerging Technology Course, PLC: Programming Language Course L: Lecture, T: Tutorial, P: Practical  
S= SDA; Skill Development Activity, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation.

Engineering Science Course (ESC/ETC/PLC) (Offered by the Department)	
S3EC02 - Computer Organization & Architecture	S3EC04 - Applied Numerical Methods for EC Engineering
S3EC03 - Electronic Measurements	S3CES3 - VLSI Process Technology
Ability Enhancement Course - III (Offered by the Department)	
S3ECA01 - Electronic System Design	S3ECA04 - Signal Processing with R
S3ECA02 - Matlab for EC Engineering	S3ECA05 - Electric Circuit Analysis

**S Common to ECE/TCE/EI/EE**

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**B.E. in Electronics and Communication Engineering**  
**SCHEME OF TEACHING AND EXAMINATION (2023 Scheme) (w.e.f. 2024-25)**

**IV Semester**

Sl. No.	Course and Course Code	Course Title	Teaching / Paper scoring Dept.	Teaching hrs.			Examination			Credits				
				Lecture	Tutorial	Practical/ Drawing	Self-Study Component	Duration in hrs.	CIE Marks		SEE Marks	Total Marks		
													L	T
1.	PCC	S4EC01 Communication System - I	ECE	42	-	-	48	3	50	50	100	3		
2.	IPCC	S4CES01 Control Systems I	ECE	42	-	28	50	3	50	50	100	4		
3.	IPCC	S4CES02 ARM Microcontroller I	ECE	42	-	28	50	3	50	50	100	4		
4.	IPCC	S4ECL01 Communication System - I Lab.	ECE	-	-	28	02	3	50	50	100	1		
5.	ESC	S4ECXX ESC/ETC/PLC.	ECE	42	-	-	48	3	50	50	100	3		
6.	BSC	S4CCA01 Biology for Engineers	BT, CH, Phy, Che	42	-	-	48	3	50	50	100	3		
7.	UHV	S4SH02 Universal Human Values Course	IEM	14	-	-	16	1½	50	50	100	1		
8.	AEC/SEC	S4ECAXX Ability Enhancement Course/ Skill Enhancement Course - IV	ECE	If offered as Theory Course			02	1½	50	50	100	1		
				If offered as Integrated Course										
				-	-	28								
9.	NCCMC	S4SMC01 National Service Scheme (NSS)	NSS CO						100	-	100	0		
		S4SMC02 Physical Education (PE) (Sports and Athletics)	PE											
		S4SMC03 Yoga	PE											
		S4SMC04 NCC	PE											
		Total									500	400	900	20
	AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)		40 hours community service to be documented and produced for the examination										

Note: PCC: Professional Core Course, IPCC: Integrated Professional Core Course, PCCL: Professional Core Course laboratory, UHV: Universal Human Value Course, NCCMC: Non Credit Mandatory Course, AEC: Ability Enhancement Course, SEC: Skill Enhancement Course, ESC: Engineering Science Course, ETC: Emerging Technology Course, PLC: Programming Language Course L: Lecture, T: Tutorial, P: Practical S= SDA: Skill Development Activity, CHE: Continuous Internal Evaluation, SEE: Semester End Evaluation.

Engineering Science Course (ESC/ETC/PLC) (Offered by the Department)	
S4EC03 - Fields, Lines and Waves	S4EC05 - Solid State Devices & Technology
S4EC04 - Industrial Electronics	S4EC06 - Data Structures with C
Ability Enhancement Course - IV (Offered by the Department)	
S4ECA01 - Communication Applications using Python	S4ECA04 - Advanced Digital Design using System Verilog
S4ECA02 - Industrial IoT	S4ECA05 - Communication Systems using GNU Radio
S4CCA07 - Advanced Technical Training Lab	

\$ Common to ECET/CE/EEE



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**B.E. in Electronics and Communication Engineering**  
**SCHEME OF TEACHING AND EXAMINATION (2023 Scheme) (w.e.f. 2025-26)**

**V Semester**

Sl. No.	Course and Course Code	Course Title	Teaching / Paper setting Dept.	Teaching hrs.				Examination			Total Credits (C) (Total hrs./30)			
				Class room Instruction (CI) (in hrs/sem)	Tutorial	Lab Instruction (LI) (in hrs/sem)	Term work (TW) and Self Learning (SL) (TW+SL) (in hrs/sem)	Total No. of hrs/sem	Duration in hrs.	CIE Marks		SEE Marks	Total Marks	
1.	PCC S5EC01	IOT and Network Technology	ECE	L 42	T -	P -	S 48	90	3	50	50	100	3	
2.	IPCC S5EC101	Digital Signal Processing	ECE	42	-	28	50	120	3	50	50	100	4	
3.	IPCC S5EC102	Communication Systems – II	ECE	42	-	28	50	120	3	50	50	100	4	
4.	PCCL S5ECL01	IOT and Network Technology Lab	ECE	-	-	28	02	30	3	50	50	100	1	
5.	PEC SECEX	Professional Elective Course - I	ECE	42	-	-	48	90	3	50	50	100	3	
6.	PROJ S5ECMP	Mini Project	ECE	-	-	42	18	60	3	50	50	100	2	
7.	AEC 5HS04	Research Methodology and IPR	ME, IM, CH	42	-	-	48	90	3	50	50	100	3	
8.	AEC ARAS	Attitude Related Analytical Skills	T&P	-	-	28	02	30	1½	50	50	100	1	
9.	HSMS SHS05	Environmental Studies	CV	28	-	-	32	60	3	50	50	100	2	
10. NCMC	SMC01	National Service Scheme (NSS)	NSS CO											
	SMC02	Physical Education (PE) (Sports and Athletics)	PEE							100	-	100	0	
	SMC03	Yoga	PEE											
	SMC04	NCC												
		<b>Total</b>								<b>550</b>	<b>450</b>	<b>1000</b>	<b>23</b>	
	AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)		40 hours community service to be documented and produced for the examination										

**Note:** HSMS: Humanity and Social Science and management Course IPCC: Integrated Professional Core Course, PCCL: Professional Core Course laboratory, EC: Professional Elective Course; PROJ: Project/Mini Project;

AEC: Ability Enhancement Course; NCMC: Non-Credit Mandatory Course, L: Lecture, T: Tutorial, P: Practical S

SDA: Skill Development Activity, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation.



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### B.E. in Electronics and Communication Engineering SCHEME OF TEACHING AND EXAMINATION (2023 Scheme) (w.e.f. 2025-26)

#### VI Semester

Sl. No.	Course and Course Code	Course Title	Teaching g/ Paper setting Dept.	Teaching hrs.					Examination			Total Credits (C) (Total hrs/30)	
				Class room Instruction (CI) (in hrs/sem)	Tutori al (in hrs/sem)	Lab Instruction (LI) (in hrs/sem)	Term work (TW) and Self Learning (SL) (TW+SL) (in hrs/sem)	Total No. of hrs/sem	Duration in hrs.	CIE Marks	SEE Marks		Total Marks
1.	PCC S6EC02	Digital VLSI Design	ECE	52	-	-	68	120	3	50	50	100	4
2.	IPCC S6EC102	Communication Systems – III	ECE	42	-	28	50	120	3	50	50	100	4
3.	PEC S6ECXX	Professional Elective Course - II	ECE	42	-	-	48	90	3	50	50	100	3
4.	OEC SOEXX	Open Elective Course – I	ECE	42	-	-	48	90	3	50	50	100	3
5.	PROJ S6ECP	Major Project Phase I	ECE	-	-	42	18	60	3	100	-	100	2
6.	PCCL S6ECL02	Digital VLSI Design Lab.	ECE	-	-	28	02	30	3	50	50	100	1
7.	HSMS SHS06	Soft Skills	T&P	-	-	-	-	-	-	100	-	100	0
8.	HSMS SHS07	Indian Knowledge System	ECE	15	-	-	-	15	-	100	-	100	0
		National Service Scheme (NSS)	NSS	-	-	-	-	-	-	-	-	-	-
		Physical Education (PE) (Sports and Athletics)	CO	-	-	-	-	-	-	100	-	100	0
9.	NCMC SMC02	Yoga	PED	-	-	-	-	-	-	-	-	-	-
		NCC	PED	-	-	-	-	-	-	-	-	-	-
		<b>Total</b>								550	250	800	17
	AAP	AICTE Activity Points (Applicable for both Regular and Lateral Entry students)		40 hours community service to be documented and produced for the examination									

Note: IPCC: Integrated Professional Core Course, PCC: Professional Core Course; PEC: Professional Elective Course; OEC: Open Elective Course; PROJ: Project Phase –I; PCCL: Professional Core Course laboratory; AEC: Ability Enhancement Course, SEC: Skill Enhancement Course; NCMC: Non Credit Mandatory Course; L: Lecture, T: Tutorial, P: Practical S= SDA: Skill Development Activity, CIE: Continuous Internal Evaluation, SEE: Semester End Evaluation.

<b>Professional Elective Courses (PEC)</b>			
<b>Communication and Networking</b>			
1	Optical Fiber Communication	10	Edge and Cloud Computing
2	Advanced Multimedia	11	Modeling & Data Networks
3	Satellite Communication	12	Software Defined Networks
4	RF & Microwave Circuit Design	13	Adhoc Wireless Networks
5	Error Control Coding	14	Wireless Sensor Networks
6	Advanced Wireless Communication	15	Radar Systems for Autonomous Driving
7	MIMO wireless Communication	16	Introduction to Quantum Information and Computing
8	Computational Electromagnetics	17	Modern Wireless Standards
9	Optical Networks	18	Integrated Sensing and Communications

<b>Signal Processing</b>			
19	Advanced Signal Processing	25	Medical Image Processing
20	Digital Image Processing	26	Data Science
21	Speech Processing	27	Deep Learning
22	DSP Algorithms & Architecture	28	Machine Learning
23	Wavelet Transforms	29	Computer Vision
24	Artificial Neural Networks	30	Speech Technology
		31	Deep Learning for Computer Vision

<b>Microelectronics</b>			
32	Low Power VLSI Design	36	Smart materials and Smart systems
33	Analog and Mixed Mode VLSI design	37	Compound semiconductor devices and applications
34	ASIC Design	38	System Verilog
35	VLSI Testing and Verification		

<b>Embedded Systems</b>			
39	System Programming & Operating System	44	Real Time Systems
40	Advanced Computer Architecture	45	Embedded System Design
41	Parallel Processing & Distributed Systems	46	System on Chip
42	Sensors for Biomedical applications	47	Automotive Electronics
43	Applied Embedded Systems	48	Automotive Embedded Systems

**Suggested flow (Stream wise) of Professional Electives****Embedded Systems**

<b>Professional Elective - I V sem</b>	<b>Professional Elective - II VI sem</b>	<b>Professional Elective - III VII sem</b>
System On Chip	Automotive Embedded system	Parallel processing & Distributed system
Advanced Computer Architecture	Applied Embedded System	Real Time System
Automotive Electronics	System programming and Operating System	
Embedded System design	Sensors for Biomedical Applications	

**Communication**

<b>Professional Elective - I V sem</b>	<b>Professional Elective - II VI sem</b>	<b>Professional Elective - III VII sem</b>
Optical Fiber Communication	Advanced Multimedia	Error Control Coding
Satellite Communication	RF & Microwave Circuit Design	Advanced Wireless Communication
Linear Algebra and its Application	Radar for Autonomous Applications	Modern Wireless Standards
Computational Electromagnetics	-----	MIMO Wireless Communication
		Integrated Sensing and Communications

**Networking**

<b>Professional Elective - I V sem</b>	<b>Professional Elective - II VI sem</b>	<b>Professional Elective - III VII sem</b>
Optical Networks	Edge and Cloud Computing	Software Defined Networks
	Modeling & Data Network	Adhoc Wireless Sensor Networks
		Wireless Sensor Networks

**Signal Processing**

<b>Professional Elective-I V</b>	<b>Professional Elective-II VI</b>	<b>Professional Elective-III VII</b>
Digital Image Processing	DSP Algorithms and Architecture	Wavelet Transforms
Speech Processing	Medical Image Processing	Data Science
Machine Learning	Artificial Neural Networks	Computer Vision
	Deep Learning	Deep Learning for Computer Vision
	Advanced Signal Processing	
	Speech Technology	

**Microelectronics**

<b>Professional Elective-I V</b>	<b>Professional Elective - II VI</b>	<b>Professional Elective-III VII</b>
System Verilog	VLSI Testing and verification	Analog and mixed mode VLSI Design
Compound Semiconductors and Devices	Smart materials and smart systems	Low power VLSI Design
	ASIC design	

**Subjects from I year to IV year in the following four streams**

<b>Stream</b>	<b>I/II Sem</b>	<b>III/IV Sem</b>	<b>V/VI Sem</b>	<b>VII/VIII Sem</b>	<b>Electives</b>
<b>Microelectronics</b>	<ul style="list-style-type: none"> <li>• Basic Electronics</li> </ul>	<ul style="list-style-type: none"> <li>• Analog Electronic Circuits</li> <li>• Digital Electronic Circuits</li> <li>• Electric Circuit Analysis</li> <li>• Control Systems</li> <li>• VLSI Process Technology</li> </ul>	<ul style="list-style-type: none"> <li>• Digital VLSI Design</li> </ul>	<ul style="list-style-type: none"> <li>• Synthesis and Timing Analysis</li> </ul>	<ul style="list-style-type: none"> <li>• Low Power VLSI</li> <li>• Smart Materials and Smart System</li> <li>• Analog and Mixed mode VLSI Design</li> <li>• ASIC Design</li> <li>• VLSI Testing and Verification</li> <li>• Sensors for Biomedical Applications</li> </ul>
<b>Signal Processing</b>		<ul style="list-style-type: none"> <li>• Mathematics for Signal Processing</li> <li>• Random Process</li> </ul>	<ul style="list-style-type: none"> <li>• Digital Signal Processing</li> </ul>		<ul style="list-style-type: none"> <li>• Advanced Signal Processing</li> <li>• Medical Image Processing</li> <li>• Digital Image Processing</li> <li>• Data Science</li> <li>• Speech Processing</li> <li>• Artificial Neural Networking</li> <li>• Machine Learning</li> <li>• Deep Learning</li> </ul>

<b>Stream</b>	<b>I/II Sem</b>	<b>III/IV Sem</b>	<b>V/VI Sem</b>	<b>VII/VIII Sem</b>	<b>Electives</b>
<b>Communication and Networking</b>		<ul style="list-style-type: none"> <li>• Fields, Lines and Waves</li> <li>• Communication System-I</li> </ul>	<ul style="list-style-type: none"> <li>• IoT &amp; Network Technology</li> <li>• Communication Systems-II</li> <li>• Communication Systems-III</li> </ul>	<ul style="list-style-type: none"> <li>• Cryptography and network security</li> </ul>	<ul style="list-style-type: none"> <li>• Error Control Coding</li> <li>• Optical Fiber Communication</li> <li>• Edge and Cloud Computing</li> <li>• Satellite Communication</li> <li>• Software Defined Networks</li> <li>• RF and Microwave Circuit Design</li> <li>• Radars system for Autonomous Driving</li> <li>• MIMO Wireless communication</li> <li>• Advanced Multimedia</li> <li>• Introduction to Quantum Information and Computing</li> </ul>
<b>Embedded Systems</b>	<ul style="list-style-type: none"> <li>• Introduction to IoT</li> </ul>	<ul style="list-style-type: none"> <li>• Computer Organization and Architecture</li> <li>• ARM Microcontroller</li> </ul>			<ul style="list-style-type: none"> <li>• Embedded System Design</li> <li>• Automotive Embedded system Design</li> <li>• Advanced Computer Architecture</li> <li>• System on Chip</li> </ul>

# **V SEM SYLLABUS**

## IOT AND NETWORK TECHNOLOGY

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: S5EC01	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand the fundamental concepts of computer network technology.
2. Describe the data communication aspects in computer networks.
3. Learn the protocols related to data link layer and network layer.
4. Explore IoT framework using Raspberry Pi.

### UNIT I

**Introduction:** OSI model, TCP/IP model, comparison.

**Physical layer:** Topology, Line configuration or Type of Connection, Data flow, Manchester encoding, Synchronous and asynchronous TDM.

**Data link layer:** Flow control protocols: stop and wait, sliding window (go back n and selective repeat).

**9 Hours**

### UNIT II

**Data Link Control:** HDLC – Types of frames, Information frame.

**Multiple access protocols:** Random access protocols - Slotted ALOHA, CSMA/CD, CSMA/CA. Controlled access protocols - Reservation, Polling, Token passing.

**8 Hours**

### UNIT III

**Network Layer:** Logical addressing: Ipv4 addresses, Ipv6 addresses, Internet Protocol: Ipv4 and IPv6 header format, Transition from Ipv4 to Ipv6.

**Routing Algorithms:** Dynamic routing algorithms - Distance Vector Routing, Link State Routing.

**8 Hours**

**UNIT IV**

**Wired LAN:** Ethernet, IEEE standards, Standard Ethernet, IEEE 802.3

**Wireless LAN:** IEEE 802.11, Bluetooth, Connecting LANs, Backbone networks and virtual LANs.

**Internet of Things:** Introduction, Definition & Characteristics of IoT, Physical design of IoT, Logical design of IoT.

**8 Hours****UNIT V**

**IoT enabling Technology:** WSN, cloud computing, communication protocols, AI for Network Management, IoT levels and deployment templates.

**IoT Physical device and Endpoints:** Introduction to Raspberry Pi, board architecture, OS on Raspberry Pi, Raspberry Pi interfaces, Programming Raspberry Pi with python.

**9 Hours****TEXT BOOKS**

1	Behrouz A Forouzan	Data Communications and Networking, McGraw Hill, 5 <sup>th</sup> Edition, 2017.
2	Arshdeep Bahga, Vijay Madisetti	Internet of Things- a Hands on Approach, 1 <sup>st</sup> Edition, 2015.

**REFERENCE BOOKS**

1	William Stallings	Data and Computer Communication, Pearson Education, 10 <sup>th</sup> Edition, 2017.
2	Alberto Leon Garcia	Communication Networks: Fundamental Concepts & Key Architectures, TMH, 10 <sup>th</sup> Edition, 2004.

**E-RESOURCES**

1	<a href="https://onlinecourses.nptel.ac.in/noc22_cs19">https://onlinecourses.nptel.ac.in/noc22_cs19</a>
2	<a href="https://nptel.ac.in/courses/106105081">https://nptel.ac.in/courses/106105081</a>
3	<a href="https://onlinecourses.nptel.ac.in/noc22_cs53">https://onlinecourses.nptel.ac.in/noc22_cs53</a>
4	<a href="https://www.juniper.net/us/en/research-topics/what-is-ai-for-networking.html">https://www.juniper.net/us/en/research-topics/what-is-ai-for-networking.html</a>
5	<a href="https://www.cisco.com/c/en/us/solutions/artificial-intelligence/artificial-intelligence-machine-learning-in-networking.html">https://www.cisco.com/c/en/us/solutions/artificial-intelligence/artificial-intelligence-machine-learning-in-networking.html</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Describe OSI reference model, TCP/IP suite and analyze framing and flow control techniques.
CO2	Demonstrate error control mechanisms and evaluate multiple access protocols.
CO3	Analyze routing algorithms and evaluate the network performance.
CO4	Compare frame formats of IEEE standards for wired and wireless LANs.
CO5	Apply the knowledge of computer network onto IoT paradigm and analyze IoT physical devices.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	3			2							1	
	CO2	3	2			1			1				1	1
	CO3	3	2	1		1			2				1	1
	CO4	3	2										1	
	CO5	3	2	1		1			2				1	1

## DIGITAL SIGNAL PROCESSING

Contact Hours/ Week:	: 3+0+2	Credits:	4
Total Lecture Hours:	: 42	CIE Marks:	50
Total Practical Hours:	: 28	SEE Marks:	50
Sub. Code:	: S5ECI01		

### Course objectives:

This course will enable students to:

1. Represent and analyze information from analog world to digital domain.
2. Discuss algorithms to reduce computations involved in converting the signal from time to frequency domain and vice-versa.
3. Prepare the students to design and realize digital filters for applications in real world.

### UNIT I

**Introduction to Digital Signal Processing:** Basic elements of a Digital Signal Processing system, Concept of frequency in continuous time and discrete-time domain Importance of Sampling (Section 1.4), Frequency ranges of natural signals.

**Discrete Fourier Transform:** Introduction, Fourier representations of finite-duration sequences, Properties of DFT, Linear convolution using DFT, Computation of Circular convolution, Spectral analysis using DFT.

**Efficient Computation of DFT – Fast Fourier Transform Algorithms.**

**9 Hours**

### UNIT II

**Frequency Domain Analysis of LTI Systems:** Frequency Response of a system with a rational system function, Computation of frequency response function, Ideal Filter Characteristics, Lowpass, Highpass, and Band pass filters, Digital Resonators, Notch Filters, Comb Filters, All pass filters, Digital sinusoidal oscillators, Invertibility of linear time invariant systems, Minimum-phase, maximum phase and mixed phase system, System identification and deconvolution.

**8 Hours**

**UNIT III**

**Design of FIR Filters:** Issues in filter design, importance of linear phase, Frequency response of linear phase FIR filters, Locations of zeros of FIR filters, Design techniques of FIR filters- Windowing method and Frequency sampling method.

**Applications of FIR filters:** Design of Hilbert transformer and Ideal differentiators.

**8 Hours****UNIT IV**

**Design of IIR filters:** Elementary properties of IIR filters, Techniques for determining IIR filter coefficients, Frequency transformations in analog domain. Digital filter design from continuous time filters- Impulse invariant technique and Bilinear transformation methods. Comparison of FIR and IIR filters. (Butterworth and Chebyshev Filter tables can be used)

**8 Hours****UNIT V**

**Basic structures for FIR systems:** Direct, Cascade, Linear Phase and Frequency sampling structures.

Basic structures for IIR systems: Direct, Cascade, and Parallel structures.

**Applications:** Filtering of long sequences: Overlap-save method and overlap-add method, DCT for Image Compression, DTMF Generation and Detection, Musical sound processing: Single echo and multiple echo filters.

**9 Hours****TEXT BOOKS**

1	J. G. Proakis and D. G. Manolakis	Digital Signal Processing: Principles, Algorithms and Applications, PHI, 2022.
2	Alan V Oppenheim and Ronald W. Schaffer	Discrete-Time Signal Processing, PHI, 3 <sup>rd</sup> Edition, 2014.

**REFERENCE BOOKS**

1	S. Sanjit K. Mitra	Digital Signal Processing: A computer-Based Approach. TMH. 4 <sup>th</sup> Edition, 2013.
2	Lonnie C. Ludeman	Fundamentals of digital signal processing, John Wiley & Sons, 2009.

**E-RESOURCES**

1	<a href="https://ocw.mit.edu/courses/res-6-008-digital-signal-processing-spring-2011/video_galleries/video-lectures/">https://ocw.mit.edu/courses/res-6-008-digital-signal-processing-spring-2011/video_galleries/video-lectures/</a> , Prof. Alan Oppenheim, MIT	
2	<a href="https://nptel.ac.in/courses/117102060">https://nptel.ac.in/courses/117102060</a> , Prof. S C DuttaRoy, IIT Delhi	

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Represent and process information in digital domain as a function of time or frequency.
CO2	Characterize discrete time LTI systems in the frequency domain.
CO3	Design a digital FIR filter for a given specification.
CO4	Design a digital IIR filter for a given specification.
CO5	Implement discrete time systems and basic signal processing algorithms for applications in Communication and Signal Processing.

**Course Articulation Matrix**

		POs										PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	1			2			2	2		2	2	2
	CO2	3	1			2			2	2		2	2	2
	CO3	3	2	2		2			2	2		2	2	2
	CO4	3	2	2		2			2	2		2	2	2
	CO5	3		3		2			2	2		2	3	2

**Integrated Lab:**

Experiments using Python/Matlab

1. Spectral Analysis using Discrete Fourier Transform
2. Linear Filtering using Discrete Fourier Transform
3. Design of LTI systems by placing poles and zeros
4. Design of FIR Filters and verifications
5. Design of IIR Filters and verification
6. Design of graphic equalizer
7. DTMF Generation and Detection
8. Echo Generation

## COMMUNICATION SYSTEMS-II

Contact Hours/ Week:	: 3+0+2	Credits:	4
Total Lecture Hours:	: 42	CIE Marks:	50
Total Practical Hours:	: 28	SEE Marks:	50
Sub. Code:	: S5ECI02		

### Course objectives:

This course will enable students to:

1.	Analyze the Microwave Passive Devices such as Magic Tee, Circulator, and Directional Coupler using S- parameters.
2.	Design of various filters using Butterworth, Stepped impedance and Kuroda's identity using microstrip technology.
3.	Interpret the working of microwave passive devices and demonstrate their applications.
4.	Estimate various antenna parameters for an isotropic radiator and an isotropic antenna array.

### UNIT I

**Scattering Parameters and Planar Transmission Lines:** Introduction to Microwave Spectrum and Bands, Applications of microwaves; S matrix representation of Two-port & multi-port network, S-parameter properties (No proof), Smith Chart and Applications.

Microstrip line (geometry, design equations), Strip line, Slot lines, Co-Planar Wave Guide - geometry only.

**8 Hours**

### UNIT II

**Microwave Filters:** Design of Low Pass Filter using Butterworth filter, Stepped impedance and Kuroda's identity method

**Power Dividers:** Wilkinson Power Divider, 90° Branch Line Coupler, Solve Basic Transmission line problems and Single stub matching using Smith Chart.

**9 Hours**

**UNIT III**

**Antenna Basics:** Physical concept of radiation, Antenna Radiation Equation and Radiation; Basic antenna parameters: Radiation patterns, Beam area, Radiation intensity, Beam efficiency, Directivity, Gain, Aperture, Effective height, Radio communication link-FRIIS.

Transmission Formula, Antenna field zones, Polarization, Polar plots for Antenna Radiation Pattern.

**9 Hours****UNIT IV**

**Antenna arrays:** Introduction, Types of Arrays, Array of n-isotropic point sources of equal amplitude and spacing, Null directions (broadside case, End-fire case), and Directivity, Examples on sketching radiation pattern, Principle of Pattern Multiplication (Qualitative).

**8 Hours****UNIT V**

**Application Specific Antennas:** Microstrip Patch Antenna, Horn Antenna, Helical Antenna, Embedded Antenna, Antennas for ground penetrating radar (GPR), Embedded antennas;

**Introduction to Smart Antennas:** Need for smart antennas, overview, smart antenna configurations, architecture of smart antenna system, benefits, drawbacks, basic principles.

**8 Hours****TEXT BOOKS**

1	David M Pozar	Microwave Engineering, John Wiley & Sons, 3 <sup>rd</sup> Edition, 2005.
2	John D Kraus, Ronald J Marhefka, Ahmad S. Khan	Antennas and Propagation, Mc Graw Hill, 5 <sup>th</sup> edition, 2017.

**REFERENCE BOOKS**

1	Matthew N. O. Sadiku and S.V. Kulkarni	Principles of Electromagnetics, Oxford University Press, 6 <sup>th</sup> Edition, 2019.
2	Constantine A. Balanis	Antenna Theory- Analysis & Design, John Wiley & Sons, 4 <sup>th</sup> edition, 2016.

**E-RESOURCES**

1	<a href="https://nptel.ac.in/courses/108101112">https://nptel.ac.in/courses/108101112</a>
2	<a href="http://acl.digimat.in/nptel/courses/video/108105114/L22.html">http://acl.digimat.in/nptel/courses/video/108105114/L22.html</a>
3	<a href="https://www.youtube.com/results?search_query=all+about+electronics">https://www.youtube.com/results?search_query=all+about+electronics</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Demonstrate the working of Microwave passive devices by analyzing S-Matrix.
CO2	Design and Analyze Micro Strip Lines and Microwave Filters.
CO3	Design Power Divider Circuits using EDA tools.
CO4	Interpret the radiation pattern for array of antennas and deduce the Directivity of the array.
CO5	Design and analyze different application specific antennas.
CO6	Design and simulate antennas for various communication applications using MATLAB/SCILAB.

**Integrated Lab:****List of Experiments:****Microwave Experiments Using Keysight Technologies Advanced Design Systems (ADS)**

1. Design and Simulation of Low Pass Filter using Stepped Impedance Method
2. Design and Simulation of Low Pass Filter using Kuroda's identity
3. Design and Simulation of 90° Branch Line Coupler
4. Design and Simulation of 180° Hybrid Coupler

5. Design and Simulation of Wilkinson Power Divider for Equal and Unequal Power Division
6. Radiation pattern for Half wave Dipole antenna
7. Radiation pattern for isotropic antenna array
8. Design of microstrip patch antenna for Wi-Fi and cellular communication
9. Design of helical antenna for monofilar axial mode of operation
10. Design and analysis of rectangular horn antenna
11. Design and analysis of smart antennas

### Course Articulation Matrix

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2			1			1			1	2	1
	CO2	2	2			1			1			1	2	1
	CO3	2	2			1			1			1	2	1
	CO4	2	2			1			1			1	2	1
	CO5	2	2			1			1			1	2	1
	CO6	2	2			1			1			1	2	1

## IOT AND NETWORK TECHNOLOGY LAB

Contact Hours/ Week:	: 0+0+2	Credits:	1
Total Practical Hours:	: 28	CIE Marks:	50
Sub. Code:	: S5ECL01	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Implement the Error correction and detection techniques of Data link layer using C programming.
2. Implement the routing protocols of network layer using C programming.
3. Setup and simulate the wired and wireless LAN scenarios using network simulator.
4. Integrate the Raspberry Pi controller to Internet of Things (IoT) for sensor data acquisition.

### PART A (using C language)

1. Develop a program to perform byte stuffing and bit stuffing for a given data.
2. Develop a program to find the transmitted data with CRC code for the given bit stream and generator polynomial.
3. Develop a program for detecting an error in the received data using CRC for the given generator polynomial.
4. Develop a program to implement a shortest path routing algorithm for a given network graph and build a routing table for the given node.
5. Develop a program to encrypt and decrypt the given message by substitution method
6. Develop a program to encrypt and decrypt the given message by transposition method

### Part B: (Using IoT Evaluation board)

1. Develop a program on Raspberry pi to upload temperature and humidity data to thingspeak cloud.
2. Develop a program on Raspberry pi to publish temperature data to MQTT broker.

3. Develop a program on Raspberry pi to subscribe to MQTT broker for temperature data and print it.
4. Develop a program to create TCP server on Raspberry pi and respond with humidity data to TCP client when requested.

**Part C: Open- ended experiments:**

1. Develop a program on Raspberry pi to retrieve temperature and humidity data from thingspeak cloud.
2. Develop a program to create UDP server on Raspberry pi and respond with humidity data to UDP client when requested.
3. Simulate multiple access protocols using C/Python.
4. Develop a Node-RED application that collects data from an IoT device, processes it, and takes an action based on the processed data over the given scenario.
5. Simulate wired and wireless LANs using packet tracer.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply the knowledge of engineering fundamentals to design an algorithm for a given problem on computer networking.
CO2	Create, implement and test the algorithms for network protocols using C Programming.
CO3	Simulate and evaluate wired and wireless LAN using Network simulator.
CO4	Integrate sensors with the Raspberry Pi controller to IoT using various IoT Protocols.
CO5	Demonstrate the ability to provide efficient solutions for complex engineering problems in the area of embedded systems individually.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	3							1			1	
	CO2	3	3			2			1	1			1	1
	CO3	3	3			2			1	1			1	1
	CO4	3	2			2			1	1			1	1
	CO5	3	2	1		2			2	1			1	1

## RESEARCH METHODOLOGY AND IPR

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SHS04	SEE Marks:	50

### Unit-I

**RESEARCH METHODOLOGY:** Objectives and motivation of research - Types of research - Research approaches - Significance of research - Research methods verses methodology - Research and scientific method - Importance of research methodology - Research process - Approaches of investigation of solutions for research problem, data collection, analysis, interpretation, necessary instrumentations- Criteria of good research. Defining the research problem: Definition of research problem - Problem formulation - Necessity of defining the problem - Technique involved in defining a problem.

**8-Hours**

### Unit-II

**LITERATURE SURVEY AND DATA COLLECTION:** Importance of literature survey - Sources of information - Assessment of quality of journals and articles - Information through internet. Effective literature studies approaches, analysis, plagiarism, and research ethics. Data - Preparing, Exploring, examining and displaying. Referencing methods.

**8-Hours**

### Unit-III

**RESEARCH DESIGN AND ANALYSIS:** Meaning of research design - Need of research design - Different research designs - Basic principles of experimental design - Developing a research plan - Design of experimental set-up - Use of standards and codes. Overview of Univariate/Multivariate analysis, Hypotheses testing and Measures of Association. Presenting Insights and findings using written reports and oral presentation.

**9-Hours**

### Unit-IV

**INTELLECTUAL PROPERTY RIGHTS (IPR):** Nature of Intellectual Property: Patents, Designs, Trade and Copyright. Process of Patenting and Development: technological research, innovation, patenting, development. Role of WIPO and

WTO ni IPR establishments, Right of Property, Common rules of IPR practices, Types and Features of IPR Agreement, Trademark, Functions of UNESCO in IPR maintenance.

**8-Hours**

**Unit-V**

PATENT RIGHTS (PR): Patent Rights: Scope of Patent Rights. Licensing and transfer of technology. Patent information and databases. Geographical Indications. New Developments in IPR: Administration of Patent System, IPR of Biological Systems, Computer Software etc. Traditional knowledge Case Studies, IPR and IITs. Licenses, Licensing of related patents, patent agents, Registration of patent agents.

**9-Hours**

**Text Books:**

1.	Prof. Kothari C. R.	Research methodology: Methods and techniques, New Age International, 5th Edition, 2023. ISBN-13: 978-9389802559.
2.	R. Ganesan	Research Methodology for Engineers, MJP Publishers, Chennai, 2011.

**Reference Books:**

1.	Cooper Donald R, Schindler Pamela Sand Sharma JK	Business Research Methods", Tata McGraw Hill Education, 11 <sup>th</sup> Edition, 2012.
2.	Catherine J. Holland	Intellectual property: Patents, Trademarks, Copyrights, Trade Secrets, Entrepreneur Press, 2007.
3.	David Hunt, Long Nguyen, Matthew Rodgers	Patent searching: tools & techniques, Wiley, 2007.
4.	The Institute of Company Secretaries of India, Statutory body under an Act of parliament	Professional Programme Intellectual Property Rights, Law and practice, September 2013.
5.	Peter S. Menel Mark A. Lemley, Robert P. Merges	Intellectual Property in the New Technological-Vol.I Perspectives, 2021.
6.	Laura R. Ford	The Intellectual Property of Nations: Sociological and Historical Perspectives on a Modern Legal Institution Paperback -2021.

**Course Outcomes:**

Upon completion of this course the student will be able to:

<b>CO1</b>	:	Describe the research process & formulate research problem.
<b>CO2</b>	:	Perform literature review, manage data & practice research ethics.
<b>CO3</b>	:	Practice basic principles of experimental design, use standard codes and carry out research analysis.
<b>CO4</b>	:	Distinguish between types of innovation, describe patenting procedure, maintenance and role of IPR establishments.
<b>CO5</b>	:	Identify the significance of patent rights, licensing, technology transfer & manage patenting system.

**CO – PO Mapping:**

CO	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PS O1	PS O2	PS O3	PS O4
<b>CO1</b>		3	2								2				
<b>CO2</b>		3	2				3				2				
<b>CO3</b>		3	3								2				
<b>CO4</b>		3	2								2				
<b>CO5</b>		3	2								2				

## ENVIRONMENTAL STUDIES

Contact Hours/ Week:	: 2-0-0	Credits:	2
Total Lecture Hours:	: 28	CIE Marks:	50
Sub. Code:	: SHS05	SEE Marks:	50

### COURSE OBJECTIVES:

This course will enable students to:

- 1 Problems of depletion of natural resources due to deforestation, agricultural practices, and adverse environmental effects, pesticides, soil erosion, mining.
- 2 Different types of energy- renewable, non-renewable and energy conservation, impact of environmental pollution on water quality, air quality, soil pollution and noise pollution.
- 3 Solid waste management- disposal, treatment of different types of solid waste including MSW, e- waste, biomedical waste, societal impact of environmental issues- ozone layer depletion, GHG effects, water conservation and harvesting and environmental protection & acts

### UNIT I

Introduction:

- Components of Environment and their interactions
- Ecology, Ecosystem and types Natural

Resources:

- Forest Resources-Deforestation, Causes of deforestation, Environmental effects of deforestation and solutions
- Water resources, World's water reserves, Hydrological cycle
- Land resources, Land degradation. Soil erosion, Causes and prevention, Soil conservation and its types
- Numerical problems on rainfall & runoff

**6 Hours**

**UNIT II**

Energy and resources:

- Types of Energy-Renewable, Non renewable & sustainable energy & their advantages and disadvantages.
- Renewable energy sources- Solar energy, Wind energy, Tidal energy, Ocean thermal energy. Geothermal energy, Hydroelectric power, Biomass energy, Hydrogen energy, Thermal power- environmental impacts
- Conservation of energy
- Numerical problems on Solar energy, Wind power

**6 Hours****UNIT III**

Environmental pollution: • Sources of pollution- Natural and anthropogenic sources  
 • Pollutants - Classification & their effects on environment • Air Pollution - Composition of clean air, Sources of air pollution, Effect of air pollution on human health and climate • Water quality – Potable water, Wholesome water, Sources of water pollution Polluted water & Contaminated water• Common impurities in water(physical, chemical and bacteriological), Effects of impurities on human health  
 • Soil Pollution – Sources, effects, and its control.  
 Noise pollution- Sources of noise, Effects on human health & its control Numerical problems on pH, hardness of water, noise pollution.

**6 Hours****UNIT IV**

Solid Waste Management

- Refuse, Garbage, Rubbish, Ash, types of solid waste
- Necessity of safe disposal, Impacts on human health and environment
- Classification of solid wastes- Quantity and composition of MSW, Collection of solid waste- methods
- Disposal of solid waste-Sanitary land-fill
- E-waste- Problems and solutions
- Biomedical waste-Impacts on human health, storage, treatment methods and disposal
- Numerical problems on moisture content, density & proportioning of land fill

**5 Hours**

**UNIT V**

Sustainable development:

- Issues on energy utilization, water conservation, concept of 3 R's, Rain water harvesting- methods.
- Global environmental issues: Population growth, Urbanization, Global warming, Acid rains, Ozone layer depletion & controlling measures.
- Environmental acts, Regulations, Role of state & central governments.
- Numerical problem on carbon foot print & rainwater harvesting.

**5 Hours****TEXT BOOKS:**

1	Joseph, B	Environmental Studies (2009), India: Tata McGraw-Hill. ISBN: 9781283922524.
2	Tripathi, A. K	Environmental Studies(2016), India: Energy and Resources Institute. ISBN:9788179935828.

**REFERENCES:**

1	Erach Bharucha	Environmental studies for Undergraduate Courses, 1 <sup>st</sup> Edition, University Press, (2013).
2	Santhosh Kumar Garg	Environmental Science and Engineering Ecology and Environmental Studies, Khanna Publishers, (2015), ISBN-10: 8174092188 ISBN-13: 978-8174092182.

**COURSE OUTCOMES:** Upon completion of this course the student will be able to:

CO1	Describe the importance of forestation, effects of deforestation, land degradation, adverse effects of mining on environment, using the principles of natural sciences compute the runoff from rainfall & estimates the conservation of water for beneficial use of humans.
CO2	Describe the Renewable sources of energy and formulate, review literature, calculate power potential of solar & wind energy by using the principles of natural sciences.
CO3	Describe the effects of pollution of air, water, soil & noise on humans and environment, identify & analyze the pollution problems related to air, water, soil & noise and quantify pollution levels & draw valid inferences using the principles of engineering sciences

CO4	Describe Impact of solid waste on human health and environment, its safe disposal. Use population data & compute percapita solid waste generation, land area requirement for sanitary landfill.
CO5	Describe the sustainable development, its importance, current global environmental issues, Present state & central governments protection acts, compute carbon foot print using data(vehicles/industries) & asses its impact on environment.

<b>CO-PO Mapping:</b> 1=> Low, 2=> Medium, 3 => Strong mapping															
	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3	PSO4
CO1						2									
CO2						2									
CO3						2									
CO4						2									
CO5						2									

# **VI SEM SYLLABUS**

## COMMUNICATION SYSTEMS-III

Contact Hours/ Week:	: 3+0+2	Credits:	4
Total Lecture Hours:	: 42	CIE Marks:	50
Total practical hours :	: 28	SEE Marks:	50
Sub. Code:	: S6ECI01		

### Course objectives:

This course will enable students to:

1.	Learn the cellular concept and traffic theory.
2.	Understand challenges in wireless communication and fading in wireless channel.
3.	Learn source encoding and decoding techniques.
4.	Learn channel encoding and decoding techniques.

### UNIT I

**OVERVIEW OF WIRELESS COMMUNICATION:** The Cellular Concept - System Design Fundamentals: Introduction, Frequency Reuse, Channel Assignment Strategies, Handoff Strategies, Interference and System Capacity, Trunking and Grade of Service, Improving Coverage & Capacity in Cellular Systems.

**9 Hours**

### UNIT II

**WIRELESS CHANNEL:** The wireless communication environment, Modelling of wireless channel, System model for narrowband signals, Rayleigh fading wireless channel, Intuition for BER in a fading channel, Channel estimation in wireless systems. Diversity in Wireless Communications: Multiple Receive Antenna system model, Symbol detection in multiple antenna systems, Diversity Order, Coherence bandwidth in wireless communications, Relation between ISI and coherence bandwidth, Doppler fading in wireless systems, Doppler impact on a wireless channel, Coherence time of the wireless channel.

**9 Hours**

**UNIT III**

**TECHNOLOGIES FOR WIRELESS COMMUNICATION:** Introduction to CDMA, Basic CDMA mechanism, spreading codes based on pseudo-noise sequences. Introduction to OFDM, Subcarrier concept, OFDM signal generation, IFFT/FFT operations in OFDM, Addition of cyclic prefix, End-to-End system model for OFDM. Introduction to MIMO, MIMO system.

**8 Hours****UNIT IV**

**SOURCE CODING:** Uncertainty, Information and Entropy, Source Coding Theorem, Huffman Coding, Discrete memory less Channels, Mutual Information, Channel Capacity, Channel Coding Theorem, Channel Capacity Theorem.

**8 Hours****UNIT V**

**CHANNEL CODING:** Types of Codes, Linear Block Codes, Cyclic Codes – Generator polynomial, Parity Check Polynomial, Encoding, Syndrome Calculation, Algebraic Structure, Convolution Coding, Convolution encoder in time and transform domain, Viterbi decoding.

**8 Hours****TEXT BOOKS**

1	Aditya K Jagannatham	Principles of Modern Wireless Communication Systems, Mc. Graw-Hill Education (India), 2019.
2	Simon Haykin	Digital Communications, John Wiley, 2017.

**REFERENCE BOOKS**

1	Andreas, F. Molisch	Wireless Communications, John Wiley & Sons, 2012,
2	Theodore S. Rappaport	Wireless Communications-Principles and Practice, Pearson Education, 2 <sup>nd</sup> Edition, 2002.
3	Shu Lin and Daniel J. Costello	Error Control Coding, Pearson Education Ltd., 2011.

**E-RESOURCES**

1	<a href="https://nptel.ac.in/courses/117104115">https://nptel.ac.in/courses/117104115</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply cellular concepts and traffic theory to evaluate the signal reception performance in a cellular network.
CO2	Characterize a wireless channel using different models and compare the performances.
CO3	Analyse 3G (CDMA). 4G (OFDM) and 5G (MIMO) technologies used in wireless communication systems.
CO4	Analyze the information characteristics of a discrete source and channels.
CO5	Apply different error control coding and decoding techniques to design and develop a communication channel.

**Course Articulation Matrix**

		POs										PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2						2	2			2	2
	CO2	3	2			1			2	2			2	2
	CO3	3	2						2	2			2	2
	CO4	3	2						2	2			2	2
	CO5	3	2			1			2	2			2	2

**Integrated Lab :**

List of Experiments:

1. Study of cellular concept and system capacity
2. Characterization of wireless channel
3. Technologies for wireless communication : study of transmitter and receiver of CDMA and OFDM
4. Source coding : Huffman coding
5. Channel capacity
6. Channel coding

## DIGITAL VLSI DESIGN

Contact Hours/ Week:	: 4+0+0	Credits:	4
Total Lecture Hours:	: 52	CIE Marks:	50
Sub. Code:	: S6EC01	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Analyze the impact of fabrication technologies: Methods for optimizing the circuit layouts.
2.	Design and implement MOS combinational circuit.
3.	Design and implement sequential MOS system by considering specifications.
4.	Analyze the impact of RC effect in post simulation.

### UNIT I

#### VLSI Design Flow:

Design Specification, Design Entry, Functional Simulation, Planning, Placement and Routing.

MOSFET I-V characteristics, Current equation, C-V characteristics, Simple capacitance model, Detailed MOS Gate Capacitance Model, MOS diffusion capacitance model.

#### Combinational Circuit Design:

CMOS Inverter, CMOS Logic circuits, NAND Gate, NOR Gate, Compound Gates(full adder, parallel adder), Pass Transistors and Transmission Gates, Tristate buffer, Multiplexers.

#### DC Transfer Characteristic:

CMOS Inverter DC Characteristics, Beta ratio effect, Noise margin, Pass transistor characteristics, NAND and NOR DC characteristics.

**11 Hours**

### UNIT II

#### CMOS Processing Technology:

Introduction, CMOS Technologies: Wafer Formation, Photolithography, Well and Channel Formation, Silicon Dioxide, Isolation, Gate Oxide, Gate and Source/Drain Formations, Contacts and Metallization, Passivation, Metrology.

**Layout Design Rules:** Well rules, transistor rules, contact rules, metal rules, via rules, other rules.

**Layout design:** CMOS Inverter, Complex CMOS logic gates by using Euler graph.

CMOS process enhancement: FINFETs, Gate all around FETs.

**10 Hours**

### UNIT III

**Circuit characterization and performance estimation:**

Introduction, delay estimation: Switch level RC delay models, linear delay model, logical effort, parasitic delay.

**Logical effort and transistor sizing:** delay in a logic gate, delay in multistage logic networks, choosing the best number of stages.

**Power dissipation:** static dissipation, dynamic dissipation, low power design. Interconnect: resistance, capacitance, delay, crosstalk.

**11 Hours**

### UNIT IV

Circuit Families: Ratioed Circuits: Pseudo nMOS, Dynamic Circuits; Domino Logic, Dual rail logic networks: Cascode Voltage Switch Logic and Complementary Pass-Transistor Circuits.

BiCMOS logic circuits: Basic BiCMOS circuit, static behavior, switching delay in BiCMOS logic circuits, BiCMOS applications.

**Non ideal Effects:** Velocity saturation and Mobility Degradation, Channel Length Modulation, Body effect, Sub threshold conduction, Junction Leakage, Tunneling and Temperature dependence.

**10 Hours**

### UNIT V

**Data path Subsystem:**

Carry-Propagate Adder, One/Zero Detectors, Comparators, Boolean Logical Operations using MUX, Unsigned array multiplication.

**Sequential MOS Logic Circuits:**

Behavior of Bistable element, SR Latch Circuit, Clocked latch and Flip Flop Circuits, CMOS D-Latch and Edge Triggered Flip-Flop.

**Semiconductor memories:**

Introduction, dynamic random access memory, static random access memory.

**10 Hours**

**TEXT BOOKS**

1	Neil H.E. Weste, David Money Harris	CMOS VLSI Design: A Circuits and Systems Perspective, Pearson, 4 <sup>th</sup> Edition, 2017.
2	Sung MO Kang, Yusuf Leblebici, Chulwoo Kim	CMOS Digital Integrated Circuits: Analysis and Design, Tata McGraw Hill, 4 <sup>th</sup> Edition, 2014.

**REFERENCE BOOKS**

1	Douglas A. Pucknell & Kamran Eshraghian	Basic VLSI Design, PHI, 3 <sup>rd</sup> Edition, 2005.
2	John P. Uyemura	Introduction to VLSI Circuits and Systems, John Wiley, 2002.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze transient and DC characteristics of CMOS circuits.
CO2	Describe the various processing steps for an integrated circuits and apply $\lambda$ -based design rules to construct optimized layout.
CO3	Estimate the delay and analysis of power dissipation in CMOS circuits.
CO4	Compare advanced MOS circuit families, analyze the secondary effects of MOSFETs.
CO5	Analyze arithmetic building blocks, sequential MOS circuits, and memory cells.

**Course Articulation Matrix**

	POs											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2			2			1	1		1	2	1
CO2	3	2			2			1	1		1	2	1
CO3	3	2			2			1	1		1	2	1
CO4	2	2			1			1	1		1	2	1
CO5	3	1			2			1	1		1	2	1

## DIGITAL VLSI DESIGN LAB

Contact Hours/ Week:	: 0+0+2	Credits:	1
Total Lecture Hours:	: 28	CIE Marks:	50
Sub. Code:	: S6ECL01	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Learn realization of Boolean expressions using different MOS families.
2.	Understand design of CMOS circuit and layout to match the given specifications.

### List of experiments:

1. Realization of Boolean expressions using pass transistors
2. Transient analysis of CMOS Logic circuit for the given Boolean expressions
3. Transient analysis of transmission gates, and realization of multiplexers
4. Design of Master slave D and T – flip flops using CMOS
5. CMOS full adder and Parallel adder
6. Realization of Pseudo-nMOS, Dynamic, and Domino circuits for the given Boolean expressions
7. Transient and DC Analysis of CMOS Inverter for the given specifications and parametric analysis, layout design of CMOS inverter and post simulation
8. Transient and DC Analysis of CMOS NAND2, layout design and post simulation
9. Transient and DC Analysis of CMOS NOR2, and optimized layout design and post simulation

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply the Boolean laws to the given expression to design and simulate CMOS circuit.
CO2	Compare the logic circuits realized using pass transistors, Transmission gates, Pseudo-nmos, Dynamic, and Domino with respect to area, delay and logic levels.
CO3	Design combinational and sequential CMOS circuits and perform the transient analysis.
CO4	Design CMOS circuits and draw layouts, back annotate and analyze.

**Course Articulation Matrix**

	POs											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
CO1	3	2	1		2			1	1			2	1
CO2	3	2	1		2			1	1			2	1
CO3	3	2	1		2			1	1			2	1
CO4	2	2	1		2			1	1			2	1

## INDIAN KNOWLEDGE SYSTEMS

Contact Hours/ Week:	: 1+0+0	Credits:	0
Total Lecture Hours:	: 15	CIE Marks:	100
Sub. Code:	: SHS07		

### Course objectives:

This course will enable students to:

1.	Rejuvenate and mainstream Indian Knowledge Systems by integrating it into the fabric of education research ecosystem.
2.	Bridge the gap between Traditional Indian Knowledge Systems and contemporary knowledge systems.
3.	Make a tangible difference to the contemporary world by mainstreaming Indian Knowledge Systems.

### UNIT I

#### Introduction to Indian Knowledge Systems (IKS):

**Overview:** Need of IKS, Importance of ancient knowledge. Defining IKS, History of IKS, Indian philosophical systems- Development and unique features, Yoga-darsana, Number system in India-Historical evidence, salient features of Indian number system, the concept of zero and its importance.

**Reference book- 1 :** 1.1; 1.2; 1.5; 3.1; 3.3.2; 6.1; 6.2; 6.2.1

**5 Hours**

### UNIT II

#### Fundamental concepts in Science in IKS:

**Knowledge:** Framework and classification. The knowledge triangle. Prameya – A Vaisesikan approach to physical reality. Dravyas – the constituents of physical reality. Attributes – the properties of substances. Unique aspects of Indian Mathematics. Great Mathematicians and their contributions. Arithmetic. Square of a number. Unique aspects of Indian astronomy.

Elements of Indian calendar. Pancanga – the Indian calendar system.

**Reference book- 1:** 7.1; 7.2; 7.2.1; 7.2.2; 8.1; 8.2; 8.3; 8.3.1; 9.1; 9.4; 9.6.

**5 Hours**

**UNIT III****Humanities and Social sciences in IKS:**

Ayurveda-Definition of health, Tri-dosas - Relationship to health, yoga way of life –relevance to health and wellness, Indian approach to psychology, The tri-guna system, The body-mind- intellect – consciousness complex, consciousness- the true nature of an individual, Arthasastra- Governance and administration, the Kautilyan state.

**Reference book- 1:** 13.1; 13.2;13.4;13.5; 13.6; 13.7; 13.8;14.1;14.2

**5 Hours****TEXT BOOKS**

1	B Mahadevan, Vinayak Rajat Bhat, Nagendra Pavana R N	Introduction to Indian Knowledge System- concepts and applications, PHI Learning Private Ltd, ISBN-978-93- 91818-21-0, 2022.
2	Amit Jha	Traditional Knowledge System in India, Atlantic Publishers and Distributors (P) Ltd., ISBN-13: 978- 8126912230, 2009.
3	Kapil Kapoor, Avadesh Kumar Singh	Knowledge Traditions and Practices of India, DK Print World (P) Ltd., Vol. 1, ISBN 81-246-0334, 2005.

**Suggested Web Links:**

1	<a href="https://www.youtube.com/watch?v=LZP1StpYEPM">https://www.youtube.com/watch?v=LZP1StpYEPM</a>
2	<a href="http://nptel.ac.in/courses/121106003/">http://nptel.ac.in/courses/121106003/</a>
3	<a href="http://www.iitkgp.ac.in/department/KS;jsessionid=C5042785F727F6EB46CBF432D7683B63">http://www.iitkgp.ac.in/department/KS;jsessionid=C5042785F727F6EB46CBF432D7683B63</a> (Centre of Excellence for Indian Knowledge System, IIT Kharagpur)
4	<a href="https://www.wipo.int/pressroom/en/briefs/tk_ip.html">https://www.wipo.int/pressroom/en/briefs/tk_ip.html</a>
5	<a href="https://unctad.org/system/files/official-document/ditcted10_en.pdf">https://unctad.org/system/files/official-document/ditcted10_en.pdf</a>
6	<a href="http://nbaindia.org/uploaded/docs/traditionalknowledge_190707.pdf">http://nbaindia.org/uploaded/docs/traditionalknowledge_190707.pdf</a>
7	<a href="https://unfoundation.org/what-we-do/issues/sustainable-development-goals/?gclid=EAIaIQobChMIInp-Jtb_p8gIVTeN3Ch27LAmPEAAAYASAAEgIm1vD_BwE">https://unfoundation.org/what-we-do/issues/sustainable-development-goals/?gclid=EAIaIQobChMIInp-Jtb_p8gIVTeN3Ch27LAmPEAAAYASAAEgIm1vD_BwE</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyse the continuous unbroken knowledge traditions of Bhārata since time immemorial.
CO2	Recognize the relevance of traditional knowledge in science
CO3	Recognize the relevance of traditional knowledge in Humanities and Social sciences

**Course Articulation Matrix**

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11
CO1	-	-	-	-	-	1	1	-	-	-	1
CO2	2	-	-	-	-	2	1	-	-	-	2
CO3	1	-			-	-	-	-	-	-	2

## PROFESSIONAL ELECTIVE COURSES (PEC)

### I. COMMUNICATION AND NETWORKING:

#### OPTICAL FIBER COMMUNICATION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE01	SEE Marks:	50

#### Course objectives:

This course will enable students to:

- |    |   |
|----|---|
| 1. | Understand basics of optical communication system   |
| 2. | Understand the propagation of light through optical fiber waveguide and the losses that occur in the optical fiber  |
| 3. | Acquire knowledge on the engineering problems of optical communication like receiver characteristics, optical links and multiplexing techniques using WDM concepts. |

#### UNIT I

**OVERVIEW OF OPTICAL FIBER COMMUNICATION:** Introduction, Historical development, general system, advantages, disadvantages, and applications of optical fiber communication, optical fiber waveguides, Ray theory, cylindrical fiber, single mode fiber, cutoff wave length, Mode- field diameter.

**8 Hours**

#### UNIT II

**TRANSMISSION CHARACTERISTICS OF OPTICAL FIBERS:** Introduction, Attenuation, absorption, scattering losses, bending loss, dispersion, Intra model dispersion, Inter model dispersion.

**8 Hours**

#### UNIT III

**OPTICAL SOURCES AND DETECTORS:** Introduction, LED's, LASER diodes, Photo detectors, Photo detector noise, Response time, double hetero structure Photo diodes, comparison of photo detectors.

**OPTICAL RECEIVER:** Introduction, Optical Receiver Operation, receiver sensitivity, quantum limit, eye diagrams, coherent detection, burst mode receiver, operation, Analog receivers.

**8 Hours**

**UNIT IV**

**ANALOG AND DIGITAL LINKS:** Analog links – Introduction, overview of analog links, CNR, multichannel transmission techniques, RF over fiber, key link parameters, Radio over fiber links, microwave photonics.

**Digital links** – Introduction, point-to-point links, System considerations, link power budget, resistive budget, short wave length band and transmission distance for single mode fibers, Power penalties, Modal noise and chirping.

**9 Hours****UNIT V**

**WDM CONCEPTS AND COMPONENTS:** WDM concepts, overview of WDM operation principles, WDM standards, multiplexer, Isolators and circulators, dielectric thin film filters, active optical components, attenuators, equalizers, multiplexers, Introduction to optical fibre cable, splicing, optical time domain reflectometer(OTDR), fibre bragg grating (FBG).

**9 Hours****TEXT BOOKS**

1	John M. Senior	Optical Fiber Communication, Pearson Education, 3 <sup>rd</sup> Edition, 2009.
2	Gerd Keiser	Optical Fiber Communications, Tata Mc-Graw Hill, 5 <sup>th</sup> Edition, 2017.

**REFERENCE BOOKS**

1	Joseph C Palais	Fiber Optic Communication, Pearson Education, 5 <sup>th</sup> Edition, 2004.
2	Ajoy Ghatak and K Thyagarajan	Introduction to fibre optics, Cambridge University Press, 2 <sup>nd</sup> Edition, 2000.

**E-RESOURCES**

1	<a href="https://nptel.ac.in/courses/108106167">https://nptel.ac.in/courses/108106167</a>
2	<a href="https://www.youtube.com/watch?v=ap00IUJm7k&amp;list=PLFW6lRTa1g83YaqmM9r2MAAiJVY93bOP7">https://www.youtube.com/watch?v=ap00IUJm7k&amp;list=PLFW6lRTa1g83YaqmM9r2MAAiJVY93bOP7</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze the basic parameters of optical fiber
CO2	Explain the channel impairments like losses and dispersion
CO3	Describe the principles of optical sources and detectors
CO4	Compare the characteristics of optical fiber receivers
CO5	Analyze Analog links, Digital links and WDM concepts

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2										2	
	CO2	2	2										2	
	CO3	2	2										2	
	CO4	2	2										2	
	CO5	2	2						2	2			2	

## ADVANCED MULTIMEDIA

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE02	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Provide basic concepts and techniques of multimedia systems
2.	Understand and compare various compression algorithms

### UNIT I

**Introduction to Data compression:** why compression? The data compression problem. **Lossless compression Algorithms:** Introduction, Measuring information, Information channel, Coding Redundancy, Run-Length Coding, Variable –Length Coding- Shannon-Fano Algorithm, Huffman coding, Adaptive Huffman coding, Dictionary –Based Coding, Arithmetic Coding, Lossless Image Compression – Differential Coding of Images, Lossless JPEG, Need for AI in multimedia communication.

**9 Hours**

### UNIT II

**Lossy compression Algorithms:** Distortion measures, The rate distortion theory, Quantization – Uniform Scalar and Nonuniform Quantization, Transform Coding – discrete Cosine Transform(DCT), Karhunen- Loeve Transform, Wavelet-Based Coding, Embedded Zerotree of Wavelet Coefficients, Set Partitioning in Hierarchical Trees, AI-based Compression techniques.

**8 Hours**

### UNIT III

**Image Compression Standards:** The JPEG Standard, The JPEG2000 Standard –Region of Interest Coding, The JPEG-LS Standard- Prediction, context determination, Residual Coding, Bilevel Image Compression Standards- JBIG Standard, Image Processing using AI.

**7 Hours**

**UNIT IV**

**Basic Video compression Techniques:** Introduction, Video Compression based on Motion Compensation, Search for Motion Vectors – Sequential Search, 2D Logarithmic Search, Hierarchical Search, H.261 – Intra-Frame Coding, Inter-frame Coding, Quantization, Encoder and Decoder, H.261 Video Bitstream, H.263- Motion Compensation, Video Processing using AI.

**8 Hours****UNIT V**

**MPEG Video Coding:** MPEG-1 – Motion Compensation, Differences from H.261, Video Bitstream, MPEG-2 – Interlaced Video, Scalabilities, Differences from MPEG-1, Overview of MPEG-4, object based Visual coding in MPEG-4 – VOP-based vs Frame-based Coding, Motion Compensation, Texture coding, Shape coding, Synthetic Object coding in MPEG-4, MPEG-4 Object types, profiles and levels, H.264 – Core features, AI in Real-Time Communication.

**8 Hours****TEXT BOOKS**

1	Khalid Sayood	Introduction to Data Compression, Morgan Kaufmann Publishers, Fifth Edition, 2017.
2	Ze-Nian Li and Mark S. Drew	Fundamentals of Multimedia, Pearson Edu. 2004.

**REFERENCE BOOKS**

1	Jerry D. Gibson, Toby Berger, Tom LOOKABAUGH, Dave Lindbergh and Richard L. Baker	Digital Compression for Multimedia, Morgan Kaufmann Publishers, 2006.
2	Ralf Steinmetz & Klara Nahrstedt	Multimedia: Computing, Communications & Applications Pearson Education, 2004.
3	Daniel Minoli and Benedict Occhiogrosso	AI Applications to Communications and Information Technologies: The Role of Ultra Deep Neural Networks Wiley-IEEE Press, 2023.

**E-RESOURCES:**

1	<a href="https://nptel.ac.in/courses/117105083">https://nptel.ac.in/courses/117105083</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply lossless entropy coding for given data.
CO2	Apply lossy compression using different transform techniques.
CO3	Describe image compression technique used in different image compression standards.
CO4	Analyze and compare different search mechanisms for motion vector.
CO5	Describe and compare video compression standards.

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2										3	
	CO2	3	2										3	
	CO3	3	2			1				1		1	3	1
	CO4	3	2			1				1		1	3	1
	CO5	3	2			1				1		1	3	1

## SATELLITE COMMUNICATION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE03	SEE Marks:	50

### Course objectives:

This course will enable students to learn:

1.	Orbital parameters necessary for the satellite to be in orbit and to communicate with earth station.
2.	Space and Earth segment and to perform Link budget analysis.
3.	Various multiple access techniques used in satellite communication.

### UNIT I

**OVER VIEW OF SATELLITE SYSTEMS:** Introduction, frequency allocation.

**ORBITS:** Introduction, Kepler laws, definitions, orbital element, apogee and perigee heights, orbit perturbations, inclined orbits, sidereal time, orbital plane.

**8 Hours**

### UNIT II

**Geostationary orbit:** Introduction, antenna, look angles, polar mix antenna, limits of visibility, earth eclipse of satellite, sun transit outage, launching orbits.

**8 Hours**

### UNIT III

**RADIO WAVE PROPAGATION:** Introduction, atmospheric loss, ionospheric effects, rain attenuation, other impairments.

**SPACE LINK:** Introduction, EIRP, transmission losses, link budget, system noise, CNR, uplink, down link, effects of rain, combined CNR.

**8 Hours**

### UNIT IV

**SPACE SEGMENT:** Introduction, power supply units, altitude control, station keeping, thermal control, TT&C, transponders, antenna subsystem.

**EARTH SEGEMENT:** Introduction, receive only home TV system, outdoor unit, indoor unit, MATV, CATV, Tx – Rx earth station.

**9 Hours**

**UNIT V**

**INTERFERENCE AND SATELLITE ACCESS:** Introduction, interference between satellite circuits, satellite access, single access, preassigned FDMA, SCPC (spade system), TDMA: pre-assigned TDMA, demand assigned TDMA, down link analysis, comparison of uplink power requirements for TDMA & FDMA, on board signal processing satellite switched TDMA.

**9 Hours****TEXT BOOKS**

1	Dennis Roddy	Satellite Communications, McGraw Hill education, 4 <sup>th</sup> Edition, 2017.
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**REFERENCE BOOKS**

1	Timothy Pratt, Charles Bostian, Jeremy Allnut	Satellite Communications, John Wiley & Sons, 2 <sup>nd</sup> Edition, 2019.
2	W.L. Pitchand, H.L. Suyderhoud, R.A.Nelson	Satellite Communication Systems Engineering, Pearson Education, 2 <sup>nd</sup> Edition, 2007.

**E-RESOURCES:**

1	<a href="https://www.youtube.com/watch?v=Alt2WNIACd4">https://www.youtube.com/watch?v=Alt2WNIACd4</a>
2	<a href="https://www.youtube.com/watch?v=dt4Ce8gQPns&amp;list=PLAnjLC20C-XQnoowCtt-67WmyxoQPu2Fi">https://www.youtube.com/watch?v=dt4Ce8gQPns&amp;list=PLAnjLC20C-XQnoowCtt-67WmyxoQPu2Fi</a>
3	<a href="https://www.youtube.com/watch?v=Alt2WNIACd4">https://www.youtube.com/watch?v=Alt2WNIACd4</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze the orbital parameters to identify the position of the satellite in an orbit.
CO2	Formulate Azimuth angle, Elevation angle and limits on visibility of a satellite from an earth station.
CO3	Design the link power budget and CNR for the space link of a satellite communication system.
CO4	Apply the knowledge of digital communication to understand space and earth segment architectures.
CO5	Identify the use of multiple access techniques in satellite communication.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2	2									2	
	CO2	2	2	2									2	
	CO3	2	2	2									2	
	CO4	2	2										2	
	CO5	2	2	2							2		2	2

## RF AND MICROWAVE CIRCUIT DESIGN

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE04	SEE Marks:	50

**Prerequisites:** Courses on Electromagnetic Field Theory and Transmission lines.

### UNIT I

**Basics of RF and Microwaves:** Introduction- Properties of RF and Microwaves, reasons for using RF/Microwaves, RF/Microwave applications, low RF and high RF circuit design considerations.

**RF Electronics:** Introduction to component basics at RF/Microwave: wire, resistors, capacitors, Inductor, definitions- Decibel, Decibel watts, space factor, ripple, bandwidth, Resonance.

**9 Hours**

### UNIT II

**Passive Circuit Design:** The Smith Chart, Application of the Smith Chart in Distributed and Lumped element circuit applications, Design of Matching networks'- Parameters and Microwave Transistor Definitions and use of S Parameters with passive and active devices. Impedance matching networks for Narrow Band, Wide band, and Quarter Wave. Introduction to resonators- Transmission line and Dielectric Resonators.

**8 Hours**

### UNIT III

**Couplers and Power dividers:** Basic properties, Types, Power Dividing and Power combining efficiency,  $180^\circ$  Hybrid Coupler, Lange Coupler, N-way combiners, corporate structures, Spatial combining.

**Phase shifters:** Types, Transmission line type, Reflection types Phase shifters, Digital phase shifters and PIN Diode Attenuators.

**8 Hours**

<b>UNIT IV</b>	
<b>Amplifier Design:</b> Stability, Amplifier Matching and Biasing Circuits Design, Unilateral and non-unilateral design - One stage and multistage design - Low-noise amplifiers - High-power amplifiers - RF/MW Amplifiers Small Signal Design, Large Signal Design.	
<b>8 Hours</b>	
<b>UNIT V</b>	
<b>Oscillator Design:</b> Resonators – Dielectric resonators – YIG resonators – Varactor resonators – Resonator measurements – Two-port oscillator design – Noise Lesson’s oscillator model – Low-noise design, Non-linear oscillator model. Challenges of RF Propagation in Underwater Environments, Microwave circuits in radar systems for shallow-water or surface monitoring, Transceiver block diagram design for underwater telemetry systems.	
<b>9 Hours</b>	
<b>TEXT BOOKS</b>	
1	Matthew. M. Radmanesh Radio Frequency and Microwave Electronics Illustrated, Pearson Education, Low price edition, 2001.
2	David M. Pozar Microwave Engineering, John Wiley & Sons, 4 <sup>th</sup> Edition, 2011.
<b>REFERENCE BOOKS</b>	
1	Reinhold Ludwig and Gene Bogdanov RF Circuit Design, Theory and Applications, Pearson Education (Asia) Pte. Ltd., 2 <sup>nd</sup> Edition, 2009.
2	Devendra. K. Mishra Radio Frequency and Microwave Communication Circuits Analysis and Design, John Wiley & Sons, 2001.
3	Chris Bowick R F Circuit Design, 2 <sup>nd</sup> Edition, 2008.
Course Outcomes: Upon completion of this course the student will be able to:	
CO1	Explain reasons for using RF/MW frequencies, limitations of lumped elements.
CO2	Analyze the RF circuits using S-parameters, Signal flow graphs and Smith charts.
CO3	Design Couplers & Power divider circuits using EDA tools.
CO4	Discuss the importance of noise, stability and gain considerations in active circuit design.
CO5	Analyze and design resonators and oscillators.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2			1			1			1	2	1
	CO2	2	2			1			1			1	2	1
	CO3	2	2			1			1			1	2	1
	CO4	2	2			1			1			1	2	1
	CO5	2	2			1			1			1	2	1

## ERROR CONTROL CODING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE05	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Learn techniques of traditional coding theory concepts.
2. Implement algorithms for error detection and correction.

### UNIT I

**Introduction to Algebra:** Groups, Fields, Binary Field Arithmetic, Construction of Galois Field GF (2<sup>m</sup>) and its basic properties, Computation using Galois Field GF (2<sup>m</sup>) Arithmetic.

**8 Hours**

### UNIT II

**Vector spaces:** Properties, matrices, Construction of G and H matrix, Single parity check codes, repetition codes, self-dual codes, Reed – Muller codes. Low density parity check (LDPC) codes, Tanner graph case study: Creation of robust measurement matrices in compressive sensing to improve accuracy of sparse signal reconstruction.

Systematic and Non-systematic cyclic codes, Encoding using Multiplication circuits, Encoder circuit using parity polynomial, Meggitt decoder, Error trapping decoding, Cyclic Hamming codes, (23, 12) Golay code, Shortened cyclic codes.

**8 Hours**

### UNIT III

**BCH Codes:** Binary primitive BCH codes, Decoding procedures, Implementation of Galois field Arithmetic, Implementation of Error correction. Non – binary BCH codes: q – ary Linear Block Codes, Primitive BCH codes over GF (q), Reed – Solomon Codes, Decoding of Non – Binary BCH and RS codes: The Berlekamp - Massey Algorithm.

Majority Logic Decodable Codes: One – Step Majority logic decoding, one – step Majority logic decodable Codes, Two – step Majority logic decoding, Multiple – step Majority logic decoding.

**9 Hours**

#### UNIT IV

**Convolutional Codes:** Encoding of Convolutional codes, Structural properties, Distance properties, Viterbi Decoding Algorithm for decoding, Soft – output Viterbi Algorithm, Stack and Fano sequential decoding Algorithms, Majority logic decoding.

**8 Hours**

#### UNIT V

**Turbo coding:** Introduction to Turbo coding and their distance properties, Design of Turbo codes.

**Burst – Error – Correcting Codes:** Burst and Random error correcting codes, Concept of Inter – leaving, cyclic codes for Burst Error correction – Fire codes, Convolutional codes for Burst Error correction.

**9 Hours**

#### TEXT BOOKS

1	Shu Lin & Daniel J. Costello, Jr	Error Control Coding, Pearson / Prentice Hall, Second Edition, 2011.
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#### REFERENCE BOOKS

1	Blahut, R.E.	Algebraic Codes for Data Transmission Cambridge University Press, 2012.
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#### Course Outcomes:

Upon completion of this course the student will be able to:

CO1	Construct Galois fields as per the requirement and perform computations using Galois Field arithmetic.
CO2	Design various linear block codes and cyclic codes as per the specifications and develop encoding/decoding circuits.

CO3	Design BCH codes as per the specifications and perform Decoding.
CO4	Perform encoding/decoding of convolution codes.
CO5	Design Turbo Codes, Burst and random error correcting codes.

### Course Articulation Matrix

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			1			1	1	1		2	1
	CO2	3	2	1		1			1	1	1		3	1
	CO3	3	2	1		1			1	1	1		3	1
	CO4	3	2			1							2	1
	CO5	3	2	1		1							2	

## ADVANCED WIRELESS COMMUNICATION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE06	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Introduce recent trends in wireless communication.
2. Understand challenges in wireless communication and fading in wireless channel.
3. Learn different technologies related to recent trends in wireless communication.

### UNIT I

**Introduction Wireless Communications:** Fast Fading Wireless Channel Modeling, Rayleigh/Ricean Fading Channels, BER Performance in Fading Channels, Diversity modeling for Wireless Communications, BER Performance Improvement with diversity, Types of Diversity – Frequency, Time, Space.

**9 Hours**

### UNIT II

**Spread Spectrum Modulation** – Introduction, Application and Advantage, Pseudo noise sequence, Pulse –Noise Jamming, Classifications: Direct Sequence SS, Frequency Hopped SS, Hybrid SS. Fast Hopping Versus Slow Hopping, Time Hopping SS systems. Synchronization of SS systems – Acquisition, Tracking. Jamming Consideration – Broadband, Partial band, Multiple tone, Pulse-repeat band, jamming suppression systems.

**9 Hours**

### UNIT III

**OFDM** – Introduction, Advantages and drawbacks, Applications and standards. Multi Carrier Spread Spectrum - Principles of various schemes, Advantages and Drawbacks. MC-CDMA and MC-DS-CDMA Signal structure, Uplink and downlink signal, Spreading and detecting techniques.

**8 Hours**

**UNIT IV**

**Multi carrier modulation** and demodulation, synchronization, channel estimation, Channel coding and decoding. Signal Constellation, Mapping, De-mapping and equalization, Adaptive technique in multi carrier transmissions, RF Issues.

**8 Hours****UNIT V**

**3G and 4G Wireless Standards:** GSM, GPRS, WCDMA, LTE, WiMAX

**8 Hours****TEXT BOOKS**

1	David Tse and Pramod Viswanath	Fundamentals of Wireless Communications Publisher: Cambridge University Press, 2005.
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**REFERENCE BOOKS**

1	K. Fazel, S. Kaiser,	Multi Carrier & Spread Spectrum Systems, Publisher: John Wiley & Sons, 2 <sup>nd</sup> Edition, 2008.
2	Ramjee Prasad	OFDM for Wireless Communications Systems, Publisher: Artech House, 2004.

**E-RESOURCES**

1	<a href="https://nptel.ac.in/courses/117104099">https://nptel.ac.in/courses/117104099</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Model the wireless fading channel and evaluate the performance using bit error rate.
CO2	Analyse and demonstrate the spread spectrum modulation application and advantages.
CO3	Demonstrate different wireless technologies along with advantages and drawbacks.
CO4	Design different channel estimation techniques.
CO5	Compare and contrast different wireless standards.

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			2			1				2	1
	CO2	3	2	1		2			1				2	1
	CO3	3	2	1		2			1				2	1
	CO4	3	2	1		2			1				2	1
	CO5	3	2			2			1				2	1

## MIMO WIRELESS COMMUNICATION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE07	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand the fundamentals of MIMO systems.
2. Learn capacity of MIMO systems and space time codes.

### UNIT I

**Introduction to MIMO channel models:** Need for MIMO systems, advantages and applications MIMO systems, diversity-multiplexing trade-off, transmit diversity schemes, advantages and applications of MIMO systems, Fading Channel Models: Uncorrelated - fully correlated - separately correlated - keyhole MIMO fading models, parallel decomposition of MIMO channel, Power allocation in MIMO: Uniform power allocation, water filling algorithm.

**9 Hours**

### UNIT II

**MIMO Channel Capacity:** Capacity for deterministic MIMO Channels: SISO – SIMO – MISO – MIMO, Capacity of random MIMO channels: SISO – SIMO – MISO – MIMO (Qualitative analysis), Capacity of independent identically distributed channels, separately correlated Rayleigh fading MIMO channels, **Bio-inspired optimization algorithms:** Particle swarm optimization algorithm (PSO), Genetic Algorithm Optimization (GA).

**9 Hours**

### UNIT III

**Space-Time Codes:** Advantages, code design criteria, Alamouti space-time codes, SER analysis of Alamouti space-time code over fading channels, Space-time block codes, Space-time trellis codes, Performance analysis of Space-time codes over separately correlated MIMO channel, Space-time turbo codes, BLAST Architectures: VBLAST-DBLAST.

**8 Hours**

**UNIT IV**

**MIMO Detection Techniques:** Maximum Likelihood, Zero Forcing, Minimum Mean Square Error, Zero Forcing Equalization with Successive Interference Cancellation, Minimum Mean Square Error Successive Interference Cancellation and Lattice Reduction based detection.

**8 Hours****UNIT V**

**Advances in MIMO:** Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, MIMO applications in RADAR, advanced AI techniques in MIMO wireless communication.

**8 Hours****TEXT BOOKS**

1	R. S. Kshetrimayum	Fundamentals of MIMO wireless communications, Cambridge University Press, 2017.
2	David Tse and Pramod Viswanath	Fundamentals of Wireless Communication, Cambridge University Press, 2005.

**REFERENCE BOOKS**

1	A.Chokhalingam and B.S. Ranjan	Large MIMO systems, Cambridge University Press, 2014.
2	B. Kumbhani and R. S. Kshetrimayum	MIMO wireless communications over generalized fading channels, CRC Press, 2017
3	T. L. Marzetta, E. G. Larsson, H. Yang and H. Q. Ngo	Fundamentals of massive MIMO, Cambridge University Press, 2016.

**E-RESOURCES**

1	<a href="https://nptel.ac.in/courses/117105132">https://nptel.ac.in/courses/117105132</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze the advantages of MIMO systems.
CO2	Determine the capacity and bit error rate for a given digital modulation scheme of SIMO, MISO, MIMO wireless communication system in Rayleigh frequency flat and frequency selective fading environment.

CO3	Analyze the inherent spatial diversity in MIMO channels through properly designed space-time codes.
CO4	Describe various algorithms used to detect the received signal in MIMO systems.
CO5	Describe the applications of MIMO systems.

### Course Articulation Matrix

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			2			2	2			2	2
	CO2	3	2			2			2	2			2	2
	CO3	3	2			2			2	2			2	2
	CO4	3	2			2			2	2			2	2
	CO5	3	1			2			2	2			2	2

## COMPUTATIONAL ELECTROMAGNETICS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE08	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Understand the concepts of computational electromagnetics.
2.	Understand numerical stability and boundary conditions.
3.	Understand the concepts of FDTD and Finite Element Method.

### UNIT I

**Analytical Methods:** Introduction, Separation of variables, Separation of variables in rectangular coordinates – Laplace equation, Separation of variables in cylindrical coordinates – Laplace equation.

**9 Hours**

### UNIT II

**Finite Difference Methods:** Finite Difference Schemes, Finite differencing of Parabolic PDE, Hyperbolic PDEs, Accuracy and Stability, Absorbing boundary conditions of FDTD, Programming Aspects.

**9 Hours**

### UNIT III

**Variational Methods:** Calculus of variations, construction of functions from PDEs, weighted residual method, Eigen value problems.

**8 Hours**

### UNIT IV

**Moment Methods:** Introduction, Integral equations, Green's function for free space, Applications- Quasi static problems and Pocklington's integral equation.

**8 Hours**

### UNIT V

**Finite Element Method:** Introduction, Solution of Laplace's equation, Solution of Poisson's equation, Solution of wave equation.

**8 Hours**

**TEXT BOOKS**

1	Matthew. N.O Sadiku	Numerical Techniques in Electromagnetics with MATLAB, CRC Press Taylors and Francies Group, 3 <sup>rd</sup> Edition, 2009.
2	Constantine A Balanis	Advanced Engineering Electromagnetic, John Wiley & Sons, 2 <sup>nd</sup> Edition, 2012.

**REFERENCE BOOKS**

1	Nathan Ida	Engineering Electromagnetic, Springer, 2 <sup>nd</sup> Edition, 2007.
2	Anastasis C. Polycarpou	Introduction to the Finite Element Method in Electromagnetics, Morgon & Claypool Publishers, 1 <sup>st</sup> Edition, 2006.

**E-Resources**

1	<a href="https://nptel.ac.in/courses/108106152">https://nptel.ac.in/courses/108106152</a>
2	<a href="https://www.youtube.com/playlist?list=PLRWKj4sFG7-4l5a3TsBwpc3-STQ2XjKXv">https://www.youtube.com/playlist?list=PLRWKj4sFG7-4l5a3TsBwpc3-STQ2XjKXv</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze the Laplace's equation using analytical methods.
CO2	Apply residual calculus in deriving and analyzing various computational techniques.
CO3	Apply and analyze Green's function for free space.
CO4	Classify and Prioritize different CEM techniques based on the applications.
CO5	Apply and analyze Poisson's and Laplace's equations using finite element method.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2			1			1			1	2	1
	CO2	2	2			1			1			1	2	1
	CO3	2	2			1			1			1	2	1
	CO4	2	2			1			1			1	2	1
	CO5	2	2			1			1			1	2	1

## OPTICAL NETWORKS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE09	SEE Marks:	50

### Course objectives:

This course will enable students to:

- |    |   |
|----|---|
| 1. | Understand the concepts of optical network.   |
| 2. | Analyse the issues like transmission aspects of Second generation fiber optic Networks and networking aspects such as architecture, control and Management. |

### UNIT I

**Introduction to Optical Networks:** Telecommunication network Architecture, services, circuit switching and packet switching, optical Networks, optical layer, transparency and all optical networks, optical packet switching, transmission basics, network evolution.

**9 Hours**

### UNIT II

**Components:** Optical amplifiers. Transmitters, Detectors, Switches, Wavelength converters.

**8 Hours**

### UNIT III

**Transmission System Engineering:** System model, Power penalty, Transmitter, receiver, optical amplifiers, Crosstalk, Dispersion, Fiber nonlinearities, overall design considerations.

**8 Hours**

### UNIT IV

**Client layers of optical network:** SONET/SDH, optical transport network, generic framing procedure, Ethernet, IP, Multiprotocol label switching.

**8 Hours**

### UNIT V

**WDM Network Elements:** Optical line terminals, optical line amplifiers, optical add/drop multiplexers, optical cross connects.

**Control and Management:** Network Management Functions, optical layer services and interfacing, Layers within the optical layer.

**9 Hours**

**TEXT BOOKS**

1	Kumar Sivarajan and Rajiv Ramaswamy	Optical Networks: A practical perspective, Morgan Kaufman, 3 <sup>rd</sup> edition, 2009.
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**REFERENCE BOOKS**

1	Biswajit Mukherjee	Optical Communication Networks, TMH, 1998.
2	Ulysees Black	Optical Networks, Pearson education, 2007.

**E-RESOURCES:**

1	<a href="https://www.youtube.com/watch?v=4W7hieXDAmc">https://www.youtube.com/watch?v=4W7hieXDAmc</a>
2	<a href="https://www.youtube.com/watch?v=bC11e6QgrqA&amp;list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl&amp;index=3">https://www.youtube.com/watch?v=bC11e6QgrqA&amp;list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl&amp;index=3</a>
3	<a href="https://www.youtube.com/watch?v=KIPFP8wke9M&amp;list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl&amp;index=11">https://www.youtube.com/watch?v=KIPFP8wke9M&amp;list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl&amp;index=11</a>
4	<a href="https://www.youtube.com/watch?v=KIPFP8wke9M&amp;list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl&amp;index=11">https://www.youtube.com/watch?v=KIPFP8wke9M&amp;list=PLHj96QRJ0kOhH8xoXXrOgkMf9ZOvjhqYl&amp;index=11</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Explain basic terms related to Optical Networks
CO2	Analyze the Optical Components
CO3	Charactering the optical transmission systems
CO4	Compare different layers of optical networks
CO5	Explain WDM networks

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2										2	
	CO2	2	2										2	
	CO3	2	2										2	
	CO4	2	2										2	
	CO5	2	2						2	2			2	2

## EDGE AND CLOUD COMPUTING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE10	SEE Marks:	50

**Pre-requisite:** Operating Systems/ RTOS, Computer Architecture, Embedded Systems, and IoT.

### Course objectives:

This course will enable students to:

1. Introduce the students to state-of-the-art technologies to enable computing at the cloud and edge as a professional subject to help in their careers and jobs.
2. Demonstrate cloud-native and edge-native architectures for computing as well as the orchestration framework needed for the control of cloud and edge applications.

### UNIT I

**Need for Compute (Hardware and Architecture Overview):** What is computing? What is the need for compute? Where does the compute happen? Cloud, edge, client. What are the relative advantages of cloud, edge, and client? Architecture of a datacenter (physical data center view of storage, accelerators, compute clusters, and over the network hardware access such as RDMA, InfiniBand, Architecture of edge and client.

**Heterogeneous compute:** Accelerators, Memory and Interconnect.

**9 Hours**

### UNIT II

**Software Components of Cloud and Edge:** Software Abstraction: Bare-Metal, Virtual Machines (Hypervisors), and Containers (Container Engine): definitions and relative differences, Monolithic Architecture Vs Microservices Architecture with examples Service-to-Service Communication: RESTfull connections, GraphQL, Khafka, gRPC, Service Mesh Architecture (SMA), Service Proxy, Side-Car-Proxy, and Controllers.

**9 Hours**

**UNIT III**

**Networking the Cloud, Edge, and Clients:** Intra-Data Center Networks, Inter-Data Center Networks, Undersea cables connecting continents, terrestrial networks, and Non-Terrestrial Networks (NTN), Distributed Virtual Networks (including container networking), Private wireless networks: Private-LTE, Private-5G, Softwarized RAN, Open RAN, Core Networks, WiFi Alliance, Industry 5.0.

**8 Hours****UNIT IV**

**Orchestration at Cloud, Edge, and Client:** Software Defined Approaches: Separation of Control and User plane, Understanding the role of Application Developers, DevOps, System Administrators, Quality Assurance and Reliability, Concept of Continuous Integration/Continuous Development (CI/CD), Continuous Orchestration and Kubernetes (K8s). Heterogenous Control Domains in an end-to-end solution.

**8 Hours****UNIT V**

**End-to-End Use Cases:** Private 5G standalone networks, Requirements of Fully Autonomous Driving and Telehealth, Industrial Control Systems with CIP protocol, content streaming and role-of-caching

**8 Hours****TEXT BOOKS**

1	Barroso, Luiz André, Urs Hölzle, and Parthasarathy Ranganathan.	The datacenter as a computer: Designing warehouse-scale machines. Springer Nature, 2019.
2	Carneiro Jr, Cloves, and Tim Schmelter	Microservices from day one: build robust and scalable software from the start. New York City: Apress, 2016
3	Agarwal, Gaurav	Modern DevOps Practices: Implement and secure DevOps in the public cloud with cutting-edge tools, tips, tricks, and techniques. Packt Publishing Ltd, 2021.

**PAPER REFERENCES**

1	Shantharama, Prateek, Akhilesh S. Thyagaturu, and Martin Reisslein	Hardware-accelerated platforms and infrastructures for network functions: A survey of enabling technologies and research studies, IEEE Access 8 (2020): 132021-132085.
2	Thyagaturu, A. S., Shantharama, P., Nasrallah, A., & Reisslein, M.	Operating systems and hypervisors for network functions: A survey of enabling technologies and research studies. IEEE Access, 2022.
3	Levinson, Jesse, et al.	Towards fully autonomous driving: Systems and algorithms." 2011 IEEE intelligent vehicles symposium (IV). IEEE, 2011.
4	Yang, Mao, et al.	OpenRAN: a software-defined ran architecture via virtualization. ACM SIGCOMM computer communication review 43.4 (2013): 549-550.

**WEB LINKS**

1	<a href="https://www.youtube.com/watch?v=CZ3wluvHeM">https://www.youtube.com/watch?v=CZ3wluvHeM</a>
2	<a href="https://www.youtube.com/@ByteByteGo/videos">https://www.youtube.com/@ByteByteGo/videos</a>
3	<a href="https://www.youtube.com/watch?v=hkXzsB8D_mo">https://www.youtube.com/watch?v=hkXzsB8D_mo</a>
4	<a href="https://www.youtube.com/watch?v=6Rv1KYgRFYQ&amp;t=96s">https://www.youtube.com/watch?v=6Rv1KYgRFYQ&amp;t=96s</a>
5	<a href="https://www.youtube.com/watch?v=bSvTVREwSNw">https://www.youtube.com/watch?v=bSvTVREwSNw</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply the knowledge of embedded systems and computer networking to understand the basic building blocks of computing systems.
CO2	Analyze the implementation of the software stack and microservices in cloud and edge.
CO3	Apply the knowledge of computer networking to understand the non-conventional networking aspects of cloud and edge.
CO4	Integrate the cloud, edge, and client with the management with engineering concepts.
CO5	Develop skills to position themselves in the IT and software industry.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
<b>COs</b>	CO1	3	2										2	
	CO2	3	2	2		1			1					2
	CO3	3	2	1									2	
	CO4	3	2	2		2			1					2
	CO5	3	2			1			1					1

## MODELING AND DATA NETWORKS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE11	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Acquire core knowledge of data network design aspects.
2.	Understand queuing theory and probability, which is the basis for the design of network.
3.	Demonstrate descriptive and analytic treatment of various network design aspects.

### UNIT I

**DELAY MODELS IN DATA NETWORKS:** Queuing Models, M/M/1, M/M/m, M/M/\_, M/M/m/m and other Markov System, M/G/1 System, infinite server systems, open and closed queuing networks, Jackson's theorem, Little's law Networks of Transmission Lines, Time Reversibility, Networks of Queues.

**9 Hours**

### UNIT II

**Performance analysis of networks:** Discrete and continuous time Markov chains, birth-death processes, time reversibility, traffic management - models, classes, scheduling.

**Basics of Probability:** Probability concepts, Network performance estimates.

**9 Hours**

### UNIT III

**Design & analysis of network nodes:** Transmission links, node design, node architecture and analysis, node processor, node memory

**Topological Design:** Selection, Multipoint connection between a Terminal, Link and link capacity assignment, Disjoint Route topology.

**8 Hours**

**UNIT IV**

**Flow control:** Network congestion, Flow control, Various Flow control techniques, Comparison, deadlocks, Protocol dead locks, Buffer dead locks.

**8 Hours****UNIT V**

**ROUTING IN DATA NETWORKS:** Introduction, Deterministic routing, Reliability in deterministic routing, disjoint deterministic routes, Adaptive routing strategies, centralized adaptive routing, Random routing, Hierarchical adaptive routing, and other adaptive routing schemes.

**8 Hours****TEXT BOOKS**

1	Dimitri Bertsekas and Robert Gallager,	Data Networks, Prentice Hall of India, 2 <sup>nd</sup> Edition, 2003.
2	Vijay Ahuja	Design and analysis of computer communication networks, McGraw Hill computer science series, 2007.

**REFERENCE BOOKS**

1	S. Keshav,	An Engineering Approach to Computer Networking, Pearson Education, 1997.
2	I. Mitrani,	Modeling of Computer and Communication Systems, Cambridge, 2020.

**E-RESOURCES:**

1	<a href="https://nptel.ac.in/courses/106101238">https://nptel.ac.in/courses/106101238</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	To apply the fundamentals of mathematics and probability to understand the delay models on data networks.
CO2	Analyse the performance of data networks using various network parameters.
CO3	Design and analyse the topological model of the network node with respect to node parameters.
CO4	Analyse and compare the flow control techniques in data network.
CO5	Analyse the routing models used in data networks.

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			2			1				2	1
	CO2	3	2			2			1				2	1
	CO3	3	2	2		2			1				2	1
	CO4	3	2			2			1				2	1
	CO5	3	2			2			1				2	1

## SOFTWARE DEFINED NETWORKS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE12	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand the fundamentals of SDN Network
2. Learn the various Network virtualization frame works
3. Articulate the programming skills of SDN and various use cases

### UNIT I

History and Evolution of Software Defined Networking (SDN): Separation of Control Plane and Data Plane, IETF Forces, Active Networking. Control and Data Plane Separation: Concepts, Advantages and Disadvantages, Open Flow protocol.

**8 Hours**

### UNIT II

Network Virtualization: Concepts, Applications, Existing Network, Virtualization Framework (VMWare and others), Mininet based examples. Control Plane: Overview, Existing SDN Controllers including, Floodlight and Open Daylight projects.

**9 Hours**

### UNIT III

Customization of Control Plane: Switching and Firewall, Implementation using SDN Concepts. Data Plane: Software-based and Hardware-based; Programmable Network Hardware.

**8 Hours**

**UNIT IV**

Programming SDNs: Northbound Application Programming Interface, Current Languages and Tools, Composition of SDNs. Network Functions Virtualization (NFV) and Software Defined Networks: Concepts, Implementation and Applications.

**8 Hours****UNIT V**

Data Center Networks: Packet, Optical and Wireless Architectures, Network Topologies. Use Cases of SDNs: Data Centers, Internet Exchange Points, Backbone Networks, Home Networks, Traffic Engineering. Assignments: Programming Assignments for implementing some of the theoretical concepts listed above.

**9 Hours****TEXT BOOKS**

1	Thomas D. Nadeau, Ken Gray	Software Defined Networks, An Authoritative Review of Network Programmability Technologies, O'Reilly Media Publication, 2013.
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**REFERENCE BOOKS**

1	Paul Goransson and Chuck Black	Software Defined Networks: A Comprehensive Approach, Morgan Kaufmann Publication, 2014.
2	Vivek Tiwari	SDN and OpenFlow for Beginners, MMDD Multimedia LLC Publisher, 2013.

**E-RESOURCES**

1	<a href="https://youtu.be/I3E-C1j-Sjg">https://youtu.be/I3E-C1j-Sjg</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Describe the basic concepts on Software Defined Networking and Separation of Control plane with data plane
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CO2	Analyze the existing network virtualization framework (VM Ware and others)
CO3	Illustrate Control Plane and Data plane implementation using SDN concepts.
CO4	Analyze network functions virtualization and programming with SDNs.
CO5	Illustrate the use cases of SDNs, such as Data centers, Backbone networks, etc.

### Course Articulation Matrix

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	1			2			2	2			2	2
	CO2	3	2			2			2	2			2	2
	CO3	3	2	2		2			2	2			2	2
	CO4	3	2			2			2	2			2	2
	CO5	3	1			2			2	2			2	2

## ADHOC WIRELESS NETWORKS

Contact Hours/ Week:	: 3+0+0	Credits :	3
Total Lecture Hours:	: 42	CIE Marks :	50
Sub. Code:	: SECE13	SEE Marks :	50

### Course objectives:

This course will enable students to:

1.	Understand the fundamental principles of Adhoc Wireless Networks.
2.	Discuss a comprehensive understanding of adhoc network MAC protocols.
3.	Outline the current and emerging trends adhoc routing protocols.
4.	Analyze energy management and security techniques in adhoc wireless networks.

### UNIT I

**AD HOC NETWORKS:** Introduction, Issues in Ad hoc wireless networks, Ad hoc wireless internet.

**7 Hours**

### UNIT II

**MAC PROTOCOLS FOR ADHOC WIRELESS NETWORKS:** Introduction, Issues in designing a MAC protocol for Ad hoc wireless Networks, Design goals of a MAC protocol for Ad hoc wireless Networks, Classification of MAC protocols. Contention - based MAC protocols with scheduling mechanism, MAC protocols that use directional antennas, Other MAC protocols.

**12 Hours**

### UNIT III

**ROUTING PROTOCOLS FOR ADHOC WIRELESS NETWORKS-1:** Introduction, Issues in designing a routing protocol for Ad hoc wireless Networks, Classification of routing protocols, Table drive routing protocol, On-demand routing protocol.

**8 Hours**

**UNIT IV**

**ROUTING PROTOCOLS FOR ADHOC WIRELESS NETWORKS-2:** Hybrid routing protocol, Routing protocols with effective flooding mechanisms, Hierarchical routing protocols, Power aware routing protocols.

**7 Hours****UNIT V**

**TRANSPORT LAYER PROTOCOLS FOR ADHOC WIRELESS NETWORKS:** Introduction, Issues in designing a transport layer protocol for Ad hoc wireless Networks, Design goals of a transport layer protocol for Ad hoc wireless Networks.

**SECURITY:** Security in wireless Ad hoc wireless Networks, Network security requirements, Issues & challenges in security provisioning.

**8 Hours****TEXT BOOKS**

1	C. Siva Ram Murthy, B.S.Manoj	Ad hoc wireless Networks, Pearson Education, 2 <sup>nd</sup> Edition, reprint 2005.
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**REFERENCE BOOKS**

1	Ozan K. Tonguz, Gianguigi Ferrari	Ad hoc wireless networks: a communication-theoretic perspective, Hoboken: Wiley, 2009.
2	Xiuzhen Cheng, Xiao Hung, Ding- Zhu Du	Ad hoc wireless Networking, Springer publishers, 2011.

**E-Resources:**

1	<a href="https://www.digimat.in/nptel/courses/video/106105160/L01.html">https://www.digimat.in/nptel/courses/video/106105160/L01.html</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Describe the fundamental concepts and issues in Adhoc Wireless Networks.
CO2	Analyse the MAC protocols of Adhoc Wireless Networks.
CO3	Classify Routing protocols of Adhoc Wireless Networks.

CO4	Analyze Routing protocols and transport layer protocols of Adhoc Wireless Networks.
CO5	Analyze transport layer protocols of Adhoc Wireless Networks.

### Course Articulation Matrix

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2										3	
	CO2	3	2	1									2	
	CO3	3	2			1			1					1
	CO4	3	2	1					1	1				1
	CO5	3	2	1									2	

## WIRELESS SENSOR NETWORKS

Contact Hours/ Week:	: 3+0+0	Credits :	3
Total Lecture Hours:	: 42	CIE Marks :	50
Sub. Code:	: SECE14	SEE Marks :	50

### Course objectives:

This course will enable students to:

1.	To introduce the challenges in deployment of WSN and issues in IOT.
2.	Acquire the knowledge of various sensor network standards and protocols for WSN.
3.	Emphasis on the practical implementation of sensor network scenarios.

### UNIT I

Introduction, Challenges for WSNs, Development of WSN, Hardware components, Energy consumption of sensor nodes, Operating systems and execution environments, Examples of sensor nodes-'MICA MOTE' family, EYES node, BTnodes.

**8 Hours**

### UNIT II

Sensor network scenarios-Sources and Sinks, single hop vs. multihop, optimization goals and figures of merit, Design principles for WSNs, Physical layer and transceiver design considerations in WSNs.

**8 Hours**

### UNIT III

Practical implementation issues-Partitioning decision, Transducer interfaces, Time based accuracy and average power consumption, Power management, Antennas and RF performance definitions.

**8 Hours**

### UNIT IV

MAC protocols for WSN, Low duty cycle protocols and wakeup concepts (STEM, SMAC), Contention based protocols, schedule based Protocols. Energy efficient unicast, Routing for mobile nodes- mobile sinks, mobile data collectors.

**9 Hours**

<b>UNIT V</b>		
Wireless sensor network standards-IEEE 802.15.4 Low rate WPAN standard, The ZIGBEE alliance etc. Future trends in wireless sensor networks: Wireless Multimedia Sensor Networks, Sensor Network Applications in Challenging Environments.		
<b>9 Hours</b>		
<b>TEXT BOOKS</b>		
1	Edgar H. Callaway Jr.	Wireless Sensor Networks - Architectures and Protocols, AUERBACH Publications, CRC Press, 2004.
<b>REFERENCE BOOKS</b>		
1	J. Zheng and A. Jamalipour,	Wireless Sensor Networks: A Networking Perspective, John Wiley & Sons, 2009.
2	Holger Karl, Andreas Willig	Protocols and Architectures for Wireless Sensor Networks, John Wiley, 2006.
<b>E-Resources:</b>		
1	<a href="https://www.digimat.in/nptel/courses/video/106105160/L01.html">https://www.digimat.in/nptel/courses/video/106105160/L01.html</a>	

<b>Course Outcomes:</b>	
Upon completion of this course the student will be able to:	
CO1	Apply the knowledge of network technology to understand the challenges of WSN.
CO2	Analyse the network scenario of sensor network and its design principles.
CO3	Demonstrate the practical implementation issue of WSN.
CO4	Analyse the MAC protocols used in WSN implementation.
CO5	Analyse the WSN IEEE standards and design the application.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
<b>COs</b>	CO1	3	2										3	
	CO2	3	2	1		2								1
	CO3	3	2			2								1
	CO4	3	2	1					1	1				1
	CO5	3	2	1					1				2	

## RADAR SYSTEMS FOR AUTONOMOUS DRIVING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE15	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Use radar techniques for target detection and tracking in autonomous driving scenario.
2. Examine real-world case studies and applications of radar systems in autonomous cars, including adaptive cruise control (ACC), collision avoidance, pedestrian detection, and intersection management.

### UNIT I

**Fundamentals of Radar Systems:** Introduction, Essential Functions of Radar, Radar System Fundamentals, Antennas for Radar Measurements, Challenges for Automotive Radar Developers, Mathematical model of Radar Range Equation, Radar Equation for Automotive Applications.

**8 Hours**

### UNIT II

**FMCW Radars:** Fundamentals, Block diagram of FMCW radars, Range and Velocity measurement using FMCW radars, Range resolution, velocity resolution, Application of FMCW radars for Autonomous driving, Case Study: TI FMCW Radar.

**9 Hours**

### UNIT III

**LiDAR for Autonomous Driving:** Introduction to LiDAR, Types of LiDAR, Components and architecture of a typical LiDAR system, Role of LiDAR in autonomous vehicles, Object detection and classification using LiDAR, Range measurement using LiDAR, Current limitations and challenges in LiDAR technology.

**9 Hours**

<b>UNIT IV</b>	
<b>Modern Radar Sensors in Advanced Automotive Architectures:</b> Motivation for Advanced Systems, The Evolving Automotive Radar Landscape, Vehicle Network and Compute Considerations, Design Considerations for Automotive Radar.	
<b>8 Hours</b>	
<b>UNIT V</b>	
<b>Automotive Radar Applications:</b> Introduction, Short-Range Radar (SRR, Long-Range Radar (LRR), Trends in Automotive Applications, Future Roadmaps Automotive Applications, Future Contributions of Automotive Applications.	
<b>8 Hours</b>	

<b>TEXT BOOKS</b>		
1	Jonah Gamba	Radar Signal Processing for Autonomous Driving, Springer, 2020.
2	Matt Markel	Radar for Fully Autonomous Driving, Artech House, 2022.
<b>REFERENCE BOOKS</b>		
1	Merrill I. Skolnik	Handbook of Radar Systems, McGraw Hill; 3 <sup>rd</sup> edition, 2008.
2	Pinliang Dong	LiDAR Remote Sensing and Applications, CRC Press, 2017.
<b>E-RESOURCES</b>		
1	Merrill I. Skolnik	Handbook of Radar Systems, McGraw Hill; 3 <sup>rd</sup> edition, 2008.
2	Pinliang Dong	LiDAR Remote Sensing and Applications, CRC Press, 2017.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Identify the key components of a radar system and their functions for autonomous cars.
CO2	Analyze the advantages and challenges of using radar in various driving scenarios.
CO3	Interpret radar signal processing algorithms and their impact on object detection, tracking, and localization.
CO4	Assess the performance metrics of radar systems, such as range, resolution, accuracy, and sensitivity.
CO5	Analyze the limitations and potential improvements of radar technology for future autonomous driving applications.

**Course Articulation Matrix**

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	CO1	2	1											2	
	CO2	2	3	2										2	
	CO3	2	2	2										2	
	CO4	2	2											2	
	CO5	2	1											1	

## INTRODUCTION TO QUANTUM INFORMATION AND COMPUTING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE16	SEE Marks:	50

**Prerequisites:** Linear Algebra

### Course objectives:

This course will enable students to:

1.	Become familiar with 1-qubit and 2-qubit gate operations and gain the ability to build simple quantum circuits.
2.	Become familiar with the concepts of superposition and entanglement and be able to analyze quantum state transformations
3.	Understand quantum algorithms (Deutsch-Jozsa, Bernstein Vazirani, Grover, and Shor) and compare effectiveness versus classical algorithms
4.	Understand the problem of noise and analyze the effectiveness of simple error correction codes.
5.	Become familiar with NISQ model of computation, and perform intelligent qubit mapping and error mitigation.

### UNIT I

**Basics of quantum computing** Superposition, Polarization of light, Single qubit notation, Measurement of Qubit, BB84 Quantum Key Dist, Bloch Sphere Notation. Model of computation (movement on Bloch Sphere), X, Y, Z, H gates, CNOT, Toffoli, Fredkin, SWAP gate, Simple circuits.

**8 Hours**

### UNIT II

**Quantum entanglement:** Entangled States, Testing for Entangled States, Bell Pair and Bell States, EPR Paradox & Bell Theorem, Conditional Instructions, Quantum Teleportation, Super dense Coding.

**8 Hours**

<b>UNIT III</b>	
<b>Simple quantum algorithms:</b> Deutsch algorithm-Types of functions, classical computation, Deutsch-Jozsa algorithm, Bernstein Vazirani algorithm-Input/output entanglement, Grover algorithm-Geometrical interpretation, Grover operator, Grover rotation-interpretation, maximum iterations, diffusion operator.	
<b>9 Hours</b>	
<b>UNIT IV</b>	
<b>Quantum error correction:</b> Types of errors, Device Level Metrics, System Level Metrics, Bench-marking, Current machines (5-50 qubit), What is NISQ Model? NISQ Metrics, Qubit Mapping Problem, Qubit Allocation Problem.	
<b>8 Hours</b>	
<b>UNIT V</b>	
<b>Programming a quantum computer:</b> The IBMQ, coding a quantum computer using a simulator to carry out basic quantum measurement and state analysis, programming using IBM quantum experience and circuit composer.	
<b>9 Hours</b>	

<b>TEXT BOOKS</b>		
1	<b>Phillip Kaye,</b> <b>Raymond Laflamme</b> <b>et. al</b>	An Introduction to Quantum Computing, Oxford University Press, 1 <sup>st</sup> Edition, 2007.
2	Eleanor Rieffel and Wolfgang Polak	Quantum Computing: A Gentle Introduction, The MIT Press, Illustrated Edition, 2014.

<b>REFERENCE BOOKS</b>		
1	M. A. Nielsen & I. Chuang	Quantum Computation and Quantum Information, Cambridge University Press, 2013.
2	Chris Bernhardt	Quantum Computing for Everyone, The MIT Press, Cambridge, 2020.

**Course Outcomes:**

Upon completion of this course the student will be able to:

<b>CO1</b>	Analyze simple states of superposition and the effect of doing the measurement in different basis states and build simple quantum circuits with single and two-qubit gates.
<b>CO2</b>	Analyze quantum circuits with entanglement.
<b>CO3</b>	Analyze simple quantum algorithms and complexity
<b>CO4</b>	Implement quantum programs in NISQ model of computing
<b>CO5</b>	Build circuits using circuit composer or Qiskit

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			2			2	2			2	2
	CO2	3	2			2			2	2			2	2
	CO3	3	2			2			2	2			2	2
	CO4	3	2	2		2			2	2			2	2
	CO5	3	1			2			2	2			2	2

## MODERN WIRELESS STANDARDS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 39	CIE Marks:	50
Sub. Code:	: SECE17	SEE Marks:	50

### Course objectives:

This course will enable students to:

- |    |  |
|----|--|
| 1. | Learn different wireless architectures                                       |
| 2. | Understand different wireless standards                                      |
| 3. | Acquire the knowledge about the technologies related to 5G wireless standard |

### UNIT I

**GSM Architecture, interfaces and Radio link features:** Introduction, GSM frequency bands, GSM PLMN, Objectives of a GSM PLMN, GSM PLMN Services, GSM Subsystems, GSM Subsystems entities, GSM interfaces, The radio interface (MS to BSC), Abits interface (BTS to BSC), A interface (BSC to MSC), Interfaces between other GSM entities, Mapping of GSM layers onto OSI layers. Radio link measurements, Radio link features of GSM, Dynamic power control, Discontinuous transmission (DTX), SFH, Future techniques to reduce interface in GSM, channel borrowing, smart antenna.

**8 Hours**

### UNIT II

**GSM logical channels and frame structure:** Introduction, GSM logical channels, allowed logical channel combinations, TCH multi frame for TCH/H, CCH multi frame, GSM frame structure, GSM bursts, Normal burst, Synchronization burst, Frequency correction channel burst, Access burst, Data encryption in GSM, Mobility management, Location registration, Mobile identification.

**8 Hours**

### UNIT III

**Code Division Multiple Access:** Introduction to CDMA technology, IS 95 system architecture, Air interface, Physical and logical channels of IS 95, Forward link and Reverse link operation, Physical and Logical channels of IS 95 CDMA, IS 95

CDMA call processing, soft handoff, evolution of IS 95 (CDMA One) to CDMA 2000, CDMA 2000 layering structure and channels.

**8 Hours**

#### UNIT IV

**Higher generation Cellular standards:** 3G standards, evolved EDGE, enhancement in 4G standard, Architecture and representative protocols, call flow for LTE, VoLTE, UMTS.

**8 Hours**

#### UNIT V

**5G Wireless Standards:** Non Orthogonal Multiple Access, Co-operative communication systems, Co-operative MIMO model, Massive MIMO, Cognitive Radio and Spectrum Sensing, millimetre wave.

**7 Hours**

#### TEXT BOOKS

1	V.K.Garg, J.E.Wilkes	Principles and Applications of GSM, PHI, 5 <sup>th</sup> Edition, 2008.
2	V.K.Garg, J.E.Wilkes	IS-95 CDMA and CDMA 2000, PHI, 4 <sup>th</sup> Edition, 2009.
3	Afif Osseiran, Jose F. Monserat, Patrick Marsch	5G Mobile and Wireless Communication Technology, 1 <sup>st</sup> Edition, Cambridge University Press, 2016.

#### REFERENCE BOOKS

1	Andy Dornan	The essential guide to wireless communications applications: from cellular systems to Wi-Fi, 2 <sup>nd</sup> Edition, Prentice Hall, 2002.
2	Misra	Wireless Communications and Networks: 3G & Beyond, Tata McGraw-Hill, 2009.

#### Course Outcomes :

Upon completion of this course the student will be able to:

CO1	Analyze the architecture of different wireless standards.
CO2	Differentiate between logical channels and frame structure.
CO3	Analyze CDMA based wireless networks.

CO4	Analyze higher generation cellular standards.
CO5	Identify and analyze the technologies of 5G wireless standards.

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	C01	3	2										1	1
	C02	3	2	1		2							1	1
	C03	3	2			2							1	1
	C04	3	2	1					1	1			1	1
	C05	3	2	1					1				1	1

## INTEGRATED SENSING AND COMMUNICATIONS

Contact Hours/Week:	3+0+0	Credits:	3
Total Lecture Hours:	42	CIE Marks:	50
Sub. Code:	SECE49	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Impart a comprehensive understanding of the principles, architecture, and benefits of integrating sensing and communication systems, along with the trade-offs and challenges involved in their joint design.
2.	Develop the ability to analyze and design signal processing and communication techniques that support both radar sensing and wireless data transmission within shared spectrum environments.
3.	Explore advanced use cases and emerging technologies such as Reconfigurable Intelligent Surfaces (RIS) and their role in enhancing ISAC systems for future applications in automotive, healthcare, and smart environments.

### UNIT-I

#### **Fundamentals of Integrated Sensing and Communications (ISAC):**

Introduction to ISAC: Motivation, Vision, and Applications, Evolution from traditional sensing and communications to ISAC, System architecture and classification of ISAC systems, Benefits and challenges of integrating sensing and communication, Spectrum sharing in ISAC systems, Key performance metrics: trade-offs between sensing and communication.

**8 Hours**

### UNIT-II

**Signal Processing Fundamentals for ISAC:** Signal models for joint radar and communication systems, Detection theory and estimation fundamentals for sensing, Target detection and parameter estimation (range, velocity, angle), Sensing parameter estimation in noisy environments. Waveform design and optimization for dual-purpose operation, Time-frequency analysis for ISAC signals.

**9 Hours**

<b>UNIT-III</b>	
<b>Communication Fundamentals for ISAC:</b> Modulation techniques suitable for ISAC (OFDM, chirp signals, etc.), Multiple access and MIMO techniques for ISAC, Channel estimation and equalization in joint systems - Interference management and mitigation in shared spectrum, Information theory perspectives of ISAC, Sensing-aided communication enhancements (e.g., adaptive beamforming).	
<b>9 Hours</b>	
<b>UNIT-IV</b>	
<b>Use Cases for ISAC:</b> Automotive radar and vehicular communications (V2X), ISAC in smart cities and intelligent transportation systems, Indoor sensing and positioning using ISAC, Surveillance and security applications, Healthcare monitoring using ISAC technologies, Case studies: mmWave automotive radar, joint communication-radar prototypes.	
<b>8 Hours</b>	
<b>UNIT-V</b>	
<b>Emerging Trends for ISAC:</b> Introduction to Reconfigurable Intelligent Surfaces (RIS), Role of RIS in ISAC system enhancement, Channel modeling and estimation in RIS-assisted ISAC, RIS-aided waveform design for joint sensing and communication, 6G ISAC networks.	
<b>8 Hours</b>	

**TEXT BOOKS**

1	Cui, Yuanhao, Fan Liu, Christos Masouros	Integrated sensing and communications, Springer Nature Singapore, 2023.
2	Kaushik, Aryan	Integrated Sensing and Communications for Future Wireless Networks: Principles, Advances and Key Enabling Technologies, Elsevier, 2024.

**E-RESOURCES**

1	<a href="https://youtu.be/pIv9xJEE1QA?si=RUFL6LXcRYqrEjft">https://youtu.be/pIv9xJEE1QA?si=RUFL6LXcRYqrEjft</a>
2	<a href="https://youtu.be/avppIElWuI4?si=lkgJav-kvhS68x7m">https://youtu.be/avppIElWuI4?si=lkgJav-kvhS68x7m</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply the foundational concepts of integrated sensing and communication systems to analyze their architecture and operational trade-offs in real-world applications.
CO2	Analyze the signal processing techniques used in ISAC systems to understand target detection and parameter estimation under various operating conditions.
CO3	Evaluate communication system components such as modulation, channel estimation, and interference management strategies for their effectiveness in ISAC environments.
CO4	Analyze diverse radar-based ISAC use cases like automotive radar, smart cities, and indoor positioning to identify technological requirements and challenges
CO5	Evaluate the role of Reconfigurable Intelligent Surfaces in enhancing ISAC performance through adaptive beamforming and intelligent environment reconfiguration.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2			1			1			1	2	1
	CO2	2	2			1			1			1	2	1
	CO3	2	2			1			1			1	2	1
	CO4	2	2			1			1			1	2	1
	CO5	2	2			1			1			1	2	1

**II. SIGNAL PROCESSING:****ADVANCED SIGNAL PROCESSING**

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE18	SEE Marks:	50

**Course objectives:**

This course will enable students to:

1. To understand the fundamentals of multirate signal processing.
2. Learn its applications in communication systems and signal processing

**UNIT I**

Review of Signals and Systems – Discrete time processing of continuous signals - Frequency domain analysis of a digital filter; Quantization error; Fourier Analysis – DFT, DTFT, DFT as an estimate of the DTFT for Spectral estimation. DFT for convolution, DFT/DCT for compression, FFT. Ideal Vs non ideal filters, Digital Filters – State Space realization, Robust implementation of Digital Filters, Robust implementation of equi – ripple FIR digital filters.

**9 Hours****UNIT II**

Multirate Systems and Signal Processing. Fundamentals – Problems and definitions; Up sampling and down sampling; Sampling rate conversion by a rational factor;  
Multistage implementation of digital filters; Efficient implementation of multirate systems.

**8 Hours****UNIT III**

DFT filter banks and Transmultiplexers – DFT filter banks, Maximally Decimated DFT filter banks and Transmultiplexers. Application of transmultiplexers in communications Modulation.

**8 Hours**

**UNIT IV**

Maximally Decimated Filter banks – Vector spaces, Two Channel Perfect Reconstruction conditions; Design of PR filters Lattice Implementations of Orthonormal Filter Banks, Applications of Maximally Decimated filter banks to an audio signal.

**9 Hours****UNIT V**

Introduction to Time Frequency Expansion; The STFT; The Gabor Transform, The Wavelet Transform; The Wavelet transform; Recursive Multi resolution Decomposition.

**8 Hours****TEXT BOOKS**

1	Roberto Cristi	Modern Digital Signal Processing, Cengage Publishers, India, (erstwhile Thompson Publications), 2003.
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**REFERENCE BOOKS**

1	S.K. Mitra	Digital Signal Processing: A Computer Based Approach, Tata McGraw Hill, 3 <sup>rd</sup> Edition, India, 2007.
2	E.C. Ifeachor and B W Jarvis	Digital Signal Processing, a practitioners approach, Pearson Education, 2 <sup>nd</sup> Edition, India, 2002 Reprint.
3	Proakis and Manolakis	Digital Signal Processing, Prentice Hall, 3 <sup>rd</sup> Edition, 1996.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Design and Analyze discrete time systems and implement
CO2	Derive an efficient implementation of discrete time system using multirate operations and polyphase decomposition
CO3	Design and analyze filter banks and transmultiplexers using DFT concept

CO4	Analyze perfect reconstruction filter banks using orthogonal basis functions and time frequency representation of signals
CO5	Demonstrate the capacity of self-learning and communication skills through simulation of discrete time systems using Matlab/Scilab/Simulink

### Course Articulation Matrix

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			1							2	
	CO2	3	2			1							2	
	CO3	3	2			1							2	
	CO4	3	2			1							2	
	CO5	3	2			1							2	

## DIGITAL IMAGE PROCESSING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE19	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand fundamentals of digital image processing and image processing algorithms.

### UNIT I

**Digital Image Fundamentals:** Fundamental Steps in Digital Image Processing, Components of an Image Processing System, Image Sampling and Quantization, Some Basic Relationships between Pixels, connected component analysis.

**Color Models :** RGB, CMY, HSV, YCbCr, LAB.

**8 Hours**

### UNIT II

**Enhancement in Spatial Domain:** Interpolation techniques: Nearest neighbor, Bilinear, bicubic.

Some Basic Intensity Transformation Functions, Histogram Processing, Fundamentals of Spatial Filtering, Smoothing Spatial Filters, Sharpening Spatial Filters.

**8 Hours**

### UNIT III

**Image Transforms and Enhancement in Frequency Domain :** Two-dimensional orthogonal & unitary transforms, Two dimensional Discrete Fourier transform, Discrete cosine transform, Hadamard transform, KL transform.

Image Smoothing Using Frequency Domain Filters, Image Sharpening Using Frequency Domain Filters.

**9 Hours**

### UNIT IV

**Image Restoration:** A Model of the Image Degradation/Restoration Process, Restoration in the Presence of Noise Only-Spatial Filtering, Linear, Position-Invariant Degradations, Estimating the Degradation Function, Inverse Filtering, Minimum Mean Square Error (Wiener) Filtering, Geometric Mean Filter.

**8 Hours**

**UNIT V**

**Image Segmentation:** Fundamentals, Point, Line and Edge Detection, Hough transform, Thresholding, Region-Based Segmentation, watershed and grabcut algorithms.

**Morphological Image Processing:** Preliminaries, Erosion and Dilation, Opening and Closing

**9 Hours**

1. Enhancement of a given image, restoration of a degraded image and quality assessment using PSNR, MSE, SSIM
2. Defect area segmentation in PCB given the reference design image and captured image.
3. Character extraction from license plates
4. Lane detection
5. Pothole detection
6. People Counting

**TEXT BOOKS**

1	Rafael C. Gonzalez and Richard E. Woods	Digital Image Processing, 4 <sup>th</sup> Edition, Pearson Education, 2018.
2	Anil K. Jain	Fundamentals of Digital Image Processing, PHI, 2011.

**REFERENCE BOOKS**

1	Jayaraman, Esakkirajan, Veerakumar	Digital Image Processing and Analysis, Mc Graw Hill India, 2009.
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**E-RESOURCES**

1	<a href="https://archive.nptel.ac.in/courses/117/105/117105135/">https://archive.nptel.ac.in/courses/117/105/117105135/</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Identify various steps and components in a digital image processing system, analyze digital images in spatial domain.
CO2	Choose a suitable technique in spatial domain to enhance a given image
CO3	Analyze an Image in transform domain, choose a suitable technique in transform domain to enhance a given image.
CO4	Develop a suitable model for image degradation and perform image restoration.

CO5	Apply various image segmentation techniques/morphological operations to partition image into regions or objects.
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### Course Articulation Matrix

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	<b>CO1</b>	3	2			1								3	
	<b>CO2</b>	3	2			1								3	
	<b>CO3</b>	3	2			1								3	
	<b>CO4</b>	3	2			1								3	
	<b>CO5</b>	3	2			1								3	

## DSP ALGORITHMS AND ARCHITECTURE

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE21	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Learn the architecture of digital signal processors
2. Implement DSP algorithms.

### UNIT I

#### Introduction to Digital Signal Processing

Introduction, A Digital Signal-Processing System, The Sampling Process, Discrete Time Sequences, Discrete Fourier Transform (DFT) and Fast Fourier Transform (FFT), Linear Time-Invariant Systems, Digital Filters, Decimation and Interpolation. **Architectures for Programmable Digital Signal-Processing Devices:** Introduction, Basic Architectural Features, DSP Computational Building Blocks.

**9 Hours**

### UNIT II

#### Architectures for Programmable Digital Signal-Processing Devices(Contd...):

Bus Architecture and Memory, Data Addressing Capabilities, Address Generation Unit, Programmability and Program Execution, Speed Issues, Features for External Interfacing. **Programmable Digital Signal Processors:** Introduction, Commercial Digital Signal-processing Devices, Architecture of TMS320C54xx Digital Signal Processors, Data Addressing Modes of TMS320C54xx Processors.

**9 Hours**

### UNIT III

**Programmable Digital Signal Processors (Contd...):** Memory Space of TMS320C54xx Processors, Program Control, TMS320C54xx Instructions and Programming, On-Chip peripherals, Interrupts of TMS320C54xx Processors, Pipeline Operation of TMS320C54xx Processors.

**8 Hours**

**UNIT IV****Implementations of Basic DSP Algorithms**

Introduction, The Q-notation, FIR Filters, IIR Filters, Implementation of FFT Algorithms, Introduction, An FFT Algorithm for DFT Computation, A Butterfly Computation, Overflow and Scaling, Bit-Reversed Index Generation, FFT Implementation on the TMS320C54xx, Computation of the Signal Spectrum.

**8 Hours****UNIT V****Interfacing Memory and Parallel I/O Peripherals to Programmable DSP Devices**

Introduction, Memory Space Organization, External Bus Interfacing Signals, Memory Interface, Parallel I/O Interface, Programmed I/O, Interrupts and I/O, Direct Memory Access (DMA).

**8 Hours****TEXT BOOKS**

1	Avatar Singh and S. Srinivasan	Digital signal processing Implementations using DSP microprocessors with examples from TMS320C54xx, Tenth Indian Reprint, Cengage Learning, 2010.
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**REFERENCE BOOKS**

1	Texas Instruments	TMS320C54x DSP Reference Set Vol. 1: CPU and peripherals, 2001.
2	Texas Instruments	TMS320C54x DSP Reference Set Vol. 2: Mnemonic Instruction Set, 2001.
3	Ifeachor E. C., Jervis B. W	Digital signal processing: A practical approach, Pearson Education, 2 <sup>nd</sup> Edition, 2002.
4	B. Venakataramani and M. Bhaskar	Digital Signal Processors, TMH, 2002.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Identify the need of basic DSP operations, formulate the logic and provide hardware solutions to implement these operations.
CO2	Identify and apply the architectural features of TMS320C54xx to provide efficient design solutions.
CO3	Develop ALP for TMS320C54xx DSP processors exploring different functional units and addressing modes.
CO4	Provide solutions for signal processing problems by implementing FFT, FIR and IIR algorithms on TMS320C54xx processor.
CO5	Design an interfacing circuit to connect DSP processor to memory and peripherals.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2										2	
	CO2	2	2										1	
	CO3	2	2	1									2	
	CO4	2	2	1									2	1
	CO5	2	2	1									2	1

## WAVELET TRANSFORMS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE22	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	To establish the theory necessary to understand and use wavelets in signal processing.
2.	To understand the different types of wavelets.
3.	To apply wavelets for speech, image and video compression

### UNIT I

Introduction: Review of Fourier theory, why wavelets, filter banks, multi-resolution analysis?

Continuous time bases and wavelets: Introduction, C-T wavelets, definition of CWT, CWT as a correlation, Constant Q-Factor filtering interpolation and time-frequency resolution, CWT as an operator, inverse CWT.

**10 Hours**

### UNIT II

Discrete-time bases and wavelets: Approximation of vectors in nested linear vector spaces, (i) example of approximating vectors in nested subspaces of a finite dimensional linear vector space: (ii) example of approximating vectors in nested subspaces of an infinite dimensional of vectors in linear vector spaces.

**9 Hours**

### UNIT III

Multi-resolution analysis: Formal definition of MRA, construction of a general orthonormal MRA (i) scaling function and subspaces, (ii) implication of dilation equation and orthogonality, a wavelet basis for MRA (i) two scale relations for (t), (ii) basis for the detail subspace (iii) direct sum decomposition, digital filtering interpolation (i) decomposition filters, (ii) reconstruction of the signal, Example

MRA (i) bases for the approximations subspaces and Harr scaling function, (ii) bases for detail subspaces and Harr wavelet.
<b>10 Hours</b>
<b>UNIT IV</b>
Examples of wavelets: Examples of orthogonal basis generating wavelets, (i) Daubechies $D_4$ scaling function and wavelet (ii) band limited wavelets, interpreting orthogonal MRAs for discrete time MRA (iii) basis functions for DWT.
<b>7 Hours</b>
<b>UNIT V</b>
Applications: Speech, audio, image and video compression, denoising, feature extraction, inverse problems.
<b>6 Hours</b>

**TEXT BOOKS**

1	Raghuveer M. Rao and Ajit S. Bopardikar	Wavelet transforms-Introduction to theory and applications, Pearson Education, 2000.
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**REFERENCE BOOKS**

1	Prasad and Iyengar	Wavelet transforms, Wiley Eastern, 2001.
2	Gilbert Strang and Nguyen Yegnanarayana	Wavelet and filter banks, Wellesley Cambridge Press, 1996

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Discuss the basics of continuous wavelet transform and its properties
CO2	Implement discrete type wavelets for vectors approximation
CO3	Apply multi-resolution analysis for subspaces
CO4	Analyse different types of wavelets
CO5	Illustrate the use of wavelets for Speech, audio, image and video compression

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3											2	
	CO2	3	2										2	
	CO3	3	2			1							2	
	CO4	3	1			1							2	
	CO5	3	1			1							2	

## ARTIFICIAL NEURAL NETWORKS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE23	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Learn basic differences between human and machine intelligence. Understand the attractive features of the biological neural networks to realize some of features through parallel and distributed processing models.
2.	Explain the biological and mathematical foundations of neural network models.
3.	Learn different learning models to train an artificial neural network.
4.	Identify various pattern recognition tasks & select suitable neural network architectures.
5.	Design, build and train neural networks to solve various pattern recognition tasks.

### UNIT I

**Review of Linear algebra:** Linear combination of vectors, linearly dependent and independent set of vectors, Vector space, subspace, basis, rank, Eigen vectors, orthogonal vectors, inner product, outer product.(No questions will appear in the end exam from these topics).

**Basics of Artificial Neural Networks:** Trends in computing, Pattern and Data, Pattern recognition tasks. Basic methods of pattern recognition, Basics of Artificial Neural Networks, Biological Neural Network, Models of neuron: McCulloch-Pitts Model, Perceptron, Adaline, topology, Supervised and unsupervised learning, Basic learning laws, Realization of logic functions using MP neuron.

**9 Hours**

### UNIT II

**Functional units of ANN & Single layer perceptron:** Basic ANN Models (architectures) for Pattern recognition task, Pattern recognition tasks by i) Feed-

forward ii) Feed-back iii) competitive learning Neural networks. Feed-forward neural network: Linear associative network, Analysis of pattern classification networks, Linear separability, Perceptron convergence theorem.		
<b>8 Hours</b>		
<b>UNIT III</b>		
<b>Multi-Layer perceptron:</b> Linear Inseparability: Hard problems, MLFFNN: Back propagation learning, Draw backs of back propagation algorithm, Heuristics to improve the performance of Back propagation learning discussion on error back propagation, Convolution neural network ( <b>CNN</b> ).		
<b>8 Hours</b>		
<b>UNIT IV</b>		
<b>Feedback Neural Networks:</b> Analysis of pattern storage networks, The Hopfield Model, Energy analysis of Hopfield model, State transition diagram, Pattern storage: Hard problems, Stochastic Networks and simulated annealing.		
<b>Competitive learning network:</b> Basic competitive learning, Analysis of pattern clustering Networks. Analysis of Feature Mapping Network.		
<b>8 Hours</b>		
<b>UNIT V</b>		
<b>Architectures for complex pattern recognition tasks:</b> Bidirectional associative memory, Architecture of Radial basis function (RBF) networks, Theorems for function approximation, RBF networks for function approximation, Covers theorem on separability of patterns, The XOR problem, RBF Networks for pattern Classification, comparison of RBF with MLP networks.		
<b>9 Hours</b>		
<b>TEXT BOOKS</b>		
1	B. Yegnanarayana	Artificial neural networks, PHI, 2010.
<b>REFERENCE BOOKS</b>		
1	Simon Haykin	Neural Networks for Pattern Recognition, Pearson Education Limited, 2004.
2	Robert J. Schalkoff	Artificial Neural Networks, Mcgraw-Hill Inc., 2004.
3	Jacek M. Zurada	Introduction to artificial neural systems, Jaico publishing house, 2003.

4	Christopher M. Bishop	Neural networks for pattern recognition, Oxford University Press (1995)
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**E-RESOURCES**

1	<a href="https://onlinecourses.nptel.ac.in/noc22_cs73/course">https://onlinecourses.nptel.ac.in/noc22_cs73/course</a>
2	<a href="https://onlinecourses.nptel.ac.in/noc22_cs124">https://onlinecourses.nptel.ac.in/noc22_cs124</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Distinguish between human and machine intelligence
CO2	Analyze various learning methods of neural networks.
CO3	Illustrate the use of feed-forward neural network for simple pattern recognition tasks.
CO4	Illustrate use of feed-back neural network for pattern storage problems.
CO5	Apply Radial basis function networks for complex pattern recognition tasks

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3												
	CO2	3	2	2		2							2	2
	CO3	3	2	2		2							2	2
	CO4	3	2	2									2	2
	CO5	3	2	2									2	2

## MEDICAL IMAGE PROCESSING

Contact Hours/ Week:	3+0+0	Credits:	3
Total Lecture Hours:	42	CIE Marks:	50
Sub. Code:	SECE24	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand various medical imaging modalities, acquisition techniques with advantages and limitations.
2. Understand processing of medical images to improve visualization and extract region of interest.

### UNIT I

**Introduction to Bio-medical Images:** Introduction, Block diagram of Computer Aided Diagnosis (CAD), Objectives of bio medical image analysis, Nature of biomedical images, body temperature as an image, Transillumination, Medical imaging types and modalities: X-ray Imaging, Computed Tomography (CT), Nuclear medicine imaging, Ultrasound Imaging, Magnetic Resonance Imaging (MRI).

**9 Hours**

### UNIT II

**Image Quality and Information content:** Difficulties in biomedical Image acquisition and analysis, Characterization of Image quality, review of concept of sampling and quantization, spatial and gray level resolution, optical density, dynamic range, contrast, histogram, entropy, blur and spread functions with reference to medical images, Fourier spectra of biomedical images.

**9 Hours**

### UNIT III

**Biomedical Image denoising:** Characterization of artifacts or noise in biomedical images, examples of noise PDFs, power line interference in biomedical images, physiological interference, signal dependent noise, multiframe averaging in confocal microscopy, mean filters, order statistics filters. Noise reduction in nuclear medicine imaging.

**8 Hours**

**UNIT IV**

**Biomedical Image enhancement::** Digital subtraction angiography, Dual energy and energy subtraction X-ray imaging, temporal subtraction, Gray scale transforms, Histogram transformation, unsharp masking, high frequency emphasis, homomorphic filtering applied to medical images.

**8 Hours****UNIT V**

**Biomedical Image Segmentation:** Thresholding and binarization, detection of isolated points and lines, edge detection, Laplacian of Gaussian (LOG), Canny's method for edge detection, Fourier domain methods for edge detection, region growing, splitting and merging applied to Medical Images.

**8 Hours****TEXT BOOKS**

1	Rangaraj M Rangayyan	Biomedical Image Analysis, CRC Press, 1 <sup>st</sup> Edition, 2004.
2	Geoff Dougherty	Digital Image Processing for Medical Applications, Cambridge University Press, 1 <sup>st</sup> Edition, 2010.

**REFERENCE BOOKS**

1	Klaus D. Toennies	Guide to Medical Image Analysis-Methods and Algorithms, Springer, 1 <sup>st</sup> Edition, 2012.
2	James S Dankan and Nicholas Ayache	Medical Image Analysis: Progress over two decades and the Challenges ahead, IEEE Transactions on PAMI, vol 22, No. 1, Jan 2000.
3	Rafael C. Gonzalez and Richard E. Woods	Digital Image Processing, Pearson Education, 4 <sup>th</sup> Edition, 2018.

**E-Resources:**

1	<a href="https://onlinecourses.nptel.ac.in/noc22_bt34/preview">https://onlinecourses.nptel.ac.in/noc22_bt34/preview</a>
2	<a href="https://onlinecourses.nptel.ac.in/noc20_ee40/preview">https://onlinecourses.nptel.ac.in/noc20_ee40/preview</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Identify various blocks of computer aided diagnosis system and objectives of biomedical image analysis, compare and contrast various medical imaging modalities.
CO2	Identify the difficulties in biomedical image acquisition and analysis, characterize medical images w r t resolution, contrast, and entropy.
CO3	Characterize noise/artifacts in biomedical images, apply suitable filters for denoising.
CO4	Choose and apply a suitable technique to enhance biomedical images.
CO5	Apply various image segmentation techniques for partitioning of medical images to identify the regions of interest.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2										3	
	CO2	3	2			1				1		1	3	1
	CO3	3	2			1				1		1	3	1
	CO4	3	2			1				1		1	3	1
	CO5	3	2			1				1		1	3	1

## DATA SCIENCE

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE25	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Describe the concept of data science, its scope in business and explain the available techniques. (L1, L2)
2.	Understand Predictive modeling, explain supervised segmentation and given data set should be able to select (through solving) the attribute for segmentation using the available techniques. (L2, L3)
3.	Explain the concept of Classification and classify (solve) a given data set. (L3)
4.	Understand and describe the concept of similarity, neighbors and clustering and apply it for any real world data. (L3, L4)
5.	Explain the concepts of mining text and other data science tasks and techniques. (L2, L4)

### UNIT I

**Introduction:** Data-Analytic Thinking: The Ubiquity of Data Opportunities, Example: Hurricane Frances, Example: Predicting Customer Churn. Data Science, Engineering, and Data-Driven Decision Making, Data Processing and “Big Data”, Data and Data Science Capability as a Strategic Asset, Data-Analytic Thinking.

**Business Problems and Data Science Solutions:** From Business Problems to Data Mining Tasks, Supervised Versus Unsupervised Methods, Data Mining and Its Results, The Data Mining Process, Business Understanding, Data Understanding, Data Preparation, Modeling, Evaluation, Deployment, Other Analytics Techniques and Technologies: Statistics, Database Querying, Data Warehousing, Regression Analysis, Machine Learning and Data Mining.

**9 Hours**

<b>UNIT II</b>	
<b>Introduction to Predictive Modeling:</b> From Correlation to Supervised Segmentation Models, Induction, and Prediction, Supervised Segmentation, Selecting Informative Attributes Example: Attribute Selection with Information Gain, Supervised Segmentation with Tree-Structured Models, Visualizing Segmentations, Trees as Sets of Rules, Probability Estimation, Example: Addressing the Churn Problem with Tree Induction.	<b>8 Hours</b>
<b>UNIT III</b>	
<b>Fitting a Model to Data:</b> Classification via Mathematical Functions: Linear Discriminant Functions, Optimizing an Objective Function, An Example of Mining a Linear Discriminant from Data, Linear Discriminant Functions for Scoring and Ranking Instances, Support Vector Machines briefly, Regression via Mathematical Functions, Class Probability Estimation and Logistic “Regression”. Logistic Regression: Some Technical Details. Example: Logistic Regression versus Tree Induction, Non Linear Functions, Support vector machines and Neural Networks. Over fitting and Its Avoidance: Fundamental Concepts, Exemplary Techniques, Regularization, Generalization, Over fitting, Over fitting Examined.	<b>8 Hours</b>
<b>UNIT IV</b>	
<b>Similarity, Neighbors, and Clusters:</b> Similarity and Distance, Nearest-Neighbor Reasoning, Example: Whiskey Analytics, Nearest Neighbors for Predictive Modeling, How Many Neighbors and How Much Influence? Geometric Interpretation, Overfitting, and Complexity Control. Issues with Nearest-Neighbor Methods. Some important Technical Details Relating to Similarities and neighbors. Clustering, Example: Whiskey Analytics Revisited, Hierarchical Clustering, Nearest Neighbors Revisited: Clustering Around Centroids. Understanding the Results of Clustering.	<b>8 Hours</b>

**UNIT V**

**Decision Analytic Thinking I:** What is a Good Model?: Evaluating Classifiers Plain Accuracy and its Problems, The confusion matrix, Problems with unbalanced Classes, Problems with Unequal Costs and Benefits.

**Representing and Mining Text:**

Why Text Is Important? Why Text Is Difficult?

Representation, Bag of Words, Term Frequency, Measuring Sparseness: Inverse Document Frequency, Combining Them: TFIDF, Example: Jazz Musicians

**Other Data Science Tasks and Techniques:** Co-occurrences and Associations: Finding Items That Go Together, Measuring Surprise: Lift and Leverage, Example: Beer and Lottery Tickets, Associations Among Facebook Likes, Profiling: Finding Typical Behavior, Link Prediction and Social Recommendation.

**9 Hours****TEXT BOOKS**

1	Foster Provost and Tom Fawcett	Data Science for Business, Published by O'ReillyMedia, Inc. First Edition, July 2013.
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**REFERENCE BOOKS**

1	Rachel Schutt & Cathy O'Neil	Doing Data Science, O'Reilly Media, 1 <sup>st</sup> Edition, October 2013.
2	Hector Cuesta	Practical Data Analysis, PACKT Publishing, First published: October 2013
3	Michael R. Berthold, Christian Borgelt, Frank Hijppner, Frank Klawonn	Guide to Intelligent Data Analysis, Springer-Verlag London Limited 2010.

<b>Course Outcomes:</b> Upon completion of this course the student will be able to:	
CO1	Apply the knowledge of mathematics to explain the concept of data science, the available techniques in data science and its scope in business.
CO2	Develop a Decision tree based on supervised segmentation and predict the class for a given data set by selecting (through solving) the attribute for segmentation using the available techniques.
CO3	Analyze the given data set, and solve a problem by performing Classification using the basics of mathematics and data science.
CO4	Develop solutions to group entities in data set and apply it for the given real world data using the basic knowledge of similarity, neighbors and clustering.
CO5	Analyze the importance of mining text (social data) and formulate the association rules based on market basket analysis.

### Course Articulation Matrix

		POs										PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	1			3			2	2			2	2
	CO2	3	2			3			2	2			2	2
	CO3	3	2			3			2	2			2	2
	CO4	3	2			3			2	2			2	2
	CO5	3	2			3			2	2			2	2

## DEEP LEARNING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE26	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Provide the mathematical and computational demands of building neural networks
2. Understand the concepts of deep learning
3. Introduce dimensionality reduction techniques
4. Apply deep learning techniques for real time applications

### UNIT I

#### Machine Learning Basics

Learning algorithms: regression - classification - clustering, under fitting and Overfitting, Hyper parameters and validation sets, Estimators, bias and variance, Maximum likelihood estimation, Supervised and Unsupervised learning algorithms, Building a Machine learning algorithm.

**9 Hours**

### UNIT II

#### Foundations of Deep Networks

Neural networks: Perceptron - Multilayer Feedforward Networks - Backpropagation learning, Activation functions: Linear - sigmoid - rectified linear and softmax, Loss functions, regularization, Deep networks: Architecture and design, Pretrained Networks - Deep Belief Networks - Generative Adversarial Networks.

**9 Hours**

### UNIT III

#### Convolutional Neural Networks (Cnns)

Convolutional Operation, Motivation, Pooling layers, Fully connected layers, A complete CNN architecture: AlexNet - VGG - Inception - ResNet, Training a Convnet: weights initialization - batch normalization - hyperparameter optimization, Variants of CNN architecture.

**8 Hours**

**UNIT IV****Sequence Modeling Using Recurrent Nets**

Recurrent Neural Networks (RNN), Bidirectional RNNs, Deep RNNs, Recursive NN, Challenge of long term dependencies, Long Short- Term Memory (LSTM) and other Gated RNNs.

**8 Hours****UNIT V****Applications Of Deep Learning**

Case studies (one in each) in Computer Vision, Speech Processing, Natural Language Processing.

**8 Hours****TEXT BOOKS**

1	Ian Goodfellow, YoshuaBengio, Aaron Courville	Deep Learning, MIT Press, 2016.
2	Josh Patterson, Adam Gibson	Deep Learning: A Practitioner's Approach, O'Reilly Media, 2017.

**REFERENCE BOOKS**

1	Tom Mitchell	Machine Learning, McGraw Hill, 3 <sup>rd</sup> Edition, 1997
2	Charu C. Aggarwal	Data Classification Algorithms and Applications, CRC Press, 2014.
3	Sandro Skansi	Introduction to Deep Learning: From Logical Calculus to Artificial Intelligence, Springer, 2018.
4	Tommaso Teofili	Deep Learning for Search, Manning Publications Company, 2018.

**E-Resources:**

1	<a href="https://www.youtube.com/watch?v=aPfkYu_qiF4&amp;list=PLyqSpQzTE6M9gCgajvQbc68Hk_JKGBAYT&amp;index=1">https://www.youtube.com/watch?v=aPfkYu_qiF4&amp;list=PLyqSpQzTE6M9gCgajvQbc68Hk_JKGBAYT&amp;index=1</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Classify machine learning algorithms and approaches.
CO2	Apply algorithms based on neural networks to perform simple learning tasks like speech recognition, digit recognition.
CO3	Compare different CNN architectures.
CO4	Model a time-series using a recurrent neural net.
CO5	Apply algorithms based on Deep Neural networks to perform speech recognition, face recognition and generative AI application.

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	1	3		3			2	3		2	2	3
	CO2	3	2	3		3			2	3		2	2	3
	CO3	3	2	3		3			2	3		2	2	3
	CO4	3	2	3		3			2	3		2	2	3
	CO5	3	2	3		3			2	3	2	2	2	3

## MACHINE LEARNING

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE27	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Learn a spectrum of machine learning algorithms with a sound mathematical background.
2. Understand technical know-how of applying these algorithms for different real-world applications.

### UNIT I

**Machine learning and Pattern recognition:** Man vs Machine interaction (HCI), Illustrative applications of machine learning, Terminology: Learning, Evaluation, Classification, Regression, A typical machine learning system: Data collection, Data preparation, feature extraction, supervised or unsupervised learning, training, model selection, the curse of dimensionality, Testing, evaluation criterion.

**Review of Probability and random process:** Probability densities, Expectations and covariance, Bayesian probabilities, Gaussian distribution, bias-variance trade off.

Decision Theory, Minimizing the misclassification rate, Minimizing the expected loss, Loss functions, The reject option, Inference and decision, loss functions for regression, demonstration.

**9 Hours**

### UNIT II

#### Linear Models for Classification

Discriminant Functions, Two classes and multiple classes, Fisher linear discriminant, Probabilistic Generative Models, Maximum likelihood solution, error probabilities and internals, error bounds for normal densities, Bayes decision theory-discrete features.

**9 Hours**

**UNIT III****Linear Models for Regression**

Linear Basis Function Models, The Bias-Variance Decomposition: Maximum likelihood and least squares, Geometry of least squares, Bayesian Linear Regression, Bayesian Model Comparison, Limitations of Fixed Basis Functions. Logistic regression, Multiclass logistic regression, Support Vector Machines.

**8 Hours****UNIT IV****Neural Networks**

Neural Networks - Introduction, Early Models, Perceptron Learning, Feed-forward Network Functions, Network Training, Parameter optimization, Local quadratic approximation, Gradient descent optimization Error Back propagation.

**8 Hours****UNIT V****Unsupervised Learning**

Clustering: Agglomerative clustering, Batchelor and Wilkins algorithm, Graph-based clustering, k-means, adaptive hierarchical clustering, Gaussian mixture model.

**8 Hours****TEXT BOOKS**

1	Alpaydin Ethem	Introduction to Machine Learning, MIT Press, 3 <sup>rd</sup> Edition, 2014.
2	Christopher Bishop	Pattern Recognition and Machine Learning, Springer, 2010.
3	Richard O Duda, Peter E Hart, and David G Stock	Pattern Classification, John Wiley and Sons, reprint by Wiley India, 2007.

**REFERENCE BOOKS**

1	S.Theodoridis and K. Koutroumbas	Pattern Recognition, Academic Press, 4 <sup>th</sup> Edition, 2009.
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2	Earl Gose, Richard Johnsonbaugh and Steve Jost	Pattern Recognition and Image Analysis, Prentice-Hall of India, 2003.
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**E-RESOURCES**

1	<a href="https://www.youtube.com/@machinelearning-sudeshnasa3607/videos">https://www.youtube.com/@machinelearning-sudeshnasa3607/videos</a> , Prof. Sudeshna Sarkar, IITKGP <a href="https://www.youtube.com/watch?v=jGwO_UgTS7I&amp;list=PLoROMvodv4rMiGQp3WXShtMGgzqpfVfbU">https://www.youtube.com/watch?v=jGwO_UgTS7I&amp;list=PLoROMvodv4rMiGQp3WXShtMGgzqpfVfbU</a>
2	<a href="https://www.youtube.com/watch?v=jGwO_UgTS7I&amp;list=PLoROMvodv4rMiGQp3WXShtMGgzqpfVfbU">https://www.youtube.com/watch?v=jGwO_UgTS7I&amp;list=PLoROMvodv4rMiGQp3WXShtMGgzqpfVfbU</a> , Stanford Online, Prof. Andrew N G

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Classify machine learning algorithms and approaches.
CO2	Use Bayesian decision theory to determine the discriminant function for a two class problem.
CO3	Apply learning algorithms based on linear regression, logistic regression support vector machines to predict continuous discrete valued output.
CO4	Apply algorithms based on neural networks to perform simple learning tasks like speech recognition, digit recognition, optical character recognition and similar cognitive applications.
CO5	Apply unsupervised learning algorithms to learn patterns from given training set of unlabeled data points.

**Course Articulation Matrix**

	POs											PSOs		
	1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	CO1	3	1			3			3	2		1	2	3
	CO2	3	2	2		3			3	2		1	2	3
	CO3	3	2	3		3			3	2		1	2	3
	CO4	3	2	2		3			3	2		1	2	3
	CO5	3	2	2		3			3	2		1	2	3

## COMPUTER VISION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE28	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. To understand fundamental concepts of computer vision providing an overview of the current methodologies and techniques.
2. To explore the theory behind fundamental computer vision tasks using mathematical framework.

### UNIT I

**Image Formation and Processing:** Introduction to basic concepts of Image, Point Operators-Pixel transforms, Color transforms, Histogram Equalization, Application – Tonal Adjustment, Linear Filtering – Separable filtering, Neighborhood Operators – Non-linear filtering, Bilateral filtering, Geometric transformations – Parametric transformations, Mesh-based warping, Application – Feature-based morphing.

**9 Hours**

### UNIT II

**Image Descriptors and Features:** Boundary descriptors, Region feature descriptors, Principal Component as Feature descriptor, Object Boundary and Shape Representations, Histogram of Oriented Gradients, Scale Invariant Feature Transform, Design Patterns.

**8 Hours**

### UNIT III

**Geometric Camera Models and Multiview Geometry:** Pinhole Cameras, Three Geometric problems, Homogeneous coordinates, Extrinsic Parameters, Intrinsic Parameters, Applications, Two-view geometry, The Essential matrix, The fundamental matrix, Two-view Reconstruction, Rectification, Multiview Reconstruction, Applications.

**8 Hours**

**UNIT IV**

**Depth Estimation and Motion Estimation:** Stereopsis: Reconstruction, Depth from Stereo, Epipolar geometry, Sparse Correspondence, 3D curves and profiles, Local models, Sub-pixel estimation, Multi-view stereo, Monocular Depth Estimation, 3D Vision, Virtual View Synthesis, Motion Estimation-Hierarchical motion estimation, Parametric motion, Optical flow.

**8 Hours****UNIT V**

**Machine Learning for Computer Vision:** Computer vision problems, Types of model, Example of Regression and Binary Classification, Applications, Modeling complex data densities, Normal classification model, Regression models: Linear regression, Non-linear regression, Classification models: Logistic regression, Unsupervised Learning – Clustering, Applications.

**9 Hours****TEXT BOOKS**

1	Richard Szeliski	Computer Vision: Algorithms and Applications, Springer, 2010.
2	Simon J.D. Prince	Computer vision: Models, Learning and Inference, Cambridge University Press, 2012.

**REFERENCE BOOKS**

1	David A Forsyth Jean Ponce	Computer Vision – A Modern Approach, PHI Learning, 2009.
2	Rafael C. Gonzalez and Richard E. Woods	Digital Image Processing, Pearson Education, 2018.
3	Richard Hartley, Andrew Zisserman	Multiple View Geometry in Computer Vision, Cambridge University Press, 2004.

**E-RESOURCES**

1	<a href="https://onlinecourses.nptel.ac.in/noc19_cs58/preview">https://onlinecourses.nptel.ac.in/noc19_cs58/preview</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze fundamental image formation techniques required for computer vision.
CO2	Identify and choose various techniques for feature extraction for further analysis
CO3	Analyze geometric concepts of camera and multiview geometry
CO4	Analyze various depth estimation and motion estimation techniques
CO5	Identify Machine Learning and Neural Network concepts and develop Computer Vision applications

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	3			1							3	1
	CO2	3	3			1							3	1
	CO3	3	3			1							3	1
	CO4	3	3			1							3	1
	CO5	3	3	1		2							3	2

## SPEECH TECHNOLOGY

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE47	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand the characteristics of speech signal and apply signal processing concepts to speech signal.
2. Get an insight into a few applications of speech processing.
3. Get a practical experience in developing automatic speech recognition engine

### UNIT I

**Speech production mechanism:** The physiological model of speech production, The mathematical (source-system) model of speech production, Categorization of speech sounds.

**Source and System Separation:** Source Linear prediction (LP) analysis, perceptual linear prediction (PLP), analysis of speech, Homomorphic speech signal deconvolution, real and complex cepstrum, application of cepstral analysis to speech signals.

**9 Hours**

### UNIT II

**Speech Coding and Synthesis:** Scalar Quantization, Vector Quantization, Waveform coding-time domain waveform coding, frequency domain waveform coding, Vcoders-cepstral vocoder, formant vocoder, linear prediction vocoder, voice codecs in cell phones.

**Speech Quality Assessment:** Subjective quality measures-intelligibility tests, quality tests, Objective quality tests-articulation index, signal-to-noise ratio, Itakura measures, LPC based parametric distances.

**9 Hours**

### UNIT III

**Speech Enhancement:** Short time spectral amplitude techniques, speech modeling and Wiener filtering, Adaptive noise cancelling, Enhancement

techniques based on fundamental frequency tracking, Microphone array processing , Modern methods in speech enhancement.

**8 Hours**

#### UNIT IV

**Introduction to Speech recognition:** Front end- Mel frequency cepstral coefficients (MFCC), RASTA-PLP cepstral co-efficient, Statistical Models-Dynamic Time Warping, Gaussian mixture modelling, Hidden Markov modelling.

**8 Hours**

#### UNIT V

**Speech Recognition in practice:** Acoustic Modelling, Punctuation Modelling (Lexicon), Language Modelling (N-Gram language models), HMM based speech recognition, End-to-end ASR systems: connectionist Temporal Classification, speech foundation models and speech Large Language Models

**8 Hours**

#### TEXT BOOKS

1	Lawrence R. Rabiner and Ronald W. Schafer	Digital processing of speech signals, Pearson Education, Second Indian Reprint, 2005.
2	J.R. Deller, J.H.L. Hansen and J.G. Proakis	Discrete Time Processing of Speech Signals, IEEE Press, e-book, 2015.

#### REFERENCE BOOKS

1	Douglas O' Shaughnessy	Review of methods for coding of speech signals, Eurasip Journal on Audio, Speech and Music Processing, Art. No. 8, 2023.
2	Douglas O' Shaughnessy	Speech Enhancement – A review of modern methods, IEEE Transactions on Human-Machine Systems, pp. 110-120, Vol. 54, issue 1, 2024.
3	S Phasha, J. Lundgren, C Ritz and Y Zou	Distributes microphone Arrays, Emerging Speech and Audio Signal Processing Platforms: A Review, Advances in Science, Technology and Engineering Systems Journal, pp. 331-343, vol. 5, No. 4, 2020.

4	Daniel Jurafsky and James H Martin	Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition”, Pearson Education, 2002.
5	Cui, W., Yu, D., Jiao, X., Meng, Z., Zhang, G., Wang, Q., Guo, Y. and King, I.,	Recent advances in speech language models: A survey. arXiv preprint arXiv:2410.03751, 2024.
6	Yang, S.W., Chang, H.J., Huang, Z., Liu, A.T., Lai, C.I., Wu, H., Shi, J., Chang, X., Tsai, H.S., Huang, W.C. and Feng, T.H.	A large-scale evaluation of speech foundation models. IEEE/ACM Transactions on Audio, Speech, and Language Processing, pp. 2884-2899, Vol. 32, 2024.

**E-Resources:**

1	<a href="https://study.iitm.ac.in/ds/course_pages/BSEE4001.html">https://study.iitm.ac.in/ds/course_pages/BSEE4001.html</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze the speech signal in time and frequency domain and relate to human speech production mechanism.
CO2	Represent speech signal in the compressed for using speech coding techniques and assess speech quality.
CO3	Improve speech quality by reducing noise and enhancing quality.
CO4	Derive features from speech signal and explain how computers recognize speech with statistical methods.
CO5	Build a continuous speech recognition system, using a standard software toolkit.

**Course Articulation Matrix**

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2	1		3			2	2			2	2
	CO2	3	2	2		3			2	2			2	2
	CO3	3	2	2		3			2	2			2	2
	CO4	3	2	2		1			2	2			2	2
	CO5	3	2	2		3			2	2			2	2

## DEEP LEARNING FOR COMPUTER VISION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE48	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand the fundamental principles of deep learning, neural networks, optimization techniques forming the basis for modern computer vision models.
2. Explore the architecture and operation of Convolutional Neural Networks (CNNs) and their ability to process and analyze image data.

### UNIT I

**Fundamentals of Image Processing and Machine Learning:** Digital image representation, Image filtering and transformations, Histogram Equalization and Thresholding, Feature engineering and dimensionality Reduction, supervised vs. Unsupervised Learning, Overview of conventional classifier methods.

**9 Hours**

### UNIT II

**Foundations of Deep Learning:** Introduction to Neural Networks, Perceptron, Multi-Layer Perceptron (MLP), Backpropagation and Gradient Descent, Activation Functions: ReLU, Sigmoid, Tanh, Loss Functions and Optimizers (SGD, Adam), Overfitting, Regularization (Dropout, L2).

**8 Hours**

### UNIT III

**Convolutional Neural Networks (CNNs) and Image Classification:** Introduction to CNNs and motivation for spatial hierarchies, Convolution, Padding, Stride, Pooling, CNN Architectures: LeNet, AlexNet, VGG, Batch Normalization, Transfer Learning, Visualization of Filters and Feature Maps

**8 Hours**

**UNIT IV**

**Object Detection and Segmentation:** Object Detection Overview, Evaluation metrics, Detection Models: R-CNN, Faster R-CNN, YOLO, SSD, Semantic vs. Instance Segmentation, U-Net, Mask R-CNN, MobileSAM (overview).

**8 Hours****UNIT V**

**Applications of Deep Learning in Computer Vision:** Real-time Face Recognition System using CNNs, Medical image analysis for tumor segmentation using U-Net on medical datasets, Object Detection in Traffic Surveillance using YOLOv5, OCR and Document Analysis.

**9 Hours****TEXT BOOKS**

1	Ian Goodfellow, Yoshua Bengio, and Aaron Courville	Deep Learning, MIT Press, 2016 -A foundational book covering deep learning theory, neural networks, and training techniques.
2	Adrian Rosebrock	Deep Learning for Computer Vision with Python, PyImageSearch, 2017.

**REFERENCE BOOKS**

1	David A Forsyth Jean Ponce	Computer Vision – A Modern Approach, PHI Learning, 2009.
2	Rafael C. Gonzalez and Richard E. Woods	Digital Image Processing, Pearson Education, 2018.

**E Resource:**

1	<a href="https://archive.nptel.ac.in/courses/106/106/106106224/">https://archive.nptel.ac.in/courses/106/106/106106224/</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Understand digital image representation techniques and their significance in image processing.
CO2	Analyze deep learning principles and their applications in computer vision.
CO3	Analyze various CNN architectures such as LeNet, AlexNet, and VGG and transfer learning techniques.
CO4	Analyze object detection and image segmentation techniques using deep learning models.
CO5	Provides hands-on experience in applying deep learning models to real-world computer vision problems.

**Course Articulation Matrix**

	POs											PSOs	
	1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2									3	
	CO2	3	2			1					1	3	1
	CO3	3	3	1		1					1	3	1
	CO4	3	3	1		1					1	3	1
	CO5	3	3	2		1					1	3	2

**III. MICROELECTRONICS:****LOW POWER VLSI DESIGN**

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE29	SEE Marks:	50

**Course objectives:**

This course will enable students to:

1. Learn various techniques for designing low power circuits and systems.
2. Describe issues related at architectural, logic, circuit and device levels and some of the techniques to overcome these difficulties.

**UNIT I**

**Introduction:** Need for Low power VLSI chips, Charging and discharging capacitance, Short circuit currents in CMOS circuit, CMOS leakage current, Static current, Basic Principles of low power design, Sources of dissipation in Digital Integrated circuits, Emerging low power approaches, Dynamic dissipation in CMOS, Effects of  $V_{dd}$  and  $V_t$ , constraints on  $V_t$  reduction, Transistor sizing and optimal gate oxide thickness.

**9 Hours****UNIT II**

**Power estimation, Simulation Power analysis:** SPICE circuit simulators, gate level logic simulation, capacitive power estimation, static state power, gate level capacitance estimation, architecture level analysis, data correlation analysis in DSP systems, Monte Carlo simulation.

**8 Hours****UNIT III**

**Low Power Circuit Techniques:** Introduction to Power consumption in circuits, Flip flops and latches, logic, High Capacitance nodes.

**8 Hours**

**UNIT IV**

**Logical Level Power Optimization:** gate reorganization, local restructuring, signal gating, logic encoding, state machine encoding, pre-computation logic.

**8 Hours****UNIT V**

**Architecture and system:** Power and Performance management, Switching activity reduction, Parallel Architecture with voltage reduction, Flow graph Transformation.

**Low power Clock Distribution:** Power dissipation in clock distribution, single driver Vs distributed buffers, Zero skew Vs tolerable skew.

**9 Hours****TEXT BOOKS**

1	Gary K. Yeap	Practical Low Power Digital VLSI Design, Springer Science & Business Media, 2012.
2	Rabaey, Pedram	Low Power Design Methodologies, Springer science, 2012.

**REFERENCE BOOKS**

1	Kaushik Roy, Sharat C. Prasad	Low-Power CMOS VLSI Circuit Design, Wiley publication, 2009.
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**E-Resources:**

1	<a href="https://www.youtube.com/watch?v=ruClwamT-R0&amp;list=PLB3F0FC99B5D89571&amp;index=1">https://www.youtube.com/watch?v=ruClwamT-R0&amp;list=PLB3F0FC99B5D89571 &amp;index=1</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Demonstrate the technique for computing the power dissipation and power issues in VLSI circuits.
CO2	Analyze various approaches of power dissipation at different levels of abstraction through simulation for power efficient circuit design.

CO3	Explore the power consumption in sequential circuits, design power efficient driver circuit for high capacitive loads.
CO4	Apply reorganization technique to design power efficient circuits.
CO5	Provide architectural solution to achieve power efficiency and issues related with clock distribution.

### Course Articulation Matrix

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	C01	3	1										2	
	C02	3	1										2	
	C03	3	2										2	
	C04	3	2										2	
	C05	3	2										2	

## ANALOG AND MIXED MODE VLSI DESIGN

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE30	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Learn fundamentals of data converters, along with various ADC & DAC architecture.
2.	Describe issue related to non-linear analog circuits.
3.	Learn sub-microns CMOS circuit design issues at low & High frequency.

### UNIT I

**Data converter fundamentals:** Analog versus Digital Discrete Time Signals, Converting Analog Signals to Data Signals, Sample and Hold Characteristics, DAC Specifications, ADC Specifications, Mixed-Signal Layout Issues.

**7 Hours**

### UNIT II

**Data Converters Architectures:** DAC Architectures, Digital Input Code, Resistors String, R-2R Ladder Networks, Current Steering, Charge Scaling DACs, Cyclic DAC, Pipeline DAC, ADC Architectures, Flash, 2-Step Flash ADC, Pipeline ADC, Integrating ADC, Successive Approximation ADC.

**12 Hours**

### UNIT III

**Non-Linear Analog Circuits:** Basic CMOS Comparator Design (Excluding Characterization), Analog Multipliers, Multiplying Quad (Excluding Stimulation), Level Shifting (Excluding Input Level shifting For Multiplier).

**8 Hours**

### UNIT IV

**Data Converter SNR:** Improving SNR Using Averaging (Excluding Jitter & Averaging onwards), Decimating Filters for ADCs (Excluding Decimating without Averaging onwards), Interpolating Filters for DAC, Band pass and High pass Sync filters.

**8 Hours**

**UNIT V**

**Sub-Microns CMOS circuit design:** Process Flow, Capacitors and Resistors, MOSFET Switch (upto Bidirectional Switches), Delay elements, adder Elements, Analog Circuits MOSFET Biasing (upto MOSFET Transition Frequency).

**7 Hours****TEXT BOOKS**

1.	R. Jacob Baker, Harry W Li, David E Boyce	CMOS Circuit Design, Layout and simulation, John Wiley publication, 1998.
2.	R. Jacob Baker	CMOS- Mixed Signal Circuit Design, (Vol II of CMOS: Circuit Design, Layout and Stimulation), John Wiley India Pvt. Ltd, 2009.

**REFERENCE BOOKS**

1.	B Razavi	Design of Analog CMOS Integrated Circuits, First Edition, McGraw Hill, 2005.
2.	P E Allen and D R Holberg	CMOS Analog Circuit Design, 2 <sup>nd</sup> Edition, Oxford University Press, 2002.

**E-Resources:**

1	<a href="https://www.youtube.com/watch?v=ZcTTkCWnQNg&amp;list=PL2135D8A0F7441AE1">https://www.youtube.com/watch?v=ZcTTkCWnQNg&amp;list=PL2135D8A0F7441AE1</a>
2	<a href="https://www.youtube.com/watch?v=oia9paQF06k&amp;list=PLG4LDxYH2oQqN5f_eGRCUveQ6xkTPWZd">https://www.youtube.com/watch?v=oia9paQF06k&amp;list=PLG4LDxYH2oQqN5f_eGRCUveQ6xkTPWZd</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze the concepts of data conversion.
CO2	Compare different data converter architectures.
CO3	Design comparator, Analog multipliers and level shifters.
CO4	Improve signal to noise ratio of data converters by filtering
CO5	Design circuits by using submicron CMOS devices.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2										2	
	CO2	2	2			1							2	
	CO3	2	2			1							2	
	CO4	2	2										2	
	CO5	2	1										1	

## ASIC DESIGN

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE31	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Classify ASICs and describe various design methodologies used in the implementation of integrated circuits.
2.	Estimate logical efforts and logical efficiency of logic cell and compute the design economics in the IC design process.
3.	Design arithmetic circuits in terms of data path elements.
4.	Formulate a process involved in VLSI testing and verification.
5.	Explore the basic techniques involved in VLSI backend design.

### UNIT I

**Introduction to ASICS:** Full Custom with ASIC, Semi custom ASICS, Standard Cell based ASIC, Gate array based ASIC, Channeled gate array, Channelless gate array, structured gate array, Programmable logic device, FPGA design flow, ASIC cell libraries.

**Design methodology:** Structure Design, Strategy, Hierarchy, Regularity, Modularity, and Locality.

**8 Hours**

### UNIT II

**ASIC library Design:** Logical effort: practicing delay, logical area and logical efficiency logical Paths, multi stage cells, optimum delay, optimum no. of stages, library cell design.

**Design Economics:** Nonrecurring and recurring engineering Costs, Fixed Costs, Schedule, Person power, example.

**8 Hours**

**UNIT III**

**Data logic cells:** Data Path Elements, Adders, Multiplier, Arithmetic Operator, I/O cell, Cell Compilers.

**Programmable ASIC:** programmable ASIC logic cell, ASIC I/O cell.

**8 Hours****UNIT IV**

**VLSI System Testing & Verification:** Introduction, Logic verification, Basic digital debugging hints, Manufacturing tests, test programs, logic verification principles, Test benches and Harnesses, regression testing, silicon debug principles Manufacturing test principles, fault modules. Observability and controllability, fault coverage, ATPG, Delay Fault Testing, design for testability, adhoc testing, scan design Built in self test.

**9 Hours****UNIT V**

**ASIC Construction Floor planning and placement and routing:** Physical Design, CAD Tools, System Partitioning, Estimating ASIC size, partitioning methods. Floor planning tools, I/O and power planning, clock planning, placement algorithms, iterative placement improvement, Time driven placement methods. Physical Design flow global Routing, Local Routing, Detail Routing, Special Routing, Circuit Extraction and DRC.

**9 Hours****TEXT BOOKS**

1.	M.J.S. Smith	Specific Integrated Circuits, Pearson Education, 2016
2.	Neil H.E.Weste, Davir Harris	CMOS VLSI Design: A Circuits and system perspectives, Addison Wesley - Pearson Education, 3rd Edition, 2010

**REFERENCE BOOKS**

1.	Jose E.France, Yannis Tsividis	Design of Analog-Digital VLSI Circuits for Telecommunication and signal processing, Prentice Hall, 1994.
2.	S. Y. Kung, H. J. Whilo House, T. Kailath	VLSI and Modern Signal Processing, Prentice Hall, 1985.
3.	Jose E. France, Yannis Tsividis	Design of Analog - Digital VLSI Circuits for Telecommunication and Signal Processing, Prentice Hall, 1994.

**E-Resources:**

1	<a href="https://www.youtube.com/watch?v=oZSv68esbgl">https://www.youtube.com/watch?v=oZSv68esbgl</a>
2	<a href="https://www.youtube.com/watch?v=4cPkr1VHu7Q">https://www.youtube.com/watch?v=4cPkr1VHu7Q</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Classify different types of ASICs and explain design techniques used in implementation of integrated circuits.
CO2	Estimate logical efforts, path delays, logical efficiency of logic cell and design economics involved in ICs Design.
CO3	Compare various programmable ASIC technologies and also analyze arithmetic circuits.
CO4	Analyze process involved in logic verification and testing of a VLSI design.
CO5	Investigate different techniques involved in physical design using CAD tools.

**Course Articulation Matrix**

		PO's											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	1										1	
	CO2	2	2	1		2			2	2		2	1	
	CO3	2	2										1	
	CO4	2	2	1									1	
	CO5	2	2	1	1	2			2	2		2	1	

## VLSI TESTING AND VERIFICATION

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE32	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Learn various fault detection and fault modeling techniques in digital circuits.
2.	Discuss different algorithms for fault detection in memories, combinational and sequential circuits.
3.	Understand various verification tools and simulators.

### UNIT I

**Introduction to Testing:** Testing Philosophy, Role of Testing, Digital and Analog VLSI Testing, VLSI Technology Trends Affecting Testing.

**Faults:** Faults in logic circuits, Breaks, Transistors Stuck-Open and Stuck-On or Stuck-Open Faults in CMOS, Basic concepts of fault detection.

**Fault modelling:** Fault equivalence, Fault collapsing and fault dominance.

**9 Hours**

### UNIT II

**Test Generation for Combinational Logic Circuits:** Test Generation Techniques for Combinational Circuits: Truth table and Fault matrix method, Path sensitization method, D-Roth algorithm, PODEM and FAN.

**8 Hours**

### UNIT III

**Design of Testable Sequential Circuits:** Ad Hoc Design Rules for Improving Testability, Design of Diagnosable Sequential Circuits, The Scan-Path Technique for Testable Sequential Circuit Design, Level-Sensitive Scan Design, Random Access Scan Technique, Partial Scan, Testable Sequential Circuit Design Using Nonscan Techniques.

**8 Hours**

**UNIT IV**

**Built-In Self Test:** Test Pattern Generation for BIST, Output Response Analysis, Circular BIST, BIST Architectures-BILBO.

**Memory Testing:** Functional RAM testing with March tests, Testing RAM Neighbourhood Pattern Sensitive Faults (NPSF), Testing RAM technology and layout related faults.

**8 Hours****UNIT V**

**Importance of Design Verification:** The importance of verification, Reconvergence model, Formal verification, Assertion based verification, Equivalence checking, Model checking, Functional verification.

**Verification Tools:** Linting tools: Limitations of linting tools, linting verilog source code, linting VHDL source code, linting OpenVera and e-source code, code reviews.

**Simulators:** Stimulus and response, Event based simulation, cycle based simulation, Co-simulators, verification intellectual property: hardware modellers, waveform viewers.

**9 Hours****TEXT BOOKS**

1	Parag K. Lala	An Introduction to Logic Circuit Testing, Morgan and Claypool Publishers, 2009.
2	M. L. Bushnell and V. D. Agrawal	Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits, Springer Science & Business Media, 2004.
3	Janick Bergeron	Writing test benches: functional verification of HDL models, Kluwer Academic Publishers, 2 <sup>nd</sup> Edition, 2003.

**REFERENCE BOOKS**

1	M. Abramovici, M.A. Breuer and A.D. Friedman	Digital Systems Testing and Testable Design, John Wiley Publications, 2012.
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**E-Resources:**

1	<a href="https://www.youtube.com/watch?v=tP9nh1g14E8&amp;t=1015s">https://www.youtube.com/watch?v=tP9nh1g14E8&amp;t=1015s</a>
2	<a href="https://archive.nptel.ac.in/courses/106/105/106105161/">https://archive.nptel.ac.in/courses/106/105/106105161/</a>
3	<a href="https://nptel.ac.in/courses/117105137">https://nptel.ac.in/courses/117105137</a>
4	<a href="https://nptel.ac.in/courses/106103016">https://nptel.ac.in/courses/106103016</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze and model faults in logic circuits.
CO2	Develop test patterns for combinational logic circuits using various algorithms.
CO3	Design testable sequential circuits.
CO4	Construct test pattern for BIST and design test algorithms for memory.
CO5	Analyze different verification tools and simulators.

**Course Articulation Matrix**

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	CO1	3	2											2	
	CO2	3	2											2	
	CO3	3	2											2	
	CO4	3	1											2	
	CO5	2	2											2	

## SMART MATERIALS AND SMART SYSTEMS

Contact Hours/ Week:	3+0+0	Credits:	3
Total Lecture Hours:	42	CIE Marks:	50
Sub. Code:	SECE33	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Explore how smart materials are integrated into sensors and actuators.
2. Understand the overview of physical and chemical techniques for thin film deposition.
3. Describe various aspects of electronic devices and circuits.
4. Understand working principles of characterization tools.
5. Analyze case studies of microsystems integrated with electronics.

### UNIT I

#### Basics of Smart materials

Smart materials, structures and Systems, Integrated Microsystems, Specialized material for Microsystems, Application of smart materials and Microsystems.

**8 Hours**

### UNIT II

#### Fabrication Technology

Thermal oxidation, Thin film deposition, Doping, Lithography, Etching, Silicon micromachining, Advanced processes for microfabrication, Metalization.

**8 Hours**

### UNIT III

#### Semiconductor Devices

Metal-semiconductor junctions, Schottky vs. Ohmic junctions, Band gap diagrams, I-V Characteristics, p-n junctions, Equilibrium and under bias (forward and reverse), Band Diagrams, I-V characteristics, Junction breakdown, Heterojunctions, The Bipolar Junction transistor, Electronic Amplifiers.

**9 Hours**

**UNIT IV****Thin film Characterization**

Overview of thin film characterization, Imaging techniques: Scanning electron microscopy (SEM), AFM, Structural properties: X-ray diffraction (XRD), Electrical properties: Resistance/resistivity –four point probe, Vander Pauw, Mechanical properties: Stress-curvature measurements.

**9 Hours****UNIT V****Actuators and Sensors**

Silicon Capacitive Accelerometer, Conductometric Gas sensor, Portable Blood Analyzer, Smart materials and Systems, Integration of Micro and smart systems, CMOS First, MEMs First, Case studies of integrated microsystem.

**8 Hours****TEXT BOOKS**

1	S.M. Sze	Semiconductor devices: Physics and Technology, 2 <sup>nd</sup> Edition, Wiley, 2008.
2	G.K. Ananthasuresh, K.J. Vinoy, S. Gopalakrishnan, K. N. Bhat, V.K. Aatre	Micro and Smart Systems, Wiley, 2011.

**REFERENCE BOOKS**

1	M. V. Gandhi and B. S. Thompson	Smart Materials and Structures, Springer 1992.
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**E-Resources:**

1	<a href="https://nptel.ac.in/courses/112108092">https://nptel.ac.in/courses/112108092</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Describe smart materials used in electronic engineering.
CO2	Analyze different techniques used for fabrication of devices.

CO3	Design circuits for microsystem and smart systems.
CO4	Identify suitable characterization tool for a device.
CO5	Integrate sensors with microsystem and smart systems.

### Course Articulation Matrix

		POs											PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
<b>COs</b>	<b>CO1</b>	3	1						2	2			2	2
	<b>CO2</b>	3	2						2	2			2	2
	<b>CO3</b>	3	2						2	2			2	2
	<b>CO4</b>	3	2						2	2			2	2
	<b>CO5</b>	3	2						2	2			2	2

## COMPOUND SEMICONDUCTOR DEVICES AND APPLICATIONS

Contact Hours/ Week:	3+0+0	Credits:	3
Total Lecture Hours:	42	CIE Marks:	50
Sub. Code:	SECE34	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand the properties of III-V compound semiconductors.
2. Know the fabrication technics of GaAs and related semiconductor devices.
3. Learn design techniques of schottky, MESFET and various RF and MW solid state devices.
4. Understand photonic devices and GaN power devices.

### UNIT I

#### Introduction to GaAs and related materials

Unit1: Properties of III-V compounds-Density of states in 2-, 1- and 0-dimensions, conduction processes, optical processes, recombination, absorption and radiations in semiconductors.

**7 Hours**

### UNIT II

#### Fabrication heterostructures

Bulk single crystal growth (Bridgeman and LEC)-Wafer fabrication and specification, Epitaxy (MBE and OMVPE) of single crystal layers, heterostructures and dissimilar materials, quantum wells, superlattices, quantum wires and quantum dots, doping techniques, emerging III-V materials (GaN).

**8 Hours**

### UNIT III

#### Schottky, MESFET and MW devices

Metal (Schottky) and ohmic contact techniques. GaAs metal-semiconductor field effect transistor (GaAs MESFET): introduction, structure, equivalent circuits, current saturation, effect of source and drain resistance, gate resistance and application of GaAs MESFET. Physics, operation and technology of RF and

microwave solid state devices- schottky, IMPATT, TRAPATT, PIT, tunnel and GUNN diodes.

**9 Hours**

#### UNIT IV

##### **HEMT, HBTs and GaN power devices**

High electron mobility transistor (HEMT)-structure, energy band line-up, equivalent circuit, HEMPT noise, pseudomorphic HEMT and applications, resonant tunneling diodes, heterojunction bipolar transistor (HBTs), GaN power devices.

**9 Hours**

#### UNIT V

##### **Photonic devices :**

light emitting diodes (LEDs), solar cells, photodetectors, lasers. photoelectronic integration of compound semiconductor devices: heterojunction phototransistor (HPT) and light amplifying optical switch (LAOS). Reliability and degradation GaAs and related devices-FETs, HBTs, LEDs and lasers.

**9 Hours**

#### **TEXT BOOKS**

1	Pallab Bhattacharya	Semiconductor optoelectronic devices, Pearson, 2 <sup>nd</sup> Edition, 2017.
2	V Swaminathan and A. T. Macrander	Material aspects of GaAs and InP based structures, Printice Hall, Englewood Cliffs, NJ, 1991.
3	Joseph Man	GaAs integrated circuits, Macmillan publishing company, Now York (1988).
4	Sitesh Kumar Roy and MonojitMitra	Microwave semiconductor devices, Printice-Hall of India Private Ltd., New Delhi, 2003.

#### **REFERENCE BOOKS**

1	M. J. Howes and D. V. Morgan	ED., Reliability and Degradation-semiconductor devices and circuits, John Wiley & Sons, New York, 1981.
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2	S. K. Gandhi,	VLSI fabrication principals-Silicon and GaAs, John Wiley & Sons, New York, 2008.
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**E-Resources:**

1 [https://www.youtube.com/watch?v=o3mpbZ\\_FRd0](https://www.youtube.com/watch?v=o3mpbZ_FRd0)

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Describe different III-V compound semiconductors, electrical and optical properties.
CO2	Apply fabrication techniques to homo and heterojunction devices.
CO3	Describe the technology used in RF and MW devices.
CO4	Design HEMT, HBTs and GaN power devices.
CO5	Analyse reliability and degradation of GaAs and related devices.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2	2										2	1
	CO2	2	2										2	1
	CO3	2	2										2	1
	CO4	2		2									2	1
	CO5	2		2									2	1

## SYSTEM VERILOG

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE35	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Understand System Verilog Language Fundamentals
2. Design Synthesizable Digital Systems
3. Develop and Utilize Testbenches for Verification
4. Importance of System Verilog Assertions
5. Apply Advanced Verification Techniques

### UNIT I

**Overview of HDL:** Introduction to System Verilog Overview and History Key features and advantages Differences from Verilog Applications in design and verification Data Types and Literals, Built-in data types, User-defined data types: typedef, enum, struct, union. Constants and literals, Operators: Arithmetic, logical, relational, bitwise, Reduction and shift operators, Operator precedence and associativity.

**8 Hours**

### UNIT II

**Procedural and Behavioral Modeling :** Procedural Blocks, Initial and always blocks, Procedural assignments: blocking vs. non-blocking, Sensitivity lists, control Flow Statements, Conditional statements: if-else, case, unique case, Looping constructs: for, while, do-while, repeat, forever, foreach, Tasks and Functions: Differences between tasks and functions, Declaring and using tasks and functions, Arguments, return values, and scope.

**8 Hours**

### UNIT III

**Advanced Data Types and Constructs :** Arrays and Queues, Fixed-size arrays, Dynamic arrays, Queues: declaration and operations, Array methods: find, sort, shuffle, Structures and Unions, Packed and unpacked structures, Unions and their applications, Packages and Interfaces: Defining and using packages, Importing and exporting package contents, Introduction to interfaces and their benefits.

**8 Hours**

**UNIT IV**

**Assertions and Functional Coverage** : System Verilog Assertions (SVA): Introduction to assertions Immediate assertions, Concurrent assertions, Assertion properties and sequences Functional Coverage Introduction to coverage concepts Cover groups and cover points Cross coverage Writing and analyzing coverage reports.

**9 Hours****UNIT V**

**Object-Oriented Programming (OOP) and Test benches** : Classes and OOP Concepts Introduction to OOP in System Verilog Defining classes and objects Constructors and methods Inheritance, polymorphism, and encapsulation Building Testbenches, Testbench architecture and components. Writing effective testbenches, Simulation and debugging techniques.

**9 Hours****TEXT BOOKS**

1	Stuart Sutherland, Simon Davidmann, and Peter Flake	System Verilog for Design: A Guide to Using System Verilog for Hardware Design and Modeling, Springer, 2 <sup>nd</sup> edition, 2006, New York.
2	Chris Spear and Greg Tumbush	System Verilog for Verification: A Guide to Learning the Test bench Language Features, Springer, 3 <sup>rd</sup> Edition, 2012.

**REFERENCE BOOKS**

1	Joseph Cavanagh	Digital Design and Verilog HDL Fundamentals, 2008, Taylor and Francis.
2	Harry Foster, Adam Krolnik, and David Lacey	Assertion-Based Design, 2 <sup>nd</sup> Edition, 2003, Kluwer Academic Publishers.
3	Srikanth Vijayaraghavan and Meyyappan Ramanathan	A Practical Guide for System Verilog Assertions, 2005, Springer.

**E-RESOURCES**

1	<a href="https://onlinecourses.nptel.ac.in/noc21_ee97/preview">https://onlinecourses.nptel.ac.in/noc21_ee97/preview</a>
2	<a href="https://www.youtube.com/watch?v=y2sOUY5FlfM&amp;list=PL40xmtPvboRs6Ng_1Q_V-1MdJH50A6Ulz">https://www.youtube.com/watch?v=y2sOUY5FlfM&amp;list=PL40xmtPvboRs6Ng_1Q_V-1MdJH50A6Ulz</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Develop the system Verilog code using data types for digital design
CO2	Select the suitable abstraction level for digital design verification
CO3	Develop system verilog code using arrays and queues
CO4	Verify digital design using assertion method
CO5	Analyze and verify the functionality of digital circuits/systems using test benches

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			1							1	1
	CO2	3	2			1							1	
	CO3	2	2			1							1	1
	CO4	3	2			2							1	
	CO5	3	2			1							1	

**IV. EMBEDDED SYSTEMS:****SYSTEM PROGRAMMING & OPERATING SYSTEM**

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE37	SEE Marks:	50

**Course objectives:**

This course will enable students to:

1. Understand basics of OS concepts and techniques, which can be easily transported to the newer OS.
2. Articulate the various management systems of OS.

**UNIT I**

**Assemblers, Compilers and Interpreters:** Elements of Assembly language programming, a simple assembly scheme, Pass structure for assemblers, Design of Two pass assemblers, A single pass Assembler for IBM PC, Compilers, Aspects of Compilation, Memory Allocation, Compilation of Control Structures, Code Optimization, Interpreters.

**9 Hours****UNIT II**

**INTRODUCTION AND OVERVIEW OF OPERATING SYSTEMS:** Operating system, Goals of an O.S, Operation of an O.S, Resource allocation and related functions, O.S and the computer system, Classes of operating systems, Batch processing system, Multi programming systems, Time sharing systems, Real time operating systems, distributed operating systems.

**9 Hours****UNIT III**

**STRUCTURE OF OS:** Operating system with monolithic structure, layered design, Virtual machine operating systems, Kernel based operating systems, and Microkernel based operating systems.

**PROCESS MANAGEMENT:** Process concept, Programmer view of processes, OS view of processes, Interacting processes, Threads.

**8 Hours**

**UNIT IV**

**MEMORY MANAGEMENT:** Memory allocation to programs, Memory allocation preliminaries, Contiguous and noncontiguous allocation to programs,

**VIRTUAL MEMORY:** Virtual memory basics, Virtual memory using paging, Demand paging, Page replacement, Page replacement policies.

**8 Hours****UNIT V**

**FILE SYSTEMS:** File system and IOCS, Files and directories, Overview of I/O organization, Fundamental file organizations, Interface between file system and IOCS, Allocation of disk space, Implementing file access.

**SCHEDULING:** Fundamentals of scheduling, Long-term scheduling, Medium and short term scheduling, Real time scheduling.

**8 Hours****TEXT BOOKS**

1	D.M.Dhamdhere,	Systems Programming and Operating Systems, Tata McGraw Hill, 2 <sup>nd</sup> Revised Edition 2011. (UNIT 1).
2	D.M. Dhamdhare	Operating Systems - A Concept based Approach, TMH, 3 <sup>rd</sup> Edition, 2010.

**REFERENCE BOOKS**

1	Operating System Concepts	A Sliberschatz and P B Galvin, Addison Wesley, 1998.
2	Modern operating system	Andrew.S.Tannenbaum, PHI, 3 <sup>rd</sup> Edition, 2008.

**E-Resources:**

1	<a href="https://onlinecourses.nptel.ac.in/noc21_cs39/preview">https://onlinecourses.nptel.ac.in/noc21_cs39/preview</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Understand the parallel computer architecture and processing techniques.
CO2	Realize shared memory and scalable multiprocessors
CO3	Design interconnection of the topologies network
CO4	Develop and apply knowledge of distributed system organization and communication.
CO5	Understand the file structure and its coordination

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2										2	
	CO2	3	2										2	
	CO3	3	2										2	
	CO4	3	2										2	
	CO5	3	2										2	

## ADVANCED COMPUTER ARCHITECTURE

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE38	SEE Marks:	50

### Course objectives:

This course will enable students to:

1. Learn multiprocessors and multicomputer.
2. Compare the performance issues related to parallel processing.

### UNIT I

**Parallel computer models:** The state of computing, Multiprocessors and multi computers, Multi-vector and SIMD computers.

**8 Hours**

### UNIT II

**Program and network properties:** Conditions of parallelism, Data and resource Dependences, Hardware and software parallelism, Program partitioning and scheduling, Grain Size and latency, Program flow mechanisms, Control flow versus data flow, Data flow Architecture, Demand driven mechanisms, Comparisons of flow mechanisms.

**9 Hours**

### UNIT III

**Principles of Scalable Performance:** Performance Metrics and Measures, Parallel Processing Applications, Speedup Performance Laws, Scalability Analysis and Approaches.

**8 Hours**

### UNIT IV

**Advanced processors:** Advanced processor technology, Instruction-set Architectures, CISC Scalar Processors (VAX 8600, Motorola MC 68040) RISC Scalar Processors (SPARC, Intel i860) Superscalar Processors (IBM RS/6000), VLIW Architectures, Vector and Symbolic processors.

**9 Hours**

<b>UNIT V</b>		
<b>Pipelining:</b> Linear pipeline processor, nonlinear pipeline processor, Instruction pipeline Design, Mechanisms for instruction pipelining, Dynamic instruction scheduling, Branch Handling techniques, branch prediction.		
<b>8 Hours</b>		
<b>TEXT BOOKS</b>		
1	Kai Hwang	Advanced computer architecture, TMH, 3 <sup>rd</sup> Edition, 2003.
<b>REFERENCE BOOKS</b>		
1	Kai Hwang and Zu	Scalable Parallel Computers Architecture, MGH. 1998.
2	M.J Flynn	Computer Architecture, Pipelined and Parallel Processor Design, Narosa Publishing, 1 <sup>st</sup> Edition, 1995.
3	D.A.Patterson And J.L.Hennessy	Computer Architecture: A quantitative Approach, Morgan Kauffmann, 5 <sup>th</sup> Edition, Feb., 2002. 2011.
<b>E-RESOURCES</b>		
1	<a href="https://nptel.ac.in/courses/106103206">https://nptel.ac.in/courses/106103206</a>	
2	<a href="https://nptel.ac.in/courses/106102229">https://nptel.ac.in/courses/106102229</a>	
3	<a href="https://onlinecourses.nptel.ac.in/noc21_cs95/preview">https://onlinecourses.nptel.ac.in/noc21_cs95/preview</a>	
4	<a href="https://www.digimat.in/nptel/courses/video/106102229/L01.html">https://www.digimat.in/nptel/courses/video/106102229/L01.html</a>	
<b>Course Outcomes:</b>		
Upon completion of this course the student will be able to:		
CO1	Analyze the various parallel computing models like multiprocessors and multicomputers, multi-vector and SIMD computers.	
CO2	Identify and analyse the program and network properties to improve the performance.	
CO3	Analyze the principles of scalable performance such as performance metrics and measures, parallel processing applications, speedup performance laws.	
CO4	Analyze and compare the advanced processor technology.	
CO5	Design linear and nonlinear pipeline processors.	

**Course Articulation Matrix**

	POs												PSOs	
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	2											1	
	CO2	2	2										1	
	CO3	2	1										1	
	CO4	2	2										1	
	CO5	3	2										2	

## PARALLEL PROCESSING & DISTRIBUTED SYSTEMS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE39	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Acquire core knowledge of parallel computer architecture and processing techniques, which can be easily, transported to practical design.
2.	Demonstrate the basic knowledge of distributed system organization and communication.
3.	Articulate the course fundamental principles and concepts.

### UNIT I

#### Part A: Parallel processing

**Introduction:** Development history, Parallel Architecture, Convergence of Parallel Architectures, Fundamental Design Issues.

**Parallel programming & its Performance:** The Parallelization Process, Partitioning for Performance Factors from the Processors' Perspective.

**9 Hours**

### UNIT II

**Shared memory multiprocessor:** Introduction, Cache Coherence, Memory Consistency, Design Space for Snooping Protocols.

**Scalable Multiprocessors:** Scalability, Bandwidth Scaling, Realizing Programming models.

**8 Hours**

### UNIT III

**Interconnection Network Design:** Introduction, Organizational Structure, Interconnection Topologies.

**Latency Tolerance:** Introduction, Overview of Latency Tolerance, Latency Tolerance in a Shared Address Space, Block Data Transfer in a Shared Address Space.

**9 Hours**

**UNIT IV****Part B: Distributed systems**

**Introduction:** Characterization, System models, Networking & Internetworking introduction, Types of networks.

**Interprocess communication:** Client server communication, group communication, communication between distributed objects (Excluding Java examples).

**8 Hours****UNIT V**

Distributed File structure, File service architecture, name services, clock events and process state, global states.

**Coordination:** Distributed mutual exclusion, Election, Replication introduction, Fault tolerant services.

**8 Hours****TEXT BOOKS**

1	D. Culler, J.P. Singh, and A. Gupta	Parallel computer architecture: A hardware/software approach. Elsevier, 2000.
2	G. Coulouris, J. Dollimore, and T. Kindberg	Distributed Systems: Concepts and Designs, 4 <sup>th</sup> Edition, Pearson Education Ltd., 2005.

**REFERENCE BOOKS**

1	Hesham El-Rewini	Advanced computer architecture and parallel processing. John Wiley & Sons, 2005.
2	Sukumar Ghosh	Distributed Systems: An Algorithmic Approach, CRC Press, 2006.

**E-Resources:**

1	<a href="https://onlinecourses.nptel.ac.in/noc21_cs39/preview">https://onlinecourses.nptel.ac.in/noc21_cs39/preview</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Explain the parallel computer architecture and processing techniques.
CO2	Realize shared memory and scalable multiprocessors
CO3	Design interconnection of the topologies network
CO4	Develop and apply knowledge of distributed system organization and communication.
CO5	Explain the file structure and its coordination

**Course Articulation Matrix**

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	CO1	3												2	
	CO2	3												2	
	CO3	3												2	
	CO4	3												2	
	CO5	3												2	

## SENSORS FOR BIOMEDICAL APPLICATIONS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE40	SEE Marks:	50

### Course objectives:

This course will enable students to :

1.	To provide the basic understanding of measurement, insight of resistive sensors and its applications in real life.
2.	To familiarize the characteristics, working principle and application of smart sensors.
3.	To provide the basic understanding of bioelectrical signals and its measurement.
4.	To impart the importance of smart sensors, sensor interface standards for wearable device applications and to provide a brief overview of the wearable technology and its impact on social life.
5.	To familiarize the concepts of various sensors for health care application.

### UNIT I

**Introduction to sensors:** Functional Elements of a Measurement System and Instruments, Applications and Classification of Instruments, General concepts and terminology of Sensor systems, Transducers classification-sensors and actuators, General input-output configurations, Static and dynamic characteristics of measurement system, Sensors and their characteristics, sensor technologies, Resistive sensors- strain gages , light dependent resistor (LDR), resistive gas sensors, capacitive sensors- variable capacitor, differential capacitor.

**8 Hours**

### UNIT II

**Smart sensors:** Accelerometers: Characteristics and working principle, Types- Capacitive, Piezoresistive, piezoelectric; Diaphragm Pressure Sensor –resistive & capacitive type . Integrated and Smart sensors, Overview of various smart sensors: Digital temperature sensor (DS1621, TMP36GZ), Humidity sensor (DHT11, DHT22, and FC28), IR sensor (FC51), Gas sensor (MQ2, MQ8), Pressure sensors (BMP180), Accelerometers (ADXL335), Structural health monitoring sensors, Introduction to MEMS and Flexible sensors.

**8 Hours**

**UNIT III**

**Bio-electric signals and electrodes:** ECG signal origin, parameters and Characteristics, electrodes for ECG, EMG, EEG, EMG signal and recording, measurement of heart rate, pulse rate, blood pressure, blood oxygen sensing, blood flow, Plethysmography, and optical blood flow measurement.

**9 Hours****UNIT IV**

**Introduction to wearable technology:** Introduction to world of wearable (WOW), Role of wearable, The Ecosystem enabling Digital Life, Ethics and standards, Attributes of wearables, Taxonomy for wearables, Challenges and opportunities, future and research roadmap, Textiles and Clothing, Wearable applications, Wearable Bio and Chemical Sensors: Introduction, System Design, Micro needle Technology, Types of Sensors, Challenges in Chemical Biochemical Sensing: Sensor Stability, Interface with the Body, Textile Integration, Power Requirements, Applications: Personal Health, Sports Performance, Safety and Security.

**8 Hours****UNIT V**

**Wearable Sensors for health care:** Wearable Inertial Sensors - Accelerometers, Gyroscopic sensors and Magnetic sensors; Modality of Measurement- Wearable Sensors, Invisible Sensors, Force and Pressure Measurement; Applications: Fall Risk Assessment, Fall Detection, Gait Analysis, Quantitative Evaluation of Hemiplegic and Parkinson's Disease patients, wearable ECG, EEG, EMG devices. IoT in health care, AI and ML in Biomedical Instrumentation and sensors, Telemedicine, applications of telemedicine.

**9 Hours****TEXT BOOKS**

1	A.K. Sawhney	Electrical and Electronic Measurements and Instrumentation, DhanpatRai, 2012.
2	R.S.Khandpur	Biomedical instrumentation: Technology and applications, Tata McGraw-Hill Publishing, 1 <sup>st</sup> edition, 2004.

**REFERENCE BOOKS**

1	L. Cromwell, FJ Weibell and EA Pfeiffer	Biomedical instrumentation and measurements, Prentice-Hall Inc., New Jersey, USA, 2 <sup>nd</sup> edition, 1990.
2	Subhas C. Mukhopadhyay	Wearable Electronics Sensors-For Safe and Healthy Living, Springer International Publishing, 2015.
3	Edward Sazonov	Wearable Sensors: Fundamentals, Implementation and Applications, Neuman Academic Press, 1 <sup>st</sup> Edition, 2014.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply the knowledge of measurements to identify the sensor characteristics which can be employed for real life applications.
CO2	Classify the special purpose sensors required for the development of smart sensors.
CO3	Analyze bioelectrical signals and measure physiological parameters.
CO4	Describe the taxonomy of the wearable devices and its design constraints for measuring physical and biological signals
CO5	Realize the concepts of wearable sensors and IoT in health care.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	1						2	2			2	2
	CO2	3	2						2	2			2	2
	CO3	3	2						2	2			2	2
	CO4	3	2						2	2			2	2
	CO5	3	2						2	2			2	2

## APPLIED EMBEDDED SYSTEMS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE41	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Understand the implementation and applications of the embedded system.
2.	Discuss the common controllers used to build the embedded system.
3.	Learn the various software development approaches and an operating system services required.

### UNIT I

#### Introduction:

An embedded system, Processors embedded into a system, Embedded hardware units and devices in a system, Embedded software in a system, Examples of embedded systems, Embedded system on chip (SoC) and use of VLSI circuits design technology, Complex systems design and processors, Design process in embedded system, Formalism of system design, Design process and design examples, Classification of embedded systems, Skills required for an embedded system designer.

**8 Hours**

### UNIT II

#### Embedded controller (PIC)

CPU architecture and instruction sets: Hardware architecture and pipelining, program memory consideration, Register file structure and Addressing modes, CPU register, Instruction set, Loop time subroutine.

Timer2 and Interrupts: Timer2 use interrupt logic, Timer2 Scalar Initialization.

External interrupts and Timers: Timer0 Compare/capture mode, Timer1/CCP programmable period scalar. Timer1 and sleep mode, PWM O/P Port B change interrupts.

**8 Hours**

**UNIT III****Low Power embedded controller:**

Low Power embedded systems, Key differentiating factors between different MSP430 families. Target applications.

MSP430 RISC CPU architecture, Compiler friendly features, Instruction set, Clock system, Reset system, Memory subsystem. On chip peripherals. Watchdog Timer, Comparator, Op-Amp, Basic Timer, Real Time Clock (RTC), ADC, DAC, SD16. Using the Low power features of MSP430. Low power modes, Clock request feature, Low power programming and Interrupt.

**9 Hours****UNIT IV****PROGRAM MODELING CONCEPTS**

Program models, Data flow graph models, State machine programming models for event controlled programs, Modeling of multiprocessor systems, UML modeling.

**Embedded RTOS**

Inter process communication, Process Management, Timer Functions, Event Functions, Memory management, Device, File, and IO Subsystems Management, Interrupt Routines in RTOS environment and handling of interrupt source calls by RTOS, Introduction to Real Time Operating System, Basic Design Using a Real Time Operating System, RTOS Task Scheduling Models, Latency, Response Times, Deadline as Performance Metric, Latency and Deadlines as Performance Metric in Scheduling Models For Periodic, Sporadic and Aperiodic Tasks, CPU Load as Performance Metric, Sporadic Task Model Performance Metric. OS security issues.

**9 Hours****UNIT V**

**Devices and communication buses:** Serial communication devices, wireless devices, Networked embedded system, wireless and mobile system protocols.

**Case Studies of applications:** Design of RTC, Wireless sensor network with Chipcon RF interfaces.

**8 Hours**

**TEXT BOOKS**

1	Raj Kamal	Embedded Systems: Architecture and Programming, TMH. 2011.
2	John B Pitman	Design with PIC Microcontrollers, Pearson Education Asia, 1 <sup>st</sup> Edition, 2002.
3	John Davies	MSP430 Microcontroller Basics, Elsevier, 2010.

**REFERENCE BOOKS**

1	PIC microcontroller	Mid range reference manual
2	MSP430 user's guide	User's guide

**E-RESOURCES**

1	<a href="https://nptel.ac.in/courses/108102169">https://nptel.ac.in/courses/108102169</a>
2	<a href="https://nptel.ac.in/courses/108102045">https://nptel.ac.in/courses/108102045</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Apply the engineering knowledge to develop an embedded application.
CO2	Analyze and evaluate the common embedded controllers and their peripherals.
CO3	Design the programming models of embedded systems and implement on the RTOS platforms.
CO4	Evaluate various software models and metrics relevant to embedded system application.
CO5	Build and evaluate the different classes of embedded system using common hardware and software development platforms and environment.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	1										2	
	CO2	3	2										3	
	CO3	3	3			1						1	3	1
	CO4	3	3			1						1	3	1
	CO5	3	3			1			1	1		1	3	1

## REAL TIME SYSTEMS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE42	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	To understand fundamental concepts of real time systems and its architectural requirements.
2.	To learn the various RTS development methodologies and real time operating system.
3.	To articulate the practical constraints of real-time system design for various applications.

### UNIT I

Introduction to real-time systems: RTS Definition, Classification of Real-time Systems, Time constraints, Classification of Programs

Computer control concepts: Sequence Control, Loop control, Supervisory control, Centralised computer control, Distributed system, Human-computer interface, Benefits of computer control systems.

**8 Hours**

### UNIT II

Computer hardware requirements: Introduction, Single chip microcontroller, Specialized processors, Process-related Interfaces, Communications Languages for real time applications: Introduction to the languages for RTS, Syntax layout and readability, Modularity and Variables, Control Structure, Exception Handling, Overview of real-time languages.

**8 Hours**

### UNIT III

Design of RTSs: Introduction, Specification documentation, Preliminary design, Single-program approach, Foreground/ background, Multi-tasking approach, Mutual exclusion.

**8 Hours**

**UNIT IV**

RTS development methodologies: Introduction, Yourdon Methodology, Requirement definition for Drying Oven, Hatley and Pirbhai Method.

Fault tolerance techniques: Introduction, Definitions, what causes Failures, Fault types, Detection and Containment, Redundancy, Integrated Failure Handling.

**9 Hours****UNIT V**

Real time operating systems: Introduction, Real-time multi-tasking OS, Scheduling strategies, Priority Structures, Task management, Scheduler and real-time clock interrupt handles, Memory Management, Code sharing, Resource control, Task co-operation and communication, Mutual exclusion, Data transfer, Liveness, Minimum OS kernel.

**9 Hours****TEXT BOOKS**

1	Stuart Bennet	Real - Time Computer Control- An Introduction, Pearson Education., 2 <sup>nd</sup> Edition, 2005.
2	C. M. Krishna, Kang. G. Shin	Real Time Systems, Mc Graw Hill, India, 1997.

**REFERENCE BOOKS**

1	Phillip. A. Laplante	Real-Time Systems Design and Analysis, PHI, 2 <sup>nd</sup> edition, 2005.
2	Raj Kamal	Embedded Systems, Tata Mc Graw Hill, India, 2008.

**E-RESOURCES**

1	<a href="https://onlinecourses.nptel.ac.in/noc21_cs98/preview">https://onlinecourses.nptel.ac.in/noc21_cs98/preview</a>
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**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Explain the basics of real time systems and its architecture.
CO2	Analyse the computer hardware requirement and communication languages for real time application.
CO3	Design different approaches of Real Time System.
CO4	Develop various methods of Real Time System and analyze fault tolerance techniques
CO5	Explain the elements of RTOS.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3											2	
	CO2	3	2										2	
	CO3	3	2	2		2							2	2
	CO4	3	2	2		2							2	2
	CO5	3	2	2									2	

## EMBEDDED SYSTEM DESIGN

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE43	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Exhibit the knowledge of representing the hardware and software in unified way.
2.	Formulate the problems and choose suitable design, processor technology and integrating the embedded system.
3.	Develop a supplement to design a software architecture in real time digital systems.

### UNIT I

**Introduction:** Overview, Optimizing the Metrics, Processor Technology, Design Technology

**Custom Single Purpose Processors:** Custom Single Purpose Processors design, optimizing Program, FSMD, data path & FSM.

**8 Hours**

### UNIT II

**General purpose processors and ASIP's:** Software and operation of general purpose processors, Programmer's View, Development Environment, ASIP's, Microcontrollers, DSP.

**Standard Peripherals:** Timers and Applications, PWM's & Application, UART, Stepper Motor Controls, A/D Converters.

**8 Hours**

### UNIT III

**Memory:** Different types of ROM's & RAM's, Cache System.

**Interfacing:** Introduction to Interfacing, Interrupts and DMA, Communication: serial Protocols, Parallel Protocols, Wireless Protocols.

**10 Hours**

**UNIT IV**

**Interrupts:** Basics, Shared Data Problem, Interrupt latency,  
**Introduction to Real Time Operating System:** Tasks and states, scheduler, tasks and data, shared data problem, reentrancy, Semaphores and shared data, semaphores problem, semaphore variants.

**8 Hours****UNIT V**

**Real Time Operating System Services:** Message Queues, Mail boxes, and Pipes, Timer Functions, Events, Memory Management, Interrupt Routines in an RTOS environment.

**8 Hours****TEXT BOOKS**

1	Frank Vahid and Tony Givargis	Embedded system Design, John Wiley, 2002.
2	David E Simon	An Embedded Software Primer, Pearson Education, 1999.

**REFERENCE BOOKS**

1	Tammy Noergaard	Embedded Systems Architecture – A Comprehensive Guide for Engineers and Programmers, Elsevier Publication, 2005.
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**TEXT BOOKS**

1	<a href="https://www.youtube.com/watch?v=TP1_F3IVjBc&amp;list=PLJ5C_6qdAvBEUjcu1ka0QY9G-zoOlXqCL">https://www.youtube.com/watch?v=TP1_F3IVjBc&amp;list=PLJ5C_6qdAvBEUjcu1ka0QY9G-zoOlXqCL</a> .
2	<a href="https://www.youtube.com/watch?v=docZGkYbruw&amp;list=PLJ5C_6qdAvBEUjcu1ka0QY9G-zoOlXqCL&amp;index=3">https://www.youtube.com/watch?v=docZGkYbruw&amp;list=PLJ5C_6qdAvBEUjcu1ka0QY9G-zoOlXqCL&amp;index=3</a> .

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Design custom single purpose processor, analyze the FSMD, FSM and optimize the processor.
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CO2	Identify and contrast the features of the general purpose processors and ASIP's processor design technologies, and illustrate the standard peripherals used to improve the productivity of the embedded system.
CO3	Design memory and the communication protocols in building an embedded system.
CO4	Apply the knowledge of software architecture to describe the difference between various embedded system architectures and the interrupt mechanism for embedded software design.
CO5	Analyse the typical RTOS services for embedded system software and apply the various intercommunication and scheduling strategies for building the embedded system software.

### Course Articulation Matrix

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3											3	
	CO2	2	2	1		1			1					
	CO3	2	2										2	
	CO4	2	2										2	
	CO5	3	1	1					1					1

## SYSTEM ON CHIP

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE44	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Understand the fundamentals of designing System-on-Chip and system architecture.
2.	Apply these fundamentals to design different real-world System on Chip Devices.

### UNIT I

**Introduction to the Systems Approach:** System Architecture, Components of the system, Hardware & Software, Processor Architectures, Memory and Addressing. System level interconnection, an approach for SOC Design, System Architecture and Complexity.

**8 Hours**

### UNIT II

**Processors:** Introduction, Processor Selection for SOC, Basic concepts in Processor Architecture, Basic concepts in Processor Micro Architecture, Basic elements in Instruction handling.

**Buffers:** Minimizing Pipeline Delays, Branches, More Robust Processors, Vector Processors and Vector Instructions extensions, VLIW Processors, Superscalar Processors.

**9 Hours**

### UNIT III

**Memory Design for SOC :** System-on-Chip and Board-Based Systems, SoC External Memory DDR, Flash, SoC Internal Memory: Placement, Size of Memory, Scratchpads and Cache Memory, SoC (On-Die) Memory Systems, Board-based (Off-Die) Memory System, Interaction between processor and memory.

**9 Hours**

**UNIT IV**

Interconnect architectures for SoC: Bus architecture, SOC Standard buses, Analytic bus models, Beyond the bus: Network on Chip (NOC) with switch interconnects, NOC examples, Layered Architecture and NIU, Evaluating Interconnect networks C.

**8 Hours****UNIT V**

**Applications of SoCs** : SOC Design approach, Applications of SoC for Image processing.

**Case study on Design and Analysis of a RISC-V based SoC:** Introduction to RISC-V ISA, Comparison with ARM ISA modular design advantages.

**8 Hours****TEXT BOOKS**

1	Michael J. Flynn and Wayne Luk	Computer System Design System-on-Chip Wiley India Pvt. Ltd.
2	Steve Furber	ARM System on Chip Architecture, Addison Wesley Professional, 2 <sup>nd</sup> Edition, 2000.

**REFERENCE BOOKS**

1	Michael Keating, Pierre Bricaud	Reuse Methodology Manual for System on Chip designs, Kluwer Academic Publishers, 2 <sup>nd</sup> Edition, 2008.
2	Ricardo Reis	Design of System on a Chip: Devices and Components, 1 <sup>st</sup> Edition, 2004.

**E-RESOURCES**

1	<a href="https://onlinecourses.nptel.ac.in/noc21_ee09/preview">https://onlinecourses.nptel.ac.in/noc21_ee09/preview</a>
2	<a href="https://archive.nptel.ac.in/courses/117/106/117106093/">https://archive.nptel.ac.in/courses/117/106/117106093/</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Learn the System on Chip design, Architecture and complexity in designing
CO2	Apply the design concepts for Processors and interconnect architecture
CO3	Recognize the type of memory required to design System on a Chip device
CO4	Identify interconnect architectures required for the design of SoC
CO5	Design a modern System-on-a-Chip Device

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2			2			2	2		2	2	2
	CO2	3	2	2		2			2	2		2	2	2
	CO3	3	2	3		2			2	2		2	2	2
	CO4	3	2	3		2			2	2		2	2	2
	CO5	3	2	2		2			2	2		2	2	2

## AUTOMOTIVE ELECTRONICS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE45	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Understand the fundamentals of automotive electronics for vehicles.
2.	Acquire the technical knowledge of applying these fundamentals to commercial vehicles.
3.	Analyze the future trend of automotive electronics.

### UNIT I

**Basics of Electronics in Automotive:** Overview automotive electronics, Motoronic Engine management system. Chassis Control domain- Traction control system, Anti Braking System, adaptive cruise control system, Occupant Safety system. Body electronics domains- Lighting, window, central locking electric system.

**8 Hours**

### UNIT II

**Vehicle system architecture:** Hardware architecture, software architecture, Network architecture.

**Control theory:** open loop control, closed loop control- case study fuel control system, speed control system, Steering components.

**8 Hours**

### UNIT III

**Automotive networking:** OSI and Autosar standards, basics of vehicle automotive system networking, Bus system: Requirements, classification, CAN, LIN, MOST, Bluetooth, Flex-ray, Coupling systems.

**8 Hours**

**UNIT IV**

**Automotive sensors and measurements:** Features of vehicle sensors, classification, smart sensors- Position sensors, Speed and RPM sensors, Pressure sensors, flow sensors, wave propagation sensors, image sensors.

**Automotive MCUs for vehicular control:** Power MCU, NXP automotive MCU case study.

**9 Hours****UNIT V**

**Automotive Diagnostics:** Electronic Control System Diagnostics, Service Bay, Diagnostic Tool, On-board Diagnostics, Model-Based Sensor Failure Detection, Expert Systems in Automotive Diagnosis.

**Future trends of Automotive Electronics:** Electric Vehicles, Hybrid Vehicles, Augmentation, and Autonomous driving assistance.

**Case study:** Contemporary commercial automotive vehicle.

**9 Hours****TEXT BOOKS**

1	Robert Bosch Gmbh (Ed.)	Bosch Automotive Electrics and Automotive Electronics Systems and Components, Networking and Hybrid Drive, John Wiley& Sons Inc., 5 <sup>th</sup> Edition, 2007.
2	Hillier	Fundamentals of Motor Vehicle Technology on Chassis and Body Electronics, Nelson Thrones, 5 <sup>th</sup> Edition, 2007.
3	William B. Ribbens	Understanding Automotive Electronics, Butterworth, Heinemann Woburn, 5 <sup>th</sup> Edition, 1998.
4	STM Reference Manual	SPC58 2B Line - 32 bit Power Architecture automotive MCU.
5	NXP Reference manual	S32K3 Microcontrollers, 2022 Edition.

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Describe the basic Vehicular design and the basic electronics block associated with.
CO2	Analyze the vehicular architecture and design the control systems involved in automotive principles.
CO3	Analyze and apply the networking principles in automotive electronics
CO4	Analyze the measurement tools and Controller architecture involved in design of automotive vehicles.
CO5	Analyze the future trends and design an automotive electronics based vehicle.

**Course Articulation Matrix**

		POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2	
COs	CO1	2	1											1	
	CO2	2	2	2										2	
	CO3	2	2	2										2	
	CO4	2	2	2										2	
	CO5	2	1											1	

## AUTOMOTIVE EMBEDDED SYSTEMS

Contact Hours/ Week:	: 3+0+0	Credits:	3
Total Lecture Hours:	: 42	CIE Marks:	50
Sub. Code:	: SECE46	SEE Marks:	50

### Course objectives:

This course will enable students to:

1.	Equip students with the knowledge and skills to develop embedded systems for automotive applications.
2.	Develop model-based design workflow for embedded algorithms.

### UNIT I

#### Embedded System Overview:

Embedded Systems in Context to Automotive, Embedded System Development Process, Building blocks of Embedded Systems, Characteristics of Automotive Embedded Systems, Role of Processors / Microcontrollers in Automotive, Criteria for selecting microcontrollers in Automotive, Concept of Build process of Embedded Application, Debugging Tools.

**8 Hours**

### UNIT II

#### Introduction to ARM Microcontroller:

Overview of ARM and RISC Design Philosophy, concept of ARM cortex M- series Microcontroller, Advanced Microcontroller Bus Architecture, Introduction to STM32H7xxx Microcontroller – Features, Architecture, Memory Organization, Pin Diagram, and I/O configuration.

**8 Hours**

**UNIT III****Embedded Application Design:**

Basic Data Types Arrays, Pointers, Storage classes, Passing Data to Functions Caller vs Callee, Structure and Bitfields, Passing Structure to Functions, Enums and Typedefs, Bit-wise Operators and Macros. Understanding the concept of HAL library and its role in embedded C programming.

**8 Hours****UNIT IV****Interfacing Applications and Interrupts:**

GPIO programming with external devices (LED, Switch, Motor control) using HAL, Configuring ADC registers, Programming timers and related control registers, applications of timer in time-sharing system, Concept of compare/capture modes, and applications of timers in PWM control, Interrupt programming with Hal – Interrupt priorities. Communication Protocol – UART.

**9 Hours****UNIT V**

**Model-Based Design, Code Generation and Simulation-Based Testing:** V-cycle and MBD Workflow, Programming with MATLAB (m-script), Simulink Modelling of Dynamic Systems, State flow Modelling, Model Architecture, Data Management. The architecture of an embedded application, Introduction to Auto-Code Generation, System specification, generating code, Data structures in generated code, Verification, and Validation in MBD, Simulink-based Testing (Creating Test Harness), verifying generated code.

**9 Hours****TEXT BOOKS**

1	Shujen Chen, Eshragh Ghaemi, Muhammad Ali Mazidi	STM32 ARM Programming for Embedded Systems, Microdigitaled, 2018.
2	Matlab model based design tool box	Documentation by MATLAB on Model-based Design.

**REFERENCE BOOKS**

1	Yifeng Zhu	E-book: Embedded Systems with ARM Cortex-M Microcontrollers in Assembly Language and C.
2	Donald Norris	E-book: Programming with STM32: Getting Started with the Nucleo-Board and C/C++.
3	Andrew N. S Loss, Dominic Symes, Chris Wright.	E-book: ARM System Developer's Guide.
4	Michael Barr and Anthony J. Massa.	E-book: Programming Embedded Systems in C and C++.

**E-RESOURCES**

1	<a href="https://www.udemy.com/course/embedded-systems-bare-metal-programming/">https://www.udemy.com/course/embedded-systems-bare-metal-programming/</a>
2	<a href="https://www.youtube.com/playlist?list=PL0XvCDGTtp12wpZ9QyFNfsEs3DjJnJMuD">https://www.youtube.com/playlist?list=PL0XvCDGTtp12wpZ9QyFNfsEs3DjJnJMuD</a>
3	<a href="https://www.edx.org/course/embedded-systems-essentials-with-arm-getting-started">https://www.edx.org/course/embedded-systems-essentials-with-arm-getting-started</a>
4	<a href="https://in.mathworks.com/help/ecoder/ug/generating-code-using-embedded-coder.html">https://in.mathworks.com/help/ecoder/ug/generating-code-using-embedded-coder.html</a>
5	<a href="https://www.mathworks.com/videos/automatic-code-generation-for-embedded-control-systems-106530.html">https://www.mathworks.com/videos/automatic-code-generation-for-embedded-control-systems-106530.html</a>

**Course Outcomes:**

Upon completion of this course the student will be able to:

CO1	Analyze Microcontroller architecture and its role in Automotive systems.
CO2	Design application code using proper language constructs and related coding guidelines for given system specifications.
CO3	Design the code using efficient software architecture, data types, qualifiers, and interrupts.
CO4	Analyze interfacing applications with external devices along with interrupt concept.
CO5	Formulate and analyze Model-based Design workflow in Automotive Industry.

**Course Articulation Matrix**

	POs											PSOs		
		1	2	3	4	5	6	7	8	9	10	11	1	2
COs	CO1	3	2										3	
	CO2	3	3			1							3	1
	CO3	3	3			1							3	1
	CO4	3	3			1							3	1
	CO5	3	3	1		2							3	2