SCHOOL OF ELECTRICAL AND COMMUNICATION

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VTR UGE 2021 CURRICULUM

School of Electrical and Communication Engineering

Department of Electronics and Communication Engineering

Vision

To be a centre of academic excellence through quality education and cutting-edge research in the diversified fields of electronics and communication engineering to meet the global challenges and produce high quality professionals.

Mission

M1: *To enrich the knowledge of graduate engineers for global requirements by promoting quality education through innovative pedagogical practices.*

M2: *To create an ambience of academic excellence by engaging in cutting-edge research and undertaking collaborative projects with academia and industry.*

M3: *To develop competence by inculcating human and moral values with leadership and professional skills.*

Programme Educational Objectives

PEO1: Our graduates will have in-depth knowledge in mathematical and engineering concepts required to solve engineering problems in the analysis and design of Electronics and Communication Devices and Systems.

PEO2: Our graduates will have the expertise to conceive, design, implement and operate the Engineering products for the societal and environmental problems.

PEO3: Our graduates will have adequate technical skills and leadership qualities in the development of innovative solutions required in core and allied industries.

PEO4: Our graduates will adapt to multidisciplinary environment using evolving technologies and achieve professional competence through higher education, research and lifelong learning.

PEO5: Our graduates will communicate effectively, practice and promote ethical, environmental, health and safety standards in their profession.

PROGRAMME OUTCOMES

PO1:	Engineering knowledge: Apply the knowledge of mathematics, science, engineering fundamentals, and an engineering specialization to the solution of complex engineering problems.
PO2:	Problem analysis: Identify, formulate, review research literature, and analyze complex engineering problems reaching substantiated conclusions using first principles of mathematics, natural sciences, and engineering sciences.
PO3:	Design/development of solutions: Design solutions for complex engineering problems and design system components or processes that meet the specified needs with appropriate consideration for the public health and safety, and the cultural, societal, and environmental considerations.
PO4:	Conduct investigations of complex problems: Use research-based knowledge and research methods including design of experiments, analysis and interpretation of data, and synthesis of the information to provide valid conclusions.
PO5:	Modern tool usage: Create, select, and apply appropriate techniques, resources, and modern engineering and IT tools including prediction and modeling to complex engineering activities with an understanding of the limitations.
PO6:	The engineer and society: Apply reasoning informed by the contextual knowledge to assess societal, health, safety, legal and cultural issues and the consequent responsibilities relevant to the professional engineering practice.
PO7:	Environment and sustainability: Understand the impact of the professional engineering solutions in societal and environmental contexts, and demonstrate the knowledge of, and need for sustainable development.
PO8:	Ethics: Apply ethical principles and commit to professional ethics and responsibilities and norms of the engineering practice.
PO9:	Individual and team work: Function effectively as an individual, and as a member or leader in diverse teams, and in multidisciplinary settings.
PO10:	Communication: Communicate effectively on complex engineering activities with the engineering community and with society at large, such as, being able to comprehend and write effective reports and design documentation, make effective presentations, and give and receive clear instructions.
PO11:	Project management and finance: Demonstrate knowledge and understanding of the engineering and management principles and apply these to one's own work, as a member and leader in a team, to manage projects and in multidisciplinary environments.
PO12:	Life-long learning: Recognize the need for, and have the preparation and ability to engage in independent and life-long learning in the broadest context of technological change.

Programme Specific Outcomes (PSOs)

PSO1:	Apply the knowledge of Electronics and Communication engineering to develop CDIO framework using modern Engineering hardware and software tools to meet societal and industrial needs
PSO2:	Design and develop smart systems using Artificial Intelligence, Data Science and Cyber Security technologies.

SCHOOL OF ELECTRICAL AND COMMUNICATION

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

CURRICULUM STRUCTURE

Course Category	Regular Credit	Lateral Entry Credit
Foundation Course (FC)	56	22
Programme Core (PC)	58	48
Programme Electives (PE)	18	18
Open Electives (OE)	12	12
Independent Learning (IL)	14	14
Industry / Higher Institute Learning Interaction (IHL)	2	2
Professional Proficiency Course (PPC)	4	4
Total	**164**	**120**

INDEX

S. No.	Course Code	Course Title	Page No.
PROGRAMME CORE COURSES			
1	10211EC101	Circuit Theory	1
2	10211EC102	Analog Electronics	4
3	10211EC103	Digital Electronics	7
4	10211EC104	Linear Integrated Circuits	10
5	10211EC105	Control Systems	13
6	10211EC106	Signals and Systems	16
7	10211EC107	Electromagnetics and Transmission Lines	19
8	10211EC108	Communication Systems	22
9	10211EC109	Microprocessor and Microcontroller	25
10	10211EC110	Data Communication Networks	28
11	10211EC111	Discrete Time Signal Processing	31
12	10211EC112	Wireless Communication	34
13	10211EC113	Antenna Theory	37
14	10211EC114	VLSI Design	40
15	10211EC115	Optical and Microwave Communication Systems	43
16	10211EC201	Embedded OS and Device Drivers	46
17	10211EC202	Internet of Things	50
18	10211EC301	Analog Integrated Circuits Laboratory	54
19	10211EC302	Digital Electronics Laboratory	57
20	10211EC303	Signal Processing Laboratory	60
21	10211EC304	Microprocessor and Microcontroller Laboratory	62
22	10211EC305	Communication Laboratory	65
23	10211EC306	Optical and Microwave Engineering Laboratory	68
PROGRAMME ELECTIVE COURSES			
Communication System Domain			
1	10212EC101	RF and Microwave Integrated Circuits	71
2	10212EC102	Cellular Mobile Communication	74
3	10212EC103	Information Theory and Coding	77

S. No.	Course Code	Course Title	Page No.
4	10212EC104	Radar and Electronic Navigation Systems	80
5	10212EC105	Satellite Communication	83
6	10212EC106	Advanced Optical Communication Systems	86
7	10212EC107	Digital TV Engineering	89
8	10212EC108	Software Defined Radio	92
9	10212EC201	Electromagnetic Interference and Compatibility	95
10	10212EC202	MIMO Wireless Communication	98
11	10212EC203	Antenna Design and Application	102
12	10212EC196	Electronic Warfare Radar Antenna Systems	105
Embedded System Domain			
13	10212EC109	Embedded System Design	108
14	10212EC110	Robotics and its Applications	111
15	10212EC111	Embedded Communication Protocols	114
16	10212EC112	Video Analytics	117
17	10212EC113	Wearable Devices	120
18	10212EC114	Process Control	124
19	10212EC204	Embedded C Programming	127
20	10212EC205	Embedded Linux and Device Drivers	130
21	10212EC206	Embedded Systems and Robotics	133
22	10212EC207	System on Chip	137
23	10212EC208	Virtual Instrumentation Programming	140
24	10212EC906	Embedded Software Engineering - I	144
25	10212EC907	Linux System Programming	147
26	10212EC908	Linux Device Drivers	151
27	10212EC910	Embedded Software Engineering - II	154
28	10212EC904	Real Time Operating System using QNX	157
Networks Domain			
29	10212EC115	High Performance Communication Networks	160
30	10212EC116	Network Security	163
31	10212EC117	Network Management	166

S. No.	Course Code	Course Title	Page No.
32	10212EC118	Next Generation Mobile Networks	169
33	10212EC119	Wireless Body Area Networks	172
34	10212EC209	Software Defined Networking	175
35	10212EC210	Cognitive Radio Networks	179
36	10212EC211	Wireless Sensor Networks and its Application	182
37	10212EC212	Flying IoT	185
Signal Processing Domain			
38	10212EC120	Advanced Digital Signal Processing	189
39	10212EC121	Estimation Theory	192
40	10212EC122	DSP Algorithms and Architecture	195
41	10212EC123	Signal Processing Techniques for Speech Recognition	198
42	10212EC124	ANN and Deep Learning	201
43	10212EC125	Fuzzy-Neural Systems	204
44	10212EC126	Biomedical Instrumentation and Imaging	207
45	10212EC175	Fundamentals of Quantum Computing	210
46	10212EC213	Digital Image and Video Processing	213
47	10212EC214	Fundamentals of Machine Learning	216
48	10212EC215	Professional Python Programming	219
49	10212EC243	Applied Programming Skills using Python	223
VLSI Domain			
50	10212EC127	Low Power VLSI Design	237
51	10212EC128	VLSI Design Techniques	240
52	10212EC129	VLSI for Wireless Communication	243
53	10212EC130	Solid State Devices	246
54	10212EC131	Architectural Design of Digital Integrated Circuits	249
55	10212EC132	Nano Scale Transistors	252
56	10212EC133	Opto Electronic Devices	255
57	10212EC134	Electronic Instrumentation	258
58	10212EC135	Nano Photonics	261
59	10212EC136	Fiber Lasers and Applications	264

S. No.	Course Code	Course Title	Page No.
60	10212EC137	Sensors and Transducers	267
61	10212EC216	FGPA Architecture Technologies and Tools	270
62	10212EC217	Electronic Circuit Simulation and PCB Design	273
63	10212EC232	Reconfigurable System Design	276
64	10212EC233	VLSI Chip Design	279
65	10212EC901	VLSI Design and Verification using System Verilog	282
SPECIALIZATION DEGREE – ELECTIVE COURSES			
Cyber Security			
1	10212EC150	Digital Forensics	285
2	10212EC151	Cryptography for Cyber and Network Security	288
3	10212EC152	Blockchain Technology	291
4	10212EC153	Automotive Cyber Security	294
5	10212EC154	Cyber Security for Smart Wearable	297
6	10212EC222	Principles of Networking and Cyber Security	300
7	10212EC223	Ethical Hacking	304
8	10212EC224	Artificial Intelligence for Cyber Security	308
9	10212EC4xx	NPTEL Course – Mandatory	--
Artificial Intelligence and Data Science			
10	10212EC155	Fundamentals of Data Science	311
11	10212EC156	Data Analysis and Visualization	314
12	10212EC157	Soft Computing	317
13	10212EC158	Statistical Inference Techniques	320
14	10212EC159	Machine Vision	323
15	10212EC174	Principles of Data Science	326
16	10212EC225	Tools for Data Science	329
17	10212EC226	Machine Learning	332
18	10212EC227	Deep Learning	336
Artificial Intelligence and Machine Learning			
22	10212EC160	Optimization Techniques	340
25	10212EC228	Data Science and Visualization	343

S. No.	Course Code	Course Title	Page No.
26	10212EC229	AI in Natural Language Processing	347
27	10212EC230	AI in Speech Processing	350
Internet of Things			
29	10212EC176	Industry 4.0 and IIoT	353
30	10212EC177	IoT Security	356
31	10212EC178	Artificial Intelligence and Machine Learning	359
32	10212EC179	Flexible and Wearable Sensors	362
33	10212EC180	Automotive Sensors and In-Vehicle Networking	365
34	10212EC234	IoT System Design and Development	368
35	10212EC236	ARM System Architecture	372
36	10212EC237	Embedded Linux	375
Integrated Circuit Technology			
38	10212EC238	SOC Design and Verification	378
39	10212EC239	SOC Design Through Physical Implementation Leading to Tape-Out	381
40	10212EC240	CAD for VLSI	384
41	10212EC241	FPGA Programming	387
42	10212EC197	Microfabrication of Semiconductor and Materials	390
43	10212EC242	AI and ML for VLSI CAD	393
44	10212EC198	Design for Testability	397
45	10212EC199	AI Circuits	400
46	10212EC902	IC Packaging	403
47	10212EC903	Verification Tools and Techniques	406
HONORS DEGREE - ELECTIVE COURSES			
Artificial Intelligence for Wireless Communication			
1	10212EC138	Introduction to Artificial Intelligence and Machine Learning	409
2	10212EC139	Wireless Communications and Networking	412
3	10212EC140	Machine learning for Wireless Communications	415
4	10212EC141	Artificial Intelligence based Wireless Network Design	418
5	10212EC142	Optimization for wireless and machine learning	421

S. No.	Course Code	Course Title	Page No.
6	10212EC143	Microwave and Millimeter Wave Communication	424
7	10212EC144	Artificial Intelligence in Optical Communication	427
8	10212EC218	Smart antennas for 5G communication	430
VLSI System Design			
9	10212EC145	Digital IC Design	433
10	10212EC146	Mixed Signal VLSI Design	436
11	10212EC147	IC Technology	439
12	10212EC148	Testing of VLSI Circuits	442
13	10212EC149	VLSI Signal Processing	445
14	10212EC219	Analog Circuit IC Design	448
15	10212EC220	Physical Design of CMOS IC	451
16	10212EC221	Reconfigurable Computing with FPGA	455
MINOR DEGREE – ELECTIVE COURSES			
Smart Communication Technologies			
1	10212EC161	Security in Communication and Networking Systems	458
2	10212EC162	Vehicular Communications and Inter-Networking Technologies	461
3	10212EC163	Sensors and Wearable Technology	464
4	10212EC164	Sensors for structural health Monitoring	467
5	10212EC165	IoT in Automotive Systems	470
6	10212EC166	M2M Communication with IoT and LTE	473
7	10212EC167	Flexible electronics for automobile applications	476
Smart Automation			
9	10212EC168	Basics of Embedded System	479
10	10212EC169	Sensors and Transducers	482
11	10212EC170	Embedded Security	485
12	10212EC171	Flexible Electronics	488
13	10212EC172	Smart City	491
14	10212EC173	Integrated Product Development	494
15	10212EC206	Embedded Systems and Robotics	497
16	10212EC231	Embedded IoT	500

S. No.	Course Code	Course Title	Page No.
5G and Beyond			
18	10212EC181	Wireless Communication	504
19	10212EC182	5G Technology	507
20	10212EC183	5G New Radio	510
21	10212EC184	Millimeter Wave Technology	513
22	10212EC185	5G Networks	516
23	10212EC186	MIMO Wireless Communication	519
24	10212EC187	5G Security	522
25	10212EC188	6G Mobile Networks	525
Semiconductor Technologies			
27	10212EC189	Semiconductor Materials and Devices	528
28	10212EC190	Semiconductor Process Technology	531
29	10212EC191	VLSI and Post CMOS Electronics	534
30	10212EC192	Semiconductor Packaging	537
31	10212EC193	VLSI Testing and Verification	540
32	10212EC194	Quantum Technologies for VLSI	543
33	10212EC195	Semiconductor Optoelectronics and Photovoltaics	546
34	10212EC235	FPGA based System Design	549
OPEN ELECTIVE COURSES			
1	10213EC101	Introduction to Robotics	552
2	10213EC102	Video Surveillance System	555
3	10213EC103	Wearable Devices	558
4	10213EC104	Wireless Communication Networks	561
5	10213EC105	Basics of Signal Processing	564
6	10213EC106	Image Processing and its Applications	567
7	10213EC107	Industrial Automation	570
8	10213EC108	Building Automation	573
9	10213EC109	Embedded Systems	576
10	10213EC110	FPGA Architectures and Applications	579
11	10213EC111	Intelligent Transport Systems	582

S. No.	Course Code	Course Title	Page No.
12	10213EC112	Wireless Communication Technologies	585
13	10213EC113	FPGA Technology and Applications	588
14	10213EC114	Basics of Embedded System	591
15	10213EC115	Basics of Sensors and Transducers	594
16	10213EC201	Vehicle Electronics & Networks	597
INDEPENDENT LEARNING			
1	10214EC501	Community Service Project	600
2	10214EC601	Minor Project I	602
3	10214EC602	Minor Project II	604
4	10214EC701	Major Project	606

VTR UGE 2021

CURRICULUM

S. No.	Course Code	Course Title	L	T	P	C
PROGRAMME CORE COURSES						
1	10211EC101	Circuit Theory	2	1	0	3
2	10211EC102	Analog Electronics	2	1	0	3
3	10211EC103	Digital Electronics	3	0	0	3
4	10211EC104	Linear Integrated Circuits	3	0	0	3
5	10211EC105	Control Systems	2	1	0	3
6	10211EC106	Signals and Systems	2	1	0	3
7	10211EC107	Electromagnetics and Transmission Lines	2	1	0	3
8	10211EC108	Communication Systems	2	1	0	3
9	10211EC109	Microprocessor and Microcontroller	3	0	0	3
10	10211EC110	Data Communication Networks	2	1	0	3
11	10211EC111	Discrete Time Signal Processing	2	1	0	3
12	10211EC112	Wireless Communication	2	1	0	3
13	10211EC113	Antenna Theory	2	1	0	3
14	10211EC114	VLSI Design	3	0	0	3
15	10211EC115	Optical and Microwave Communication Systems	2	1	0	3
16	10211EC201	Embedded OS and Device Drivers	2	0	2	3
17	10211EC202	Internet of Things	2	0	2	3
18	10211EC301	Analog Integrated Circuits Laboratory	0	0	4	2
19	10211EC302	Digital Electronics Laboratory	0	0	2	1
20	10211EC303	Signal Processing Laboratory	0	0	2	1
21	10211EC304	Microprocessor and Microcontroller Laboratory	0	0	2	1
22	10211EC305	Communication Laboratory	0	0	2	1
23	10211EC306	Optical and Microwave Engineering Laboratory	0	0	2	1
		TOTAL CREDIT				**58**

S. No.	Course Code	Course Title	L	T	P	C
PROGRAMME ELECTIVE COURSES						
Communication System Domain						
1	10212EC101	RF and Microwave Integrated Circuits	3	0	0	3
2	10212EC102	Cellular Mobile Communication	3	0	0	3
3	10212EC103	Information Theory and Coding	3	0	0	3
4	10212EC104	Radar and Electronic Navigation Systems	3	0	0	3
5	10212EC105	Satellite Communication	3	0	0	3
6	10212EC106	Advanced Optical Communication Systems	3	0	0	3
7	10212EC107	Digital TV Engineering	3	0	0	3
8	10212EC108	Software Defined Radio	3	0	0	3
9	10212EC201	Electromagnetic Interference and Compatibility	2	0	2	3
10	10212EC202	MIMO Wireless Communication	2	0	2	3
11	10212EC203	Antenna Design and Application	2	0	2	3
12	10212EC196	Electronic Warfare Radar Antenna Systems	3	0	0	3
Embedded System Domain						
13	10212EC109	Embedded System Design	3	0	0	3
14	10212EC110	Robotics and its Applications	3	0	0	3
15	10212EC111	Embedded Communication Protocols	3	0	0	3
16	10212EC112	Video Analytics	3	0	0	3
17	10212EC113	Wearable Devices	3	0	0	3
18	10212EC114	Process Control	3	0	0	3
19	10212EC204	Embedded C Programming	2	0	2	3
20	10212EC205	Embedded Linux and Device Drivers	1	0	4	3
21	10212EC206	Embedded Systems and Robotics	1	0	4	3
22	10212EC207	System on Chip	1	0	4	3
23	10212EC208	Virtual Instrumentation Programming	1	0	4	3
24	10212EC906	Embedded Software Engineering - I	2	0	2	3
25	10212EC907	Linux System Programming	2	0	2	3
26	10212EC908	Linux Device Drivers	2	0	2	3
27	10212EC910	Embedded Software Engineering - II	2	0	2	3
28	10212EC904	Real Time Operating System using QNX	2	0	2	3
Networks Domain						
29	10212EC115	High Performance Communication Networks	3	0	0	3
30	10212EC116	Network Security	3	0	0	3
31	10212EC117	Network Management	3	0	0	3

S. No.	Course Code	Course Title	L	T	P	C
32	10212EC118	Next Generation Mobile Networks	3	0	0	3
33	10212EC119	Wireless Body Area Networks	3	0	0	3
34	10212EC209	Software Defined Networking	2	0	2	3
35	10212EC210	Cognitive Radio Networks	2	0	2	3
36	10212EC211	Wireless Sensor Networks and its Application	2	0	2	3
37	10212EC212	Flying IoT	2	0	2	3
Signal Processing Domain						
38	10212EC120	Advanced Digital Signal Processing	3	0	0	3
39	10212EC121	Estimation Theory	3	0	0	3
40	10212EC122	DSP Algorithms and Architecture	3	0	0	3
41	10212EC123	Signal Processing Techniques for Speech Recognition	3	0	0	3
42	10212EC124	ANN and Deep Learning	3	0	0	3
43	10212EC125	Fuzzy-Neural Systems	3	0	0	3
44	10212EC126	Biomedical Instrumentation and Imaging	3	0	0	3
45	10212EC175	Fundamentals of Quantum Computing	3	0	0	3
46	10212EC213	Digital Image and Video Processing	2	0	2	3
47	10212EC214	Fundamentals of Machine Learning	2	0	2	3
48	10212EC215	Professional Python Programming	2	0	2	3
49	10212EC243	Applied Programming Skills using Python	2	0	2	3
VLSI Domain						
50	10212EC127	Low Power VLSI Design	3	0	0	3
51	10212EC128	VLSI Design Techniques	3	0	0	3
52	10212EC129	VLSI for Wireless Communication	3	0	0	3
53	10212EC130	Solid State Devices	3	0	0	3
54	10212EC131	Architectural Design of Digital Integrated Circuits	3	0	0	3
55	10212EC132	Nano Scale Transistors	3	0	0	3
56	10212EC133	Opto Electronic Devices	3	0	0	3
57	10212EC134	Electronic Instrumentation	3	0	0	3
58	10212EC135	Nano Photonics	3	0	0	3
59	10212EC136	Fiber Lasers and Applications	3	0	0	3
60	10212EC137	Sensors and Transducers	3	0	0	3
61	10212EC216	FGPA Architecture Technologies and Tools	2	0	2	3
62	10212EC217	Electronic Circuit Simulation and PCB Design	1	0	4	3
63	10212EC232	Reconfigurable System Design	1	0	4	3
64	10212EC233	VLSI Chip Design	1	0	4	3

S. No.	Course Code	Course Title	L	T	P	C
65	10212EC901	VLSI Design and Verification using System Verilog	2	0	4	4
		Minimum no. of credits to be Completed				**18**

SPECIALIZATION DEGREE – ELECTIVE COURSES

S. No.	Course Code	Course Title	L	T	P	C
Cyber Security						
1	10212EC150	Digital Forensics	3	0	0	3
2	10212EC151	Cryptography for Cyber and Network Security	3	0	0	3
3	10212EC152	Blockchain Technology	3	0	0	3
4	10212EC153	Automotive Cyber Security	3	0	0	3
5	10212EC154	Cyber Security for Smart Wearable	3	0	0	3
6	10212EC222	Principles of Networking and Cyber Security	2	0	2	3
7	10212EC223	Ethical Hacking	2	0	2	3
8	10212EC224	Artificial Intelligence for Cyber Security	2	0	2	3
9	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
Artificial Intelligence and Data Science						
10	10212EC155	Fundamentals of Data Science	3	0	0	3
11	10212EC156	Data Analysis and Visualization	3	0	0	3
12	10212EC157	Soft Computing	3	0	0	3
13	10212EC158	Statistical Inference Techniques	3	0	0	3
14	10212EC159	Machine Vision	3	0	0	3
15	10212EC174	Principles of Data Science	3	0	0	3
16	10212EC225	Tools for Data Science	1	0	4	3
17	10212EC226	Machine Learning	2	0	2	3
18	10212EC227	Deep Learning	2	0	2	3
19	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
Artificial Intelligence and Machine Learning						
20	10212EC157	Soft Computing	3	0	0	3
21	10212EC159	Machine Vision	3	0	0	3
22	10212EC160	Optimization Techniques	3	0	0	3
23	10212EC226	Machine Learning	2	0	2	3
24	10212EC227	Deep Learning	2	0	2	3

S. No.	Course Code	Course Title	L	T	P	C
25	10212EC228	Data Science and Visualization	2	0	2	3
26	10212EC229	AI in Natural Language Processing	2	0	2	3
27	10212EC230	AI in Speech Processing	2	0	2	3
28	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
Internet of Things						
29	10212EC176	Industry 4.0 and IIoT	3	0	0	3
30	10212EC177	IoT Security	3	0	0	3
31	10212EC178	Artificial Intelligence and Machine Learning	3	0	0	3
32	10212EC179	Flexible and Wearable Sensors	3	0	0	3
33	10212EC180	Automotive Sensors and In-Vehicle Networking	3	0	0	3
34	10212EC234	IoT System Design and Development	2	0	2	3
35	10212EC236	ARM System Architecture	2	0	2	3
36	10212EC237	Embedded Linux	2	0	2	3
37	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
Integrated Circuit Technology						
38	10212EC238	SOC Design and Verification	2	0	2	3
39	10212EC239	SOC Design Through Physical Implementation Leading to Tape-Out	2	0	2	3
40	10212EC240	CAD for VLSI	2	0	2	3
41	10212EC241	FPGA Programming	2	0	2	3
42	10212EC197	Microfabrication of Semiconductor and Materials	3	0	0	3
43	10212EC242	AI and ML for VLSI CAD	2	0	2	3
44	10212EC198	Design for Testability	3	0	0	3
45	10212EC199	AI Circuits	3	0	0	3
46	10212EC902	IC Packaging	3	0	0	3
47	10212EC903	Verification Tools and Techniques	3	0	0	3
48	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
HONORS DEGREE - ELECTIVE COURSES						
Artificial Intelligence for Wireless Communication						
1	10212EC138	Introduction to Artificial Intelligence and Machine Learning	3	0	0	3
2	10212EC139	Wireless Communications and Networking	3	0	0	3

S. No.	Course Code	Course Title	L	T	P	C
3	10212EC140	Machine learning for Wireless Communications	3	0	0	3
4	10212EC141	Artificial Intelligence based Wireless Network Design	3	0	0	3
5	10212EC142	Optimization for wireless and machine learning	3	0	0	3
6	10212EC143	Microwave and Millimeter Wave Communication	3	0	0	3
7	10212EC144	Artificial Intelligence in Optical Communication	3	0	0	3
8	10212EC218	Smart antennas for 5G communication	2	0	2	3
9	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
VLSI System Design						
10	10212EC145	Digital IC Design	3	0	0	3
11	10212EC146	Mixed Signal VLSI Design	3	0	0	3
12	10212EC147	IC Technology	3	0	0	3
13	10212EC148	Testing of VLSI Circuits	3	0	0	3
14	10212EC149	VLSI Signal Processing	3	0	0	3
15	10212EC219	Analog Circuit IC Design	2	0	2	3
16	10212EC220	Physical Design of CMOS IC	1	0	4	3
17	10212EC221	Reconfigurable Computing with FPGA	1	0	4	3
18	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**

MINOR DEGREE – ELECTIVE COURSES

S. No.	Course Code	Course Title	L	T	P	C
Smart Communication Technologies						
1	10212EC161	Security in Communication and Networking Systems	3	0	0	3
2	10212EC162	Vehicular Communications and Inter-Networking Technologies	3	0	0	3
3	10212EC163	Sensors and Wearable Technology	3	0	0	3
4	10212EC164	Sensors for structural health Monitoring	3	0	0	3
5	10212EC165	IoT in Automotive Systems	3	0	0	3
6	10212EC166	M2M Communication with IoT and LTE	3	0	0	3
7	10212EC167	Flexible electronics for automobile applications	3	0	0	3
8	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
Smart Automation						

S. No.	Course Code	Course Title	L	T	P	C
9	10212EC168	Basics of Embedded System	3	0	0	3
10	10212EC169	Sensors and Transducers	3	0	0	3
11	10212EC170	Embedded Security	3	0	0	3
12	10212EC171	Flexible Electronics	3	0	0	3
13	10212EC172	Smart City	3	0	0	3
14	10212EC173	Integrated Product Development	3	0	0	3
15	10212EC231	Embedded IoT	2	0	2	3
16	10212EC206	Embedded Systems and Robotics	1	0	4	3
17	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
5G and Beyond						
18	10212EC181	Wireless Communication	3	0	0	3
19	10212EC182	5G Technology	3	0	0	3
20	10212EC183	5G New Radio	3	0	0	3
21	10212EC184	Millimeter Wave Technology	3	0	0	3
22	10212EC185	5G Networks	3	0	0	3
23	10212EC186	MIMO Wireless Communication	3	0	0	3
24	10212EC187	5G Security	3	0	0	3
25	10212EC188	6G Mobile Networks	3	0	0	3
26	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**
Semiconductor Technologies						
27	10212EC189	Semiconductor Materials and Devices	3	0	0	3
28	10212EC190	Semiconductor Process Technology	3	0	0	3
29	10212EC191	VLSI and Post CMOS Electronics	3	0	0	3
30	10212EC192	Semiconductor Packaging	3	0	0	3
31	10212EC193	VLSI Testing and Verification	3	0	0	3
32	10212EC194	Quantum Technologies for VLSI	3	0	0	3
33	10212EC195	Semiconductor Optoelectronics and Photovoltaics	3	0	0	3
34	10212EC235	FPGA based System Design	1	0	4	3
35	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				**18**

OPEN ELECTIVE COURSES

S. No.	Course Code	Course Title	L	T	P	C
1	10213EC101	Introduction to Robotics	3	0	0	3
2	10213EC102	Video Surveillance System	3	0	0	3
3	10213EC103	Wearable Devices	3	0	0	3

S. No.	Course Code	Course Title	L	T	P	C
4	10213EC104	Wireless Communication Networks	3	0	0	3
5	10213EC105	Basics of Signal Processing	3	0	0	3
6	10213EC106	Image Processing and its Applications	3	0	0	3
7	10213EC107	Industrial Automation	3	0	0	3
8	10213EC108	Building Automation	3	0	0	3
9	10213EC109	Embedded Systems	3	0	0	3
10	10213EC110	FPGA Architectures and Applications	3	0	0	3
11	10213EC111	Intelligent Transport Systems	3	0	0	3
12	10213EC112	Wireless Communication Technologies	3	0	0	3
13	10213EC113	FPGA Technology and Applications	3	0	0	3
14	10213EC114	Basics of Embedded System	3	0	0	3
15	10213EC115	Basics of Sensors and Transducers	3	0	0	3
16	10213EC201	Vehicle Electronics & Networks	2	0	2	3
17	10212EC4xx	NPTEL Course – Mandatory	0	0	0	3
Minimum no. of credits to be Completed						**12**

S. No.	Course Code	Course Title	Weeks	Degree	C
MOOC COURSES – NPTEL					
PROGRAMME ELECTIVE					
1	10212EC401	Signal Processing for mm Wave Communication for 5G and beyond	12	Artificial Intelligence for Wireless Communication (Honors)	3
2	10212EC402	C-based VLSI Design	12	VLSI System Design (Honors)	3
3	10212EC403	Privacy and Security in Online Social Media	12	Cyber Security (Specialization Elective)	3
4	10212EC404	Introduction to Industry 4.0 and Industrial Internet of Things	12	Smart Communication Technologies (Minor)	3
5	10212EC405	Introduction to Embedded System Design	12	Smart Automation (Minor)	3
6	10212EC406	Millimeter Wave Technology	8	Communication System Domain	2
7	10212EC407	Optical Wireless Communications for Beyond 5G Networks and IoT	12	Communication System Domain	3
8	10212EC408	Embedded Sensing, Actuation and Interfacing Systems	12	Embedded Domain	3
9	10212EC409	Sensors and Actuators	12	Embedded Domain	3

S. No.	Course Code	Course Title	Weeks	Degree	C
10	10212EC410	Information Security - 5 - Secure Systems Engineering	8	Specialization (Cyber Security)	2
11	10212EC411	Natural Language Processing	12	ECE(AIML) & ECE(AIDS)	3
12	10212EC412	Reinforcement Learning	12	ECE(AIML) & ECE(AIDS)	3
13	10212EC413	Design and Analysis of VLSI Subsystems	12	VLSI Domain	3
14	10212EC414	Cyber Security and Privacy	12	Specialization (Cyber Security)	3
15	10212EC415	Modern Digital Communication Techniques	12	Communication System Domain	3
16	10212EC416	Operating System Fundamentals	12	Embedded Domain	3
17	10212EC417	Responsible & Safe AI systems	12	AIML & AIDS Domain	3
18	10212EC418	VLSI Design Flow: RTL to GDS	12	VLSI Domain	3
19	10212EC419	Foundations of Cyber Physical Systems	12	5G and Beyond (Minor) & CS	3
20	10212EC420	Semiconductor device modelling and Simulation	12	VLSI Domain	3
21	10212EC421	5G Wireless Standard Design	12	Specialization (Cyber Security)	3
22	10212EC422	Cloud Computing	12	Specialization (Cyber Security)	3
23	10212EC423	Analog VLSI Design	12	VLSI Domain	3
24	10212EC424	Microsensors and Nanosensors	12	Embedded Domain	3
25	10212EC425	Problem Solving Through Programming in C	12	ECE(AIML) & ECE(AIDS)	3
26	10212EC426	Applied Linear Algebra for Signal Processing, Data Analytics and Machine Learning	12	ECE(AIML) & ECE(AIDS)	3
27	10212EC427	Pattern Recognition and Application	12	ECE(AIML) & ECE(AIDS)	3
OPEN ELECTIVE					
1	10213EC401	Introduction To Industry 4.0 and Industrial Internet of Things	12	Open Elective	3
2	10213EC402	Biomedical Signal Processing	12		3
3	10213EC403	CMOS Digital VLSI Design	8		2
4	10213EC404	Introduction to Photonics	12		3
5	10213EC405	A Basic Course on Electric and Magnetic Circuits	12		3

S. No.	Course Code	Course Title	Weeks	Degree	C
6	10213EC406	Introduction to Semiconductor Devices	12		3
7	10213EC407	Optimization Theory and Algorithms	12		3
8	10213EC408	Microelectronics: Devices to Circuits	12		3
9	10213EC409	Embedded Systems Design	12		3
10	10213EC410	Principles of Digital Communication	12		3
11	10213EC412	System Design for Sustainability	12		3
12	10213EC413	Real Time Digital Signal Processing	12		3

INDEPENDENT LEARNING COURSES

S. No.	Course Code	Course Title	L	T	P	C
1	10214EC501	Community Service Project	0	0	2	**1**
2	10214EC601	Minor Project I	0	0	4	**2**
3	10214EC602	Minor Project II	0	0	4	**2**
4	10214EC701	Major Project	0	0	18	**9**
		Minimum no. of credits to be Completed				**14**

PROFESSIONAL PROFICIENCY COURSES

S. No.	Course Code	Course Title	L	T	P	C
1	10216GE901	Soft Skills – I	-	-	2	1
2	10216GE902	Soft Skills – II	-	-	2	1
3	10216GE903	Aptitude Skills – I	-	-	2	1
4	10216GE904	Aptitude Skills – II	-	-	2	1
		Minimum no. of credits to be Completed				**4**

S. No.	Course Code	Course Title	L	T	P	C
Industry/Higher Learning Institute Interaction (IHL)						
1.	10215EC101	Security and Privacy in 6G Networks	1	0	0	1
2.	10215EC102	Ethical Hacking and Pen Testing	1	0	0	1
3.	10215EC107	Fundamentals of MEMS	1	0	0	1
4.	10215EC108	Internet of Things	1	0	0	1
5.	10215EC109	SOC Design Flow	1	0	0	1
6.	10215EC110	Geospatial Modeling in Precision Agriculture and Plant Science	1	0	0	1
7.	10215EC111	UAV/Drone Technology and its Applications	1	0	0	1
8.	10215EC112	Remote Sensing and Digital Image Processing	1	0	0	1

S. No.	Course Code	Course Title	L	T	P	C
9.	10215EC801	Inplant Training	0	0	0	1
10.	10215EC901	PCB Design and Assembly	2	0	0	2
11.	10215EC906	Data Analytics	0	0	2	1
12.	10215EC914	Next Generation of Wired and Wireless Networks	1	0	0	1
13.	10215EC915	Fieldbus Architectures	1	0	0	1
14.	10215EC916	Machine Learning	2	0	0	2
15.	10215EC917	Digital Forensics and Incident Response	1	0	0	1
16.	10215EC918	Cybersecurity Threat Handling and Incident Response	1	0	0	1
17.	10215EC920	Digital Forensics	1	0	0	1
18.	10215EC921	Innovation through Design Thinking	1	0	0	1
19.	10215EC922	Virtual Reality for Gaming Industry	1	0	0	1
20.	10215EC923	Introduction to Digital Forensics Tools	1	0	0	1
21.	10215EC924	Application of Sensors in Wearable Devices	1	0	0	1
22.	10215EC925	Radar System in Space Applications	1	0	0	1
23.	10215EC926	Medical Coding for Healthcare Analysis	1	0	0	1
24.	10215EC927	Gamification in Healthcare	1	0	0	1
25.	10215EC928	Smart Materials for Electronics Applications	1	0	0	1
26.	10215EC929	Penetration Testing and Cybersecurity	1	0	0	1
27.	10215EC930	RF Energy Harvesting System	1	0	0	1
28.	10215EC931	Sensor Integration with IoT	1	0	0	1
29.	10215EC932	Advanced Antenna Design and Measurement Techniques	1	0	0	1
30.	10215EC933	IoT 4.0 for Graduates	1	0	0	1
31.	10215EC934	Energy Management and Industry 4.0	1	0	0	1
32.	10215EC938	Quantum Computing	1	0	0	1
33.	10215EC939	Digital Forensics with real case study	1	0	0	1
34.	10215EC940	Cloud Forensics	1	0	0	1
35.	10215EC941	Smart Automation	1	0	0	1
36.	10215EC943	Introduction to In Vehicle Networking	1	0	0	1
37.	10215EC944	Technology Trends of Automotive CAN Bus	1	0	0	1
38.	10215EC945	Antenna and Beamforming for Modern Communication Systems	1	0	0	1
39.	10215EC946	RF & Microwave Circuit Design	1	0	0	1
40.	10215EC947	Self-Haling and Shape Memory Polymers	1	0	0	1
41.	10215EC948	Polymer Nanomaterials for Electronics and Allied Industries	1	0	0	1
42.	10215EC951	Energy Storage Technologies for Electronics Applications	1	0	0	1
43.	10215EC952	Quantum Networking: The Future of Secure	1	0	0	1

S. No.	Course Code	Course Title	L	T	P	C
		Communications				
44.	10215EC953	Innovation for Electronics and Communication Engineers	1	0	0	1
45.	10215EC955	Innovation Through Design Thinking	1	0	0	1
46.	10215EC956	TinyML and Embedded AI with ESP-32	1	0	0	1
		Minimum no. of credits to be Completed				**2**

COURSE CODE	COURSE TITLE	L	T	P	C
10211EC101	CIRCUIT THEORY	2	1	0	3

a) Course Category :

Programme Core

b) Preamble :

The course deals with the analysis of circuits through Graph theory, Network theorems, Fundamentals of AC circuit analysis, concepts of resonance, transients through differential equations and two port networks.

c) Prerequisite :

Nil

d) Related Courses :

Electromagnetics and Transmission Lines

e) Course Outcomes:

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Infer the basics of circuit analysis and graph theory	K2
CO2	Interpret circuits using network theorems	K2
CO3	Solve the problems on RL, RC and RLC DC transient circuits	K3
CO4	Discuss the characteristics of AC steady state analysis and power analysis.	K2
CO5	Illustrate the parameters of the two port networks and the concepts of resonance	K2

f) Correlation of COs with POs and PSOs:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	L	-	-	L	L	-	-	M	H	L	L	-
CO2	H	H	L	-	-	L	L	-	-	M	H	L	L	L
CO3	M	M	L	-	-	-	M	-	-	M	M	L	L	L
CO4	H	H	L	-	-	-	-	-	-	M	M	L	L	L
CO5	M	M	L	-	-	M	-	-	-	M	M	L	L	L

g) Course Content:

UNIT I BASICS OF CIRCUIT ANALYSIS & GRAPH THEORY 9

Review of KCL, KVL, Node and Mesh Analysis; Analysis using dependent current sources and voltage source, Resistors in series and parallel – Voltage and Current division rule, Graph Theory: Incidence- Duality & Dual networks

UNIT II NETWORK THEOREMS 9

Source Transformation – Superposition Theorem – Thevenin's Theorem – Norton's Theorem– Maximum Power Transfer Theorem – Reciprocity Theorem

UNIT III DC TRANSIENT ANALYSIS 9

RL and RC Circuits: Source free circuit – Properties of Exponential Response and Step functions – Natural and Forced Response Driven RL and RC circuits – RLC Circuits: Source free damped and under damped parallel RLC circuit – Critical Damping – Source free series RLC–Complete Response and lossless Circuits.

UNIT IV AC STEADY STATE AND POWER ANALYSIS 9

Analysis of AC steady state circuits: Characteristics, Forced Response to Sinusoidal functions, Phasor Relationship to passive components – Impedance and admittance – Application of Network Theorems – Power Analysis: Instantaneous – Average and RMS- Power, Power factor and Energy.

UNIT V TWO PORT NETWORKS AND RESONANCE CIRCUITS 9

Two port Networks – Impedance Parameter – Admittance Parameter – Transmission parameter, Hybrid Parameters and their inter relationship – Series and parallel resonance: frequency response, Quality factor and Bandwidth

Total: 45 Hrs

h) Learning Recourses:

Text Books

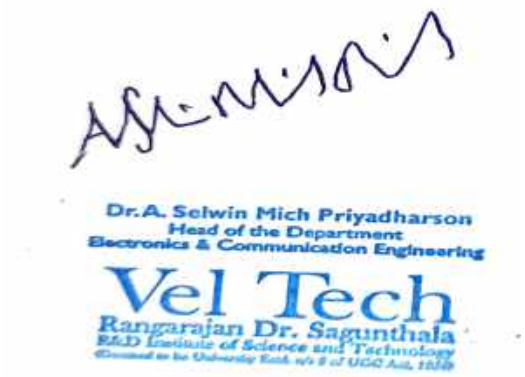
1. W.H. Hayt and I. E. Kemmerley, "Engineering Circuits Analysis", McGraw Hill Education 8th edition, 2014.
2. Franklin F Kuo, "Network Analysis and Synthesis", Wiley Toppan, 2nd edition, 1966.
3. M. E. Van Valkenburg, "Network Analysis", 3rd edition, PHI, 2014.
4. S. Salivahanan, "Circuit Theory – Analysis and Synthesis", First Impression, Pearson, 2020.

Reference Books

1. Joseph A. Edminister, "Electric Circuits", Schaum's outline series, McGraw-Hill 1987
2. A. Sudhakar, Shyammohan S. Palli, "Circuits and Networks", Tata McGraw-Hill, 4th edition, 2015
3. Smarajit Ghosh, "Network Theory Analysis & Synthesis", PHI learning, 1st Ed, 2005
4. Chakrabarti A, "Circuits Theory Analysis and Synthesis", Dhanpath Rai & Sons, New Delhi, 2018.
5. P. M. Chandrashekharaiah, "Electric Circuits and Network Analysis", CBS Publishers & Distributors Pvt. Ltd, 2018
6. T. Nageswara Rao, "Electric Circuits", A.R. Publications, 1999

Online Resources

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-002-circuits-and-electronics-spring-2007/lecture-notes.
2. https://nptel.ac.in/courses/108/102/108102042.
3. https://www.daenotes.com/search/node?keys=circuit%20Analysis.



Course Code	Course Title	L	T	P	C
10211EC102	**ANALOG ELECTRONICS**	**2**	**1**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

This course provides the basic and design knowledge about electronic circuit analysis using BJT and MOSFET which involves feedback, oscillator, high frequency amplifiers and its applications

c) Prerequisite

Nil

d) Related Courses

Linear Integrated Circuits, Communication Systems.

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the operation of basic semiconductor and its devices.	K2
CO2	Compare the performance of different biasing types used for transistor operation.	K2
CO3	Apply the ' h' parameters and small signal model for different transistor configuration	K3
CO4	Interpret the effect of feedback, feedback amplifier and oscillators	K2
CO5	Illustrate the various types of tuned and power amplifiers.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO 7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	H	M	L	-	L	-	-	-	-	-	-	L	L	-
CO2	M	M	L	-	L	-	-	-	L	-	-	-	-	-
CO3	M	H	L	M	L	-	-	-	-	-	-	-	L	-
CO4	M	M	L	-	M	L	-	L	M	L	L	-	L	-
CO5	M	M	L	-	H	-	-	-	L	M	M	L	L	-

g) Course Content

UNIT I SEMICONDUCTOR DEVICES 9

Overview of semiconductor, PN Diode : Varactor diode, LED, PIN diode and Laser diode-Working principle and application of Zener diode - Rectifiers-Clipper and clamper-Basic principle and working of SCR, UJT.

UNIT II DC BIASING OF TRANSISTOR 9

Introduction–Working principle of BJT-Transistor characteristics-CB, CE, CC -Thermal runaway, DC Biasing-BJT: Fixed -Emitter-Stabilized-Voltage-Divider - Compensation techniques.

UNIT III TRANSISTOR AMPLIFIER 9

Two port system approach, The Hybrid Equivalent model, Approximate Hybrid equivalent circuit, Hybrid Π model: CE, CC and CB configurations

UNIT IV FEEDBACK AMPLIFIER AND OSCILLATORS 9

Basic concept of Feedback, Feedback connection types, Input and output impedance of feedback configurations - characteristics of negative feedback, Oscillators**:** Principles of sinusoidal oscillator - RC oscillators: phase shift, Wien bridge - LC oscillators: Hartley, Colpitts, crystal oscillator.

UNIT V TUNED AND POWER AMPLIFIERS 9

Tuned amplifier: single tuned, double tuned and stagger tuned amplifier - Power amplifiers: Transformer coupled Class A power amplifier, Class B amplifier operation, Transformer coupled Push-pull circuits, Complimentary symmetry circuits, Class C power amplifier.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Boylestead &Neshelsky, "Electronic Devices & Circuits" , Pearson Education / PHI Ltd, 11th edition, 2010.
2. S.Salivahanan, N.Suresh Kumar and A.Vallavaraj, "Electronic Devices and Circuits", McGraw-Hill, 5th edition, 2022.
3. David .A. Bell, "Electric Circuits And Electronic Devices Oxford University Press", 5th Edition, 2010.

Reference Books

1. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw-Hill, 2007.
2. Bapat K N, "Electronic Devices & Circuits", McGraw Hill, 1992.
3. Halkias .C.," Integrated Electronics" ,2nd Edition, Tata McGraw-Hill, 2001
4. Sedra and Smith, "Microelectronic circuits", Oxford University Press, 5th ed.
5. Donald L.Schilling and Charles Belove, "Electronic Circuits", Tata McGraw Hill, 3rdEdition, 2003.
6. Dr. R. S. Sedha, "A Textbook of Electronic Circuits" , S. Chand, 2014.

Online Resources

1. Analog Electronics Course (nptel.com)

Course Code	Course Title	L	T	P	C
10211EC103	**DIGITAL ELECTRONICS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

The primary aim of this course is to understand the fundamental behind digital logic design and gain experience in using them for meeting any design specification. The course includes fundamentals of Boolean algebra, combinational and sequential circuits and introduction to HDL.

c) Prerequisite

Nil

d) Related Courses

Microprocessor and Microcontroller, VLSI design

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Basedon Revised Bloom's Taxonomy)
CO1	Interpret the concept of boolean minimization techniques and HDL in digital circuits	K2
CO2	Construct the combinational circuits such as encoder, multiplexer and write HDL program for this circuits	K3
CO3	Utilize the concept of sequential circuits such as counters, shift registers and write HDL program for this circuits	K3
CO4	Solve asynchronous sequential circuits for simple application	K3
CO5	Explain the applications of digital electronics	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2
CO1	H	M	L	M	M	-	-	-	-	-	L	-	M	
CO2	H	M	H	L	H	-	-	-	-	-	-	M	L	
CO3	H	M	H	L	H	-	-	-	-	-	-	M	L	L
CO4	H	M	M	M	-	-	-	-	-	-	M	L	M	L
CO5	H	L	M	L	-	M	-	-	-	-	L	-	L	L

g) Course Content

UNITI DIGITAL SYSTEM FUNDAMENTALS 10

Number System; Boolean algebra and Switching Functions; Boolean Minimization using K Map and Tabulation method-NAND and NOR Realization- Introduction to Verilog – Structural, Dataflow and Behavioral modeling.

UNITII COMBINATIONAL CIRCUITS 10

Design procedure – Half adder – Full Adder – Half subtractor– Full subtractor – Parallel binary adder/ Subtractor - Carry Look Ahead adder – Serial Adder/Subtractor – BCD adder – Binary Multiplier – Binary Divider – Multiplexer/ Demultiplexer – decoder – encoder – parity checker – parity generators – code converters – Magnitude Comparator , Structural, Dataflow and Behavioral modeling of combinational logic circuits (Multiplexer, Demultiplexer, decoder and encoder).

UNITIII SEQUENTIAL CIRCUITS 10

Flip Flops and Memory devices: RAM – Static and Dynamic, ROM, PROM, EPROM, EEPROM; Counters and Shift registers: Binary, BCD and programmable modulo counters, Shift register counters; Sequential circuit design: using Mealy and Moore model. Structural, Dataflow and Behavioral modeling of sequential logic circuits (counters and shift registers)

UNITIV ASYNCHRONOUS SEQUENTIAL CIRCUITS 10

Analysis Procedure, Circuits with latches; Design Procedure, Reduction of state and flow table; Race free state assignment; Hazards; ASM chart; Design examples

UNITV APPLICATIONS OF DIGITAL ELECTRONICS 5

Multiplexing displays – Frequency counters – Time measurements – Using the ADC0804: Standalone operation, span adjust, zero shift, testing – microprocessor compatible A/D converters.

Total: 45 Hrs

h) Learning Resources

i) Text Books

1. M. Morris Mano, Michael D Ciletti, Digital Design, 5th Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.
2. Donald. P. Leach, Digital principles and applications, 7th Edition, McGraw-Hill, 2012.
3. S.Salivahanan, S. Arivazhagan, Digital Circuits and Design, 5th Edition, Oxford University Press, 2018
4. W.H. Hayt and I.E.Kemmerley, "Engineering Circuits Analysis", McGraw Hill Education 8th Ed, 2014.

Reference Books

1. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.
2. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2003 Donald D.Givone, Digital Principles and Design, TMH
3. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982.

Online Resources

1. http://www.learnabout-electronics.org.
2. https://onlinecourses.nptel.ac.in/noc22_ee55/preview
3. https://courses.cs.washington.edu/courses/csep567/10wi/lectures/Lecture2.pdf

Course Code	Course Title	L	T	P	C
10211EC104	**Linear Integrated Circuits**	**3**	**0**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

Linear Integrated Circuits introduces the basic building blocks of the Integrated circuits along with fundamental concepts of electronic circuits like operational amplifiers, rectifiers and timers and acquire the knowledge in the analysis and design IC based circuits.

c) Prerequisite

NIL

d) Related Courses

VLSI Design, Circuit Theory

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe the characteristics of operational amplifiers.	K2
CO2	Illustrate the various linear and non-linear applications of Op-Amp	K2
CO3	Manipulate different waveform generator circuits using op-amp and Timer IC555	K2
CO4	Construct ADC and DAC using operational amplifiers., and analyze Active filters using op-amp	K3
CO5	Explain the operation of PLL and special function Op-Amp ICs	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	L	-	-	-	-	-	L	-	L	-	-
CO2	H	M	L	L	L	-	L	-	-	-	-	L	-	-
CO3	H	M	M	-	L	L	-	-	M	-	-	-	L	-
CO4	H	M	M	-	L	L	L	-	-	L	L	M	-	-
CO5	H	M	M	M	L	L	L	L	M	M	L	-	L	-

g) Course Content

UNIT I CHARACTERISTICS OF OP-AMP 9

Integrated Circuits- Classification of ICs - Op Amp: Ideal Characteristics Internal Circuit-Differential Amplifier-Open loop and Closed loop configuration-DC Characteristics and AC Characteristics - Current Source: Widlar source, Frequency Compensation

UNIT II LINEAR AND NON-LINEAR OP-AMP CIRCUITS 9

Linear: Inverting and Non-inverting voltage amplifiers, summing, scaling and averaging amplifiers, Subtractor, voltage follower, Instrumentation amplifiers, V to I and I to V converters, Non Linear: Differentiators, Integrators, Clippers, Clampers & Active Limiters, Log and Antilog Amplifiers, Precision Rectifiers

UNIT III WAVEFORM GENERATORS 9

Comparator, Regenerative comparator, sine wave generators, Astable multivibrator and Monostable multivibrator, triangle wave generators, saw tooth wave function generator – 555 Timer: Functional Diagram, Monostable and Astable operation,

UNIT IV D/A & A/D CONVERTERS AND ACTIVE FILTERS 9

D/A conversion: D/A conversion techniques, weighted resistor DAC and R-2R Ladder DAC – A/D conversion: A/D conversion techniques, Flash type ADC, Monolithic ADC and Ramp type ADC, Active Filters Design First order: LPF -Butterworth Filter, HPF and BPF

UNIT V PLL AND SPECIAL FUNCTION ICs 9

PLL: Phase detector/comparator, VCO, Applications: Frequency Multiplication / Division, Frequency Synthesizer – XR-2206 Function Generators, IC 723 general purpose regulator, Audio Power amplifier

Total: 45 Hrs

h) Learning Resources

Text Books

1. D. Roy Choudhry and Shail B. Jain, "Linear Integrated Circuits"- (4/e), New Age International Pvt. Ltd, 2011.
2. R. Gayakwad, “Op-amps and Linear Integrated Circuits”, (4/e), PHID.
3. S.Salivahanan & V S Kanchana Bhaaskaran, “Linear Integrated Circuits”, 2nd Edition, Tata McGraw Hill, New Delhi.

Reference Books

1. S. Franco, “Design with Operational Amplifiers and Analog Integrated Circuits”, (3/e) TMH, 2003.
2. R. F. Coughlin & F. F. Driscoll, “Operational Amplifiers and Linear Integrated circuits”, PHI, 1996.
3. D. A. Bell, “Solid State pulse circuits”, (4/e), PHI.
4. Milman Gravel, “Micro- electronics”, McGraw Hill, 1991.

Online Resources

1. https://www.tutorialspoint.com/linear_integrated_circuits_applications/index.htm
2. https://www.circuitstoday.com/category/integrated-circuits
3. https://onlinecourses.nptel.ac.in/noc20_ee13/preview

Course Code	Course Title	L	T	P	C
10211EC105	**CONTROL SYSTEMS**	**2**	**1**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

This course aims to provide a basic knowledge about control system, its significance, transfer function, open and closed loop systems, mathematical model of electrical and mechanical systems, time domain and frequency domain analysis of I order and II order systems and their specifications, stability analysis in time and frequency domain, design of compensators viz., lag and lead compensators, characteristics and significance of P, PI and PID controllers and State Space analysis.

c) Prerequisite

Signals and Systems

d) Related Courses

Linear Integrated Circuits, Analog Communication Systems

e) Course Outcomes

On successful completion of this course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Choose the concepts of control system components and derive the mathematical model of electrical and mechanical systems.	K3
CO2	Determine the Time response of I order and IIorder systems for various test signals and examine the system stability using time domain approach.	K3
CO3	Sketch the Frequency response of I order andII order systems and examine the system stability using frequency response plots.	K3
CO4	Develop controllers and compensators forControl System analysis using Frequencydomain approach.	K3
CO5	Apply the concept of State-Space for ControlSystem Analysis.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	L	-	-	L	-	-	L	-	L	-	-
CO2	M	L	-	-	M	-	-	-	M	L	-	L	-	-
CO3	M	L	-	-	M	-	-	-	M	L	-	L	-	-
CO4	L	L	-	M	-	L	L	L	-	-	L	L	L	-
CO5	M	M	L	L	M	-	-	-	M	L	-	M	M	-

g) Course Content

UNIT I CONTROL SYSTEM COMPONENTS AND REPRESENTATIONS 9

Basic components of control system – open loop and closed loop systems: differential equation - transfer function, modeling of electric systems, translational and rotational mechanical systems - block diagram reduction techniques - signal flow graph

UNIT II TIME DOMAIN AND STABILITY ANALYSIS 9

Standard test signals – Transient and Steady state response of first order systems and second order systems –Stability; Concept and definition, characteristic equation, location of poles - Routh Hurwitz criterion: relative stability - Root locus Technique: construction and properties

UNIT III FREQUENCY DOMAIN AND STABILITY ANALYSIS 9

Frequency domain Specification - Gain Margin, Phase Margin; Bode plot, Polar plot – Stability analysis using frequency response methods; Correlation between time domain and frequency domain specification

UNIT IV COMPENSATORS AND CONTROLLERS 9

Realization of basic compensators- series, parallel and series - parallel compensation - Lead and Lag networks – Design of Lead and Lag compensator using Bode plot – Introduction to P, PI, PD and PID Controllers

UNIT V CONTROL SYSTEM ANALYSIS USING STATE SPACE 9

State variable representation – Canonical Realization - Conversion of state variable models to transfer functions - Conversion of transfer functions to state variable models - state transition Matrix - Concepts of Controllability and Observability.

Total : 45 Hrs

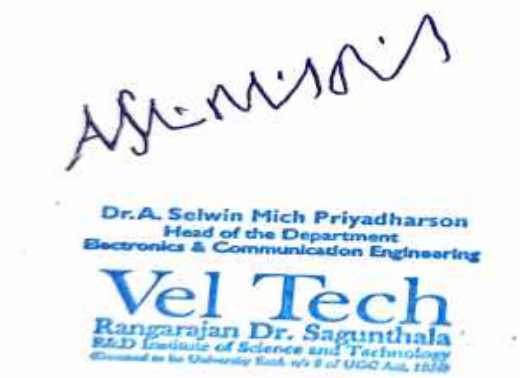
h) Learning Resources

Text Books

1. Norman S. Nise, Control System Engineering, 2019, 8th Edition, John Wiley & Sons
2. M.Gopal, ―Control System – Principles and Design‖, Tata McGrawHill, 4th Edition, 2012.

Reference Books

1. Modern Control Systems by Richard C. Dorf and Robert H. Bishop, 14th Edition, Pearson, 2021.
2. Ogata, K., "Modern Control Engineering", Prentice Hall of India Ltd., 5th Edition, New Delhi, 2022.
3. S. K. Bhattacharya, Control System Engineering, 3rd Edition, Pearson,2013.



Course Code	Course Title	L	T	P	C
10211EC106	SIGNALS AND SYSTEMS	2	1	0	3

a) Course Category

Programme Core

b) Preamble

The signals existing in the real world are analog in nature and hence processing of this signal in continuous mode or discrete mode becomes essential in engineering applications. This course provides the knowledge on continuous and discrete time signals and systems and its analysis.

c) Prerequisite

Fourier series and Transform Techniques

d) Related Courses

Discrete Time Signal Processing

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify the types of continuous time and discrete time signals,systems and their properties	K2
CO2	Apply Fourier Transform, Laplace transform and its properties forthe analysis of continuous time signals.	K3
CO3	Use Fourier and Laplace transforms to examine the continuous timesystems and realize it.	K3
CO4	Construct the discrete time signals using DTFT, Z transform and theirproperties.	K3
CO5	Make use of DTFT and Z transform to examine the discrete timesystems with realization.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	L	L	M	-	-	-	L	L	-	L	L	M
CO2	H	H	L	L	M	-	-	-	L	L	-	L	L	M
CO3	H	H	L	L	M	-	-	-	L	L	-	L	L	M
CO4	H	H	L	L	M	-	-	-	L	L	-	L	L	M
CO5	H	H	L	L	M	-	-	-	L	L	-	L	L	M

g) Course Content

UNIT I CLASSIFICATION OF SIGNALS AND SYSTEMS 9

Introduction to signals - Classification of signals – Continuous time, Discrete Time, Elementary signals - Basic operations on signals - Analysis and synthesis of signals using Singularity function - Continuous and Discrete Time Systems – Classification, LTI system – Properties.

UNIT II CONTINUOUS TIME SIGNALS 9

Fourier analysis of continuous time signals: Review of Fourier series- Continuous Time Fourier transform - Properties of continuous time FT - Laplace Transform - Properties of Laplace Transform.

UNIT III CONTINUOUS TIME SYSTEMS 9

Convolution Integral - Frequency response of continuous time LTI systems using Fourier Transform and Laplace Transform - Realization of CT systems: direct forms, cascade and parallel, Application of CT Systems.

UNIT IV DISCRETE TIME SIGNALS 9

Sampling of Continuous Time signals and aliasing, Fourier analysis of discrete time signals: Discrete time Fourier series, Discrete Time Fourier transform - Properties of DTFT, Z Transform, Properties of Z Transform

UNIT V DISCRETE TIME SYSTEMS 9

Convolution sum, Frequency response of discrete time LTI systems using Discrete Time Fourier Transform and Z Transform, Realization of DT systems: direct forms, cascade, parallel - Applications of DT systems

Total: 45 Hrs

h) Learning Resources

Text Books

1. Allan V. Oppenheim et al, "Signals, Systems and Inference", Pearson Education Global edition – 2022 (UNIT I-V)

Reference Books

1. S Salivahanan, "Signals and Systems", McGraw-Hill International, 2018.
2. S.Haykin and B. VanVeen "Signals and Systems" Second edition Paper back - I, Wiley, 2021.
3. M. Mandal and A. Asif, "Continuous and Discrete Time Signals and Systems, Cambridge, 2007.
4. Michael J. Roberts, "Fundamentals of Signals and Systems", book by Michael J. Roberts, McGraw-Hill Higher Education, 2008.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc21_ee28/preview (Signals and Systems)
2. https://archive.nptel.ac.in/courses/108/104/108104100/ (Principles of Signals and Systems)

COURSE CODE	COURSE TITLE	L	T	P	C
10211EC107	ELECTROMAGNETICS AND TRANSMISSION LINES	2	1	0	3

a) Course Category

Programme Core

b) Preamble

This course provides the students with different coordinate systems and familiarizing with the different concepts of electrostatic, magnetostatic and time varying electromagnetic systems. It also exposes the students to the ideas of electromagnetic waves and structure of transmission lines and lines at high radio frequencies.

c) Prerequisite courses

Nil

d) Related Courses

Antenna Theory, Optical and Microwave Communication Systems

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Apply the concept and derivation of Electrostatic theorems and laws	K3
CO2	Describe the basic Magnetostatic theorems and laws and infer the magnetic properties of matter	K2
CO3	Interpret electromagnetic waves and its propagation in different medium and wave polarization	K2
CO4	Interpret the concepts of guided structures used in power distribution and communication	K2
CO5	Apply the concepts of impedance matching techniques using Smith chart	K3

f. Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	L	-	-	-	-	L	L	-	M	-	-
CO2	H	H	L	L	-	-	-	-	L	L	-	L	-	-
CO3	H	M	M	L	-	-	-	L	L	L	-	M	L	-
CO4	H	H	M	L	L	L	L	L	L	L	-	M	L	-
CO5	H	M	M	M	L	L	M	L	L	L	-	M	L	-

g) Course Content

UNIT I ELECTROSTATIC FIELDS 9

Review of scalar and vector field: Dot and Cross products, Cartesian, Cylindrical, Spherical coordinates systems, physical interpretation of gradient, divergence and curl - Gauss's law - Stoke's Theorem - Electric field due to point-charges - Electrostatic potential - Laplace and Poisson's equation in one-dimension - Electric flux density - Boundary conditions

UNIT II STEADY MAGNETIC FIELDS 9

Lorentz Law of force, magnetic field intensity (H) - Biot-Savart's Law - Ampere's Law - Magnetic field intensity due to straight conductors, infinite sheet of current, at the centre of the toroid, along the axis of the circular loop and solenoid -Magnetic flux density (B) – Magnetic moment- Boundary conditions – Magnetic Scalar and vector potential - Magnetic force - Inductance

UNIT III MAXWELLS EQUATIONS AND PLANE WAVE 9

Continuity equation - Displacement current - Maxwell's equation - Boundary conditions – Plane wave equation in conducting and non-conducting media, Phase velocity, Group velocity, Depth of penetration, Conductors and dielectrics, Impedance of conducting medium, Brewster Angle, Poynting vectors and Poynting theorem.

UNIT IV TRANSMISSION LINE 9

Cascaded T sections: Line parameters - Transmission Line Equation – infinite line- Waveform distortion – distortionless line- Reflection Line – Input and Transfer Impedance - Open and Short Circuited Lines - Reflection Factor and Reflection Loss

UNIT V LINE AT HIGH FREQUENCIES 9

Dissipation less line: Voltage and Current - Input impedance - Open and short-circuited lines - Power and impedance measurements- Standing Waves– Impedance Matching in High Frequency Lines using Smith Chart.

Total: 45 Hrs

h) Learning Resources

Text Books

1. W.H Hayt. and J.A. Buck: "Engineering Electromagnetics", McGraw Hill Publications, 6th Ed, 2017
2. M.N.O. Sadiku and S.V. Kulkarni, "Principles of Electromagnetics", 6th ed., Oxford (Asian Edition), 2015
3. J.D.Ryder "Networks, Lines and Fields", PHI, 2nd Ed, 1978
4. E C Jordan and K G Balmain, "Electromagnetic Waves and Radiating Systems", PHI, 2nd Ed,2015

Reference Books

1. J.F.D Kraus,Keith. R.Carver "Electromagnetics", 5th edition, McGraw Hill,2010
2. M.N.O.Sadiku and S.V. Kulkarni, "Principles of Electromagnetics", 6th ed., Oxford (Asian Edition), 2015
3. N. Narayana Rao,"Elements of Engineering Electromagnetics", Pearson, 6th Ed, 2006

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_ee59/preview
2. http://simons.berkeley.edu/talks/peter-richtarik-2013-10-23
3. Introduction to Convex Optimization in Machine Learning

Course Code	Course Title	L	T	P	C
10211EC108	COMMUNICATION SYSTEMS	2	1	0	3

a) Course Category
Programme Core

b) Preamble
This course provides an introduction about all types of analog, digital modulation and demodulation techniques with its applications. This course also provides the information about the baseband and passband transmission schemes, enabling the student to determine errors.

c) Prerequisite
Analog Electronics

d) Related Courses
Cellular Mobile Communication, Satellite Communication

e) Course Outcomes
On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the behavior of amplitude modulation and detection schemes and explain transmitter and receiver characteristics.	K2
CO2	Explain the various features of angle modulation and demodulation techniques and compare their performances	K2
CO3	Illustrate the influence of noise over communication systems through random process and noise theory	K2
CO4	Apply the concept of sampling and various wave form coding schemes.	K3
CO5	Identify the baseband transmission techniques and modulation schemes in pass band transmission.	K3

f) Correlation of COs, POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H	L	H	L	-	-	L	L	-	-	-	-	-
CO2	M	H	L	H	L	-	-	L	L	-	-	-	-	-
CO3	M	L	L	L	-	M	-	L	L	-	L	M	M	-
CO4	H	H	H	H	H	-	-	L	L	L	L	H	H	-
CO5	H	L	L	L	M	-	-	L	L	L	L	-	L	-

g) Course Content

UNIT I AMPLITUDE MODULATION 9

Modulation - Need for Modulation - Frequency Spectrum and Bandwidth, Principles of Amplitude Modulation: AM Envelope - Modulation Index, AM Modulator and Demodulator: DSBSC- SSBSC- VSB, AM Transmitter, AM Receiver: Superheterodyne Receiver.

UNIT II ANGLE MODULATION 9

Angle Modulation - Phase and Frequency Modulation, Narrow Band FM and Wideband FM, FM Modulator: Generation of FM by Parameter Variation Method - Armstrong's Indirect Method, FM Demodulator: Frequency Discriminator - Foster Seeley Discriminator - Balanced Slope Detector- PLL Detector.

UNIT III RANDOM PROCESS AND NOISE THEORY 9

Random Variables, Random Process: Stationary Process-Ergodic Process-Gaussion Process, Transmission of Random Process Through Linear Systems, Noise: Shot Noise - Thermal and White Noise - Narrow Band Noise - Noise Equivalent Bandwidth - - Noise Figure, Capture and Threshold Effect, Noise in AM.

UNIT IV SAMPLING PROCESS AND WAVE FORM CODING 9

Basic elements of a digital communication system, Sampling Theorem - Sampling and signal recovery, PAM-PWM-PPM, Quantization Process: Quantization Noise and Error, Modulation: PCM-DM-ADM-DPCM

UNIT V BASE BAND AND PASS BAND TRANSMISSION 9

Matched filter –Intersymbol Interference- Correlative coding -Adaptive Equalization-Eye patterns, Digital modulation schemes: Generation-Detection-BW of ASK, FSK, PSK, QPSK, QAM.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Simon Haykins, "Communication Systems", John Wiley, 4th Edition, 2000.
2. Herbert Taub, Donald L Schilling, and Goutam soha "Principles of Communication Systems", 4th Edition, Tata McGraw Hill, 2014.
3. John G. Proakis, "Digital Communication" McGraw Hill 3rd Edition, 1995.

Reference Books

1. Taub & Schilling, "Principles of Digital Communication",28th reprint, Tata McGraw-Hill, 2003
2. R. P Singh and S.D. Sapre "Communication Systems-Analog and Digital", 2nd Edition, Tata McGraw Hill, 2007.
3. John G. Proakis, Masoud Salehi "Fundamentals of Communication Systems" Pearson Education, 2006.
4. Bruce Carlson, "Communication Systems" 5th Edition, Tata Mc Graw Hill. 2010
5. Sam K. Shanmugam, "Analog& Digital Communication" John Wiley, 2006
6. Wayne Tomasi "Electronic Communication Systems", 5th Edition, Pearson education in south Asia print 2011.

Online Resources

1. http://www.sp4comm.org/docs/chapter12.pdf
2. http://www.talkingelectronics.com/Download%20eBooks/Principles%20of%20electronics/CH-16.pdf
3. https://www.youtube.com/watch?v=QEubAxBfqKU
4. https://youtu.be/kVQ7mr2TU2U
5. https://youtu.be/uf-X7zuFo5A
6. http://www.csun.edu/~skatz/katzpage/sdr_project/sdr/FM_and_PM.pdf

Course Code	Course Title	L	T	P	C
10211EC109	**MICROPROCESSOR AND MICROCONTROLLER**	**3**	**0**	**0**	**3**

a) Course Category

Programme core

b) Preamble

The purpose of this course is to provide students with the emphasis on architecture, programming and system design of microprocessors and microcontroller. It also provides knowledge to solve real world problems in an efficient manner.

c) Prerequisite

Digital Electronics

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the functionalities of 8085 microprocessor architectures and assembly language programming.	K2
CO2	Summarize the functionalities of 8086 microprocessor architectures and assembly language programming.	K2
CO3	Illustrate the functionalities of 8051 microcontroller architectures and assembly language and C programming.	K2
CO4	Relate the functionalities of different peripheral devices, and port RTC.	K2
CO5	Outline the architectures and features of PIC and ARM microcontrollers and their applications.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	H	M	M	L	H	-	-	L	L	L	-	-	M	M
CO2	H	M	M	L	H	-	-	L	L	L	-	-	M	M
CO3	H	M	M	L	H	-	-	L	L	L	-	-	M	H
CO4	M	L	-	-	-	-	-	-	L	L	-	-	M	-
CO5	M	L	M	-	-	-	-	-	L	L	M	M	M	M

g) Course Content

UNIT I 8085 MICROPROCESSOR 9

Introduction to 8085 architecture, addressing modes, instruction formats, instruction set , timing diagram, memory mapping and assembly language programming.

UNIT II 8086 MICROPROCESSOR 9

Introduction to 8086 architecture, features, signals, addressing modes, instruction formats, instruction set, I/O and memory interfacing, interrupts, minimum mode and maximum mode operation, assembly language programming.

UNIT III 8051 ARCHITECTURE 10

Hardware features, architecture, internal RAM structure, special function registers, addressing modes, instruction set, memory organization, I/O ports and circuits, timers, interrupts, interfacing of external memory, assembly language programming and C programming.

UNIT IV PERIPHERAL DEVICES 9

Parallel Peripheral Interface (8255), Timer/Counter (8253), Serial Communication/UART (8251), A/D and D/A Interface, Keyboard and Display Controller (8279), Interrupt Controller (8259), DMA Controller (8237), Real Time Clock.

UNIT V EMBEDDED SYSTEMS APPLICATIONS USING PIC AND ARM MICROCONTROLLERS 8

PIC: Introduction, features, architecture-ARM: Features and Classifications-Case Studies PIC /ARM: Temperature Control System, Motor Speed Control System, Traffic light System, Elevator System, Data Acquisitions System.

Total: 45 Hours

h) Learning Resources

Text Books

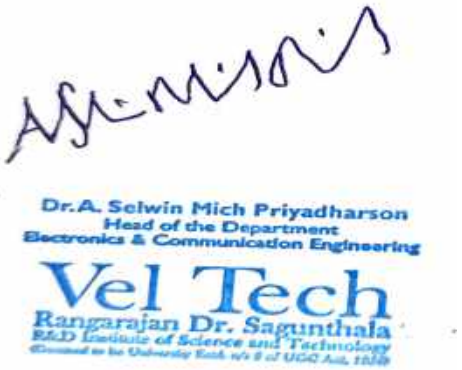
1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 6th Edition, Penram International Publishing, 2018.
2. A.K Ray & K.M. Burchandi, Advanced Microprocessor and peripherals Architectures, Programming and interfacing", Third edition, Tata McGraw-Hill, 2017.
3. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D McKinlay, the 8051 Microcontroller and embedded systems using assembly and C, Second Edition Pearson Education Asia, 2006.
4. Danny Causey, Muhammad Ali Mazidi, and Rolin D. McKinlay "PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18", Second Edition. Pearson Education, 2011.
5. Muhammad Ali Mazidi, Sarmad Naimi, and Sepehr Naimi "AVR Microcontroller and Embedded Systems: Using Assembly and C", Second Edition, Pearson Education, 2011.

Reference Book

1. Kenneth J Ayala, The 8051 Microcontroller Architecture, programming and Application, Fourth Edition, Penram International Publishers,2004.

Online Resources

1. Animated Working of 8085 Microprocessor with addition program (YouTube), https://www.youtube.com/watch?v=te5Xe3TgPC4
2. 8086 Microprocessor Architecture, Instruction Cycle [Animated] (YouTube), https://www.youtube.com/watch?v=XX9rDGTBGgQ
3. What is a Microcontroller and How does it Works? (YouTube), https://www.youtube.com/watch?v=uz0jTNSQ37Y
4. Difference between Microprocessor and Microcontroller (YouTube), https://www.youtube.com/watch?v=dcNk0urQsQM
5. PIC VS ARM Micro controller with Example (YouTube), https://www.youtube.com/watch?v=rcezcKA3b08



Course Code	Course Title	L	T	P	C
10211EC110	**DATA COMMUNICATION NETWORKS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

The purpose of this course is to provide the knowledge of fundamental concepts of networking, protocols, architectures and applications.

c) Prerequisite

Nil

d) Related Courses

Network Security, Network Management, High Performance Communication Networks

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the fundamental concepts of data communication networks and its architecture model.	K2
CO2	Summarize the various functions of data link layer and LAN architecture.	K2
CO3	Apply the knowledge of different types of switching androuting protocols	K2
CO4	Outline the concepts of end to end process and application protocols	K2
CO5	Infer the Queuing model and advance switchingconcepts.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	-	-	L	-	-	L	L	L	-	L	L	-
CO2	H	M	-	-	L	-	-	-	L	L	-	L	-	-
CO3	H	M	L	L	L	-	-	-	L	L	-	L	L	-
CO4	H	M	-	-	L	-	-	L	L	L	-	L	-	-
CO5	H	M	L	-	-	-	-	-	L	L	-	L	L	-

g) Course Content

UNIT I INTRODUCTION TO DATA COMMUNICATION AND NETWORKING DEVICE 9

Evolution of data Networks-Network fundamentals: Data rate, Channel capacity, modes of communication-Network Topologies- Categories of Networks- ISO/OSI Reference Model -TCP/IP Model-Networking and Inter Networking Devices: Repeaters, Hubs, Bridges, Switches, Routers, Gateways.

UNIT II DATA LINK LAYER & LOCAL AREA NETWORK 9

Logical Link Control –Types of error: single bit error- Burst error-Error Detection Techniques: CRC - checksum-Error Correction Technique: Hamming code –Flow control protocol: ARQ protocols-Medium Access Control: Random Access Protocols.

UNIT III SWITCHING & ROUTING TECHNOLOGIES 9

Circuit switching-packet switching-message switching-Internetworking- IP Addressing: IPv4 - Subnetting: classful-CIDR-IPv6-Routing: Distance Vector - Link State Routing Protocols.

UNIT IV END-END PROTOCOLS 9

Process-process delivery: Basics of Port addressing and Sockets- TCP, UDP and SCTP-TCP congestion control- Application protocols: WWW, HTTP, SMTP, FTP.

UNIT V QUEUING MODELS & ADVANCED SWITCHING 9

Markov chain theory - Queuing model basics and L - M/M/1 and its variants - M/G/1, G/M/1-applications of queuing model, -Introduction to Software Defined Networking.

Total: 45 Hrs

h) Learning Resources

Text books

1. James F. Kurose, Keith W. Ross, "Computer Networking: A Top-Down Approach", 5thEdition, Pearson Publications, 2012.
2. Behrouz A. Forouzan, "Data Communication and Networking", 2nd Edition, McGraw-Hill, 2003.

Reference books

1. William Stallings, "Data and Computer Communication", Prentice Hall of India. Eighth edition.
2. Andrew S. Tanenbaum, "Computer Networks", Prentice Hall.

Course Code	Course Title	L	T	P	C
10211EC111	**DISCRETE TIME SIGNAL PROCESSING**	**2**	**1**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

Discrete Time Signal Processing provides an introduction to the basic concepts of signal processing to acquire knowledge on systems using various transformation techniques. It also invokes students to realize the different filter structures and to develop algorithms for signal processing.

c) Prerequisite

Signals and Systems

d) Related Courses

Advanced Digital Signal Processing, Digital Image and Video Processing

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Demonstrate the use of DFT and its properties for linear filtering applications.	K3
CO2	Use suitable transformation technique to design Digital IIR filters.	K3
CO3	Apply windowing and sampling techniques to design FIR filter.	K3
CO4	Illustrate the finite word length effects in filters.	K3
CO5	Explain Multirate Signal Processing and the architecture, addressing modes of TMS320C67XX processor	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2
CO1	H	H	M	L	M	-	-	-	L	L	-	L	L	L
CO2	H	H	M	M	M	-	-	-	L	L	-	L	M	M
CO3	H	H	M	M	M	-	-	-	L	L	-	L	M	M
CO4	H	H	M	M	L	-	-	-	L	L	-	L	L	L
CO5	M	M	M	M	L	-	-	-	L	L	-	L	L	L

g) Course Content

UNIT I DISCRETE FOURIER TRANSFORMS 9

DFT and its properties - Circular Convolution Methods – Linear filtering: Overlap add and overlap save methods - FFT algorithms: Radix-2 FFT algorithms, Decimation in Time, Decimation in Frequency algorithms.

UNIT II IIR FILTER DESIGN 9

Analog filter design: Butterworth and Chebyshev filter – Discrete time IIR filter from analog filter: IIR filter design by using Approximation of derivatives, Impulse Invariance, Bilinear transformation – Filter design (LPF, HPF) using frequency translation.

UNIT III FIR FILTER DESIGN 9

Linear phase FIR filter - Filter design using windowing techniques (Rectangular Window, Hamming Window and Hanning Window) – Frequency sampling techniques – Structures of FIR: Direct form, Cascade, Linear Phase structures.

UNIT IV FINITE WORDLENGTH EFFECTS 9

Fixed point and Floating point arithmetic - Quantization- Truncation and Rounding errors - Quantization noise- Coefficient quantization error – Product quantization error – Overflow error – Limit cycle oscillations– Scaling.

UNIT V MULTIRATE SIGNAL PROCESSING, DSP PROCESSORS AND APPLICATIONS 9

Decimation–Interpolation–Sampling rate conversion by a rational factor - DSP processor: Harvard architecture, Pipelining, MAC unit, TMS320C67XX processor Architecture, Addressing modes - Application – Sub band coding – Musical Sound processing.

Total: 45 Hrs

h) Learning Resources

Text Books

1. John G. Proakis & Dimitris G. Manolakis, "Digital Signal Processing– Principles, Algorithms & Applications", 5th edition, Pearson Education/Prentice Hall, 2021.

Reference Books

1. S. Salivahanan, A. Vallavaraj, C. Gnanapriya, "Digital Signal Processing", Tata Mc GrawHill Publication, 4th edition 2019.
2. Emmanuel C. Ifeachor, & Barrie. W. Jervis, "Digital Signal Processing-A Practical Approach", 2nd edition, Pearson Education/ Prentice Hall, 2002.
3. Sanjit K. Mitra, "Digital Signal Processing–A Computer Based Approach", Tata McGraw Hill, 2011.
4. A.V.Oppenheim, R.W.Schaferand J.R.Buck, "Discrete-Time Signal Processing", 3rd edition, Pearson, 2021.

Online Resources

1. TMS320C67x/C67x+ DSP CPU and Instruction Set Reference Guide (Rev. A)
2. Study Materials | Digital Signal Processing | Supplemental Resources | MIT OpenCourseWare Digital Signal Processing | Supplemental Resources
3. https://www.youtube.com/watch?v=_HATc2zAhcY Introduction to convolution operation
4. https://www.youtube.com/watch?v=r18Gi8lSkfM Fourier Transform, Fourier Series and Frequency Spectrum
5. https://www.tutorialspoint.com/digital_signal_processing/dsp_discrete_fourier_transform_introduction.htm

Course Code	Course Title	L	T	P	C
10211EC112	WIRELESS COMMUNICATION	2	1	0	3

a) Course Category

Programme Core

b) Preamble

This course addresses the fundamental concepts of wireless communication and provides an overview of modulation and multipath mitigation techniques. It covers multiple access techniques, multi user systems and various wireless communication standards.

c) Prerequisite

Communication Systems

d) Related Courses

MIMO Wireless Communication, Cellular Mobile Communication

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret a wireless channel and evolve design a cellular system based on resource availability	K2
CO2	Identify suitable modulation schemes for the wireless channel and systems.	K3
CO3	Discuss different types of equalization and diversity techniques to improve the quality of wireless communication	K2
CO4	Compare multiple access techniques in wireless communication	K2
CO5	Demonstrate the various types of wireless networks and standards	K2

f) Correlation of COs, POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	M	M	M	L	-	-	-	-	-	L	-	M	-	-
CO2	H	M	M	M	L	-	-	-	-	L	L	L	M	-
CO3	L	L	L	M	L	-	-	-	-	L	L	M	M	-
CO4	M	L	L	M	L	-	-	-	-	L	L	M	M	-
CO5	L	L	M	L	H	-	M	-	-	M	L	H	-	M

g) Course Content

UNIT I CELLULAR CONCEPTS AND MOBILE RADIO PROPAGATION 9

Overview of wireless communication– Cellular concept: Frequency reuse, Hand off, System capacity – Radio Propagation: Large scale path loss, Reflection, Diffraction, Scattering- Small scale fading – Multipath channel parameters : Doppler shift, Doppler spread – Types of fading: Flat fading, Frequency selective fading, Fast fading and Slow fading.

UNIT II MODULATION TECHNIQUES 9

Overview of digital modulation – Linear modulation: Principles of Offset QPSK– Constant envelope modulation: Minimum Shift Keying, Gaussian Minimum Shift Keying, – Spread spectrum modulation techniques: DS-SS, FH-SS

UNIT III MULTIPATH MITIGATION TECHNIQUES 9

Equalization : Adaptive equalization , Linear and Non-Linear equalization – Zero Forcing, and Minimum Mean Square Error Algorithms – Micro and Macro diversity – Diversity combining techniques –Transmit diversity – Rake receiver.

UNIT IV MULTI USER SYSTEMS 9

Multiuser channels : Uplink and downlink – Multiple Access : FDMA, TDMA, CDMA, SDMA, Hybrid techniques –Power control – Uplink/downlink channel capacity – MIMO multiuser systems.

UNIT V WIRELESS COMMUNICATION STANDARDS 9

Evolution – 3G Overview: WCDMA/UMTS, 3GPP Network structure – 4G features and challenges – IMS , LTE system over view and physical channels, WiMax/IEEE802.16– Advanced broad band wireless access : UWB, AWS – 5G wireless system : Architecture and 5G deployment.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Rappaport. T.S., “Wireless communications”, Pearson Education, 2nd Edition, 2010.
2. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2007.
3. Andreas F.Molisch, “Wireless Communications”, John Wiley , 2006.
4. Ajay R. Mishra, “Cellular technologies for emerging markets:2G, 3G and beyond” John Wiley, 2010
5. Simon Haykin & Michael Moher, “Modern Wireless Communications”, Pearson Education, 2007.

Reference Books

1. Vijay. K. Garg, “Wireless Communication and Networking”, Morgan Kaufmann Publishers, 2007.
2. Kaveth Pahlavan,. K. Prashanth Krishnamurthy, "Principles of Wireless Networks", Prentice Hall of India, 2006.
3. Clint Smith. P.E., and Daniel Collins, “3G Wireless Networks”, 2nd Edition, Tata McGraw Hill, 2007.
4. William Stallings, "Wireless Communications and networks" Pearson / Prentice Hall of India, 2nd Ed., 2007

Online Resources

1. https://onlinecourses.nptel.ac.in/noc21_ee66/preview
2. http://www.sp4comm.org/docs/chapter12.pdf
3. https://onlinecourses.nptel.ac.in/noc23_ee75/preview
4. https://nptel.ac.in/courses/117104099
5. https://nptel.ac.in/courses/108105134

Course Code	Course Title	L	T	P	C
10211EC113	**ANTENNA THEORY**	**2**	**1**	**0**	**3**

a) Course Category
Programme Core

b) Preamble
This course provides the basic concepts of waveguides and antenna fundamentals. It also discusses about the antenna arrays, special antennas and radio propagation in guided systems.

c) Prerequisite
Electromagnetics and Transmission lines

d) Related Courses
Optical & Microwave Communication Systems, RF and Microwave Integrated Circuits

e) Course Outcomes
On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the propagation characteristics of guided waves between parallel planes, rectangular waveguide and circular waveguide.	K3
CO2	Explain the basic antenna parameters and various techniques involved in parameter measurements.	K2
CO3	Explain the design and operation of various types of antenna arrays.	K2
CO4	Apply the antenna characteristics to design various types of linear and planar antennas.	K3
CO5	Explain the knowledge of the structure of atmosphere, types of communication and propagation methods.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	L	L	L	-	-	-	M	L	-	L	L	-
CO2	H	M	L	L	L	-	-	-	M	L	-	L	L	-
CO3	H	M	L	L	-	-	-	-	M	L	-	M	L	-
CO4	H	M	M	L	L	L	L	-	M	L	-	L	-	-
CO5	H	M	M	L	L	L	L	L	M	L	-	L	-	-

g) Course Content

UNIT I WAVE GUIDES 9

General Wave behaviours along uniform Guiding structures - Transverse Electromagnetic waves - Transverse Magnetic waves - Transverse Electric waves - TM and TE waves between parallel planes - TM and TE waves in rectangular wave guides - TM and TE waves in Circular wave guides

UNIT II ANTENNA FUNDAMENTALS 9

Basic antenna parameters: gain, directivity, beam solid angle, beam width and effective aperture calculations - Effective height - wave polarization - antenna temperature - radiation resistance - radiation efficiency - antenna field zones - principles of reciprocity - Duality of antennas - Concept of retarded potential - Field, directivity and radiation resistance of an infinitesimal dipole - half wave dipole - Measurement of radiation pattern – gain

UNIT III ANTENNA ARRAYS 9

Two element Array - N-Element Linear Array: Uniform Amplitude and Spacing, Non-Uniform Amplitude and Spacing, Directivity- Principle of pattern multiplication - Grating lobes - Planar Array: Broadside, End fire & Binomial arrays, Dolph Chebyshev arrays

UNIT IV SPECIAL ANTENNAS 9

Principles of Horn - Parabolic dish antenna - Casse grain antenna - Travelling wave antenna - Principle and applications of V and rhombic antenna - Principle of Log periodic antenna array and Helical antenna - Rectangular Patch antenna - Antennas for mobile base station and handset - Phased Array antenna

UNIT V RADIO WAVE PROPAGATION 9

Radio wave propagation – Modes- structure of atmosphere- sky wave propagation- effect of earth‘s magnetic field- Ionospheric abnormalities and absorption- space wave propagation-LOS Distance - Field strength of space wave - duct propagation - VHF and UHF Mobile radio propagation - tropospheric scatter propagation

Total : 45 Hrs

h) Learning Resources

Text Books

1. E.C. Jordan and K.G.Balmain "Electro Magnetic Waves and Radiating System, Pearson Education, 2nd Edition, 2015.
2. Warren L Stutzman and Gary A Thiele, "Antenna Theory and Design", John Wiley and Sons, 2nd Edition, 2009.

Reference Books

1. A. Balanis, "Antenna Theory: Analysis and Design", Wiley Publications. 3rd Edition, 2016.
2. John D Kraus, "Antennas for all Applications", 3rd Edition, McGraw Hill, 2005.
3. Collin R.E, "Antennas & Radio Wave Propagation", McGraw Hill. 1985.
4. Terman, "Electronics & Radio Engineering", 4/e, McGraw Hill.
5. Thomas A. Milligan, "Modern Antenna Design", Wiley, 2nd, Edition, 2005.
6. Constantine A.Balanis, P .Loannides, "Introduction to Smart Antennas",1organ & Claypool Publisher's series, 1st Edition, 2007.

Online Resources

1. http://www.cdeep.iitb.ac.in/nptel/Electrical%20&%20Comm%20Engg/Transmissiones % 20and%20E M%20Waves/TOC.html.
2. http://nptel.ac.in/courses/117101056.
3. www.antenna-theory.com.
4. http://www.dxzone.com/catalog/Antennas
5. http://www.engr.sjsu.edu/rkwok/EE172/Antenna_Fundamental.pdf.

Course Code	Course Title	L	T	P	C
10211EC114	**VLSI DESIGN**	**3**	**0**	**0**	**3**

a) Course Category

Programme Core

b) Preamble

This course provides comprehensive understanding of CMOS logic and VLSI design principles.it aims to introduce various aspects of CMOS technology, VLSI design, fabrication processes, circuit theory, sequential circuits, and arithmetic building blocks used in digital systems.

c) Prerequisite

Digital Electronics

d) Related Courses

Low power VLSI

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain CMOS logic implementation for gates and VLSI design flow	K2
CO2	Summarize the CMOS fabrication and processing technology.	K2
CO3	Interpret the I-V, C-V and DC characteristics of CMOS transistors.	K2
CO4	Construct the sequential circuits using CMOS transistors	K3
CO5	Illustrate the arithmetic building blocks and memories using CMOS circuits.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	-	-	-	-	-	-	-	-	H	-	-
CO2	H	M	L	L	L	-	L	-	-	-	-	L	-	-
CO3	H	L	L	L	L	L	-	-	L	-	-	L	-	-
CO4	H	H	H	M	M	L	-	-	-	-	-	L	L	L
CO5	H	M	M	M	M	L	-	L	L	L	-	H	L	L

g) Course Content

UNIT I CMOS LOGIC AND VLSI DESIGN FLOW 9

Review of MOS Transistors: nMOS, pMOS – Logic gates: CMOS Inverter – CMOS NAND Gate – CMOS NOR Gate – Compound Gates – Pass Transistor and Transmission Gates – Tristate – Multiplexers – VLSI Design Flow: Y-Chart.

UNIT II CMOS FABRICATION AND PROCESSING TECHNOLOGY 9

CMOS Fabrication and Layout: Inverter Cross Section – Layout Design Rules – Gate Layout – Stick Diagrams – CMOS Processing Technology: Background, Wafer Formation, Photolithography, Well and Channel Formation – SiO_2: Isolation, Gate Oxide, Gate and Source/Drain Formation – Contacts and Metallization – Passivation – Metrology.

UNIT III CMOS THEORY 9

MOS Transistor Theory – Ideal I-V Characteristics – C-V Characteristics – Non ideal I-V Effects – DC Transfer Characteristics: Static CMOS inverter DC characteristics, Beta ratio effect, Noise margin – Pass transistor DC characteristics.

UNIT IV SEQUENTIAL CIRCUITS 9

Sequencing Static Circuits – Circuit Design for Latches and Flip – Flops – Static Sequencing Element Methodology – Sequencing Dynamic Circuits – Synchronizer.

UNIT V ARITHMETIC BUILDING BLOCKS AND MEMORY ARCHITECTURE 9

Adders: Single bit Addition, Carry-Ripple Adder, Carry Skip Adder, Carry-Look ahead Adder –Multipliers: Binary Multiplication, Array Multiplier – Shifters: Funnel Shifter source Generator, Funnel Shifter, Barrel Shifter – Comparator – Counters - Memories: one bit SRAM, one bit DRAM,

Total: 45 Hrs

h) Learning Resources

Text Books

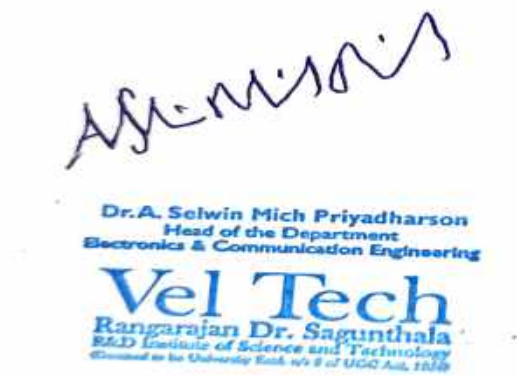
1. Neil H.E. Weste and David Money Harris,"CMOS VLSI Design: A Circuits and Systems Perspective", 4th Edition,Pearson Education,2015.
2. Douglas A. Pucknell and Kamran Eshraghian, "Basic VLSI Design", 3rd Edition, PHI, 2017.
3. John.P.Uyemura, "Introduction to VLSI Circuits and Systems", Wiley Publisher, 2006.

Reference Books

1. Jan M. Rabaey, A. Chandrakasan, B. Nikolic, Digital Integrated Circuits: A Design Perspective", 2nd Edition, Pearson, 2016.

Online Resources

1. http://www.cmosvlsi.com/coursematerials.html
2. http://freevideolectures.com/Subject/VLSI-and-ASIC-Design.



Course Code	Course Title	L	T	P	C
10211EC115	**OPTICAL AND MICROWAVE COMMUNICATION SYSTEMS**	**2**	**1**	**0**	**3**

a) Course Category
Programme Core

b) Preamble
This course deals with the fundamentals of optical fibers, sources, and detectors. Students will get familiarize with Microwave components and its Scattering parameters, Solid state devices, tubes and measurements.

c) Prerequisite
Antenna Theory

d) Related Courses
RF & Microwave Integrated circuits, Satellite Communication, Radar and Electronic Navigational system.

e) Course Outcomes
On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the fundamentals of optical fibers and its different types of losses, dispersion	K2
CO2	Explain the concepts of optical light sources anddetectors for optical fiber communication	K2
CO3	Apply the properties of S parameters to study the characteristics of microwave components.	K3
CO4	Compare the working principle of different solid state-based devices.	K2
CO5	Demonstrate the working principle of Microwave tubes and Measurement techniques.	K2

f) Correlation of COs, POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	-	-	-	L	-	-	L	L	L	L	-
CO2	H	M	M	-	-	-	-	-	-	-	M	L	L	-
CO3	H	M	M	L	M	L	L	-	L	L	-	L	M	-
CO4	H	M	M	-	-	-	-	-	-	-	-	L	L	-
CO5	H	M	M	L	M	L	-	-	L	L	M	L	L	-

g) Course Content

UNIT I OPTICAL FIBER FUNDAMENTALS 9

Evolution of Optic Communications - Basic Optical Laws – Light Propagation in fiber - Fiber Types - Splicing Techniques and Connectors – Attenuation, Absorption, Scattering Losses, Bending Losses, Core and Cladding Losses – Dispersion: Group Delay, Material Dispersion, Waveguide Dispersion, Intermodal Dispersion.

UNIT II OPTICAL SOURCES, DETECTORS AND SYSTEMS 9

Intrinsic and extrinsic material-direct and indirect band gaps-LED structures-Surface emitting LED-Edge emitting LED-quantum efficiency and LED power - light source materials-modulation of LED- LASER diodes. Detectors: PIN photo detector, Avalanche photo diodes, Photo detector noise-noise sources.

UNIT III MICROWAVE COMPONENTS AND TWO PORT NETWORKS 9

Microwave frequencies - advantages and applications, scattering matrix formulation: Concept of N port scattering matrix representation - S parameters properties, Passive microwave devices: bends – corners – attenuators , S Matrix Calculations for 2 port Junction: E plane and H plane Tees - Magic Tee, Directional Coupler - Circulator and Isolator.

UNIT IV MICROWAVE SOLID STATE DEVICES 9

Transit time limitations in Microwave Bipolar Transistors, Power frequency limitations, Gunn effect: RWH theory - High-field domain and modes of operation -Avalanche transit time devices: IMPATT and TRAPATT diodes, parametric amplifiers

UNIT V MICROWAVE TUBES AND MEASUREMENTS 9

Microwave vacuum tube-based devices, Limitations of conventional tubes at microwave frequencies, Two cavity Klystron - velocity modulation – Reflex klystron - Traveling wave tube, Magnetron. Measurement of Power, Wavelength, Impedance,Attenuation, SWR.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Gerd Keiser, "Optical Fiber Communication" McGraw -Hill International, 4th Edition. 2010.
2. John M. Senior, “Optical Fiber Communication”, Second Edition, Pearson Education, 2007
3. Annapurna Das and Sisir K Das, “Microwave Engineering”, Third edition Tata McGraw Hill Inc., 2009.
4. David M. Pozar, "Microwave Engineering", Third Edition, Wiley India.2012.

Reference Books

1. J.Gower, "Optical Communication System", Prentice Hall of India, 2001.
2. Mathew M Radmanesh, “RF and Microwave Electronics”, Prentice Hall, 2000.
3. Samuel Y Liao, “Microwave Devices & Circuits” Third Edition Prentice Hall of India, 2006.
4. Thomas H Lee, “Planar Microwave Engineering: A Practical Guide to Theory, Measurements and Circuits”, Cambridge University Press, 2004.

Online Resources

1. https://en.wikipedia.org/wiki/Microwave_engineering
2. http://www.microwaveeng.com
3. Microwave and RF Information for Engineers | Microwave Calculators, Encyclopedia, Discussion Forum (microwaves101.com)
4. Optical Communications - Course (nptel.ac.in)
5. Microwave Engineering - Course (nptel.ac.in)

Course Code	Course Title	L	T	P	C
10211EC201	**EMBEDDED OS AND DEVICE DRIVERS**	**2**	**0**	**2**	**3**

a) Course Category

Programme Core

b) Preamble

This course provides the fundamental concept of how operating system schedules the various embedded computational process in real time applications.

c) Prerequisite

Microprocessor and Microcontroller

d) Related Courses

Embedded Linux and Device Drivers

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts of operating system and RTOS objects and simulate RTX51 based embedded OS code for 8051 microcontroller using Keil IDE.	K2, S3
CO2	Summarize the concept of board support package and simulate boot loader interface.	K2, S3
CO3	Illustrate the concept of embedded storage architecture.	K2
CO4	Compare the various embedded file systems, storage space optimization techniques and develop Linux C programs to implement Linux file system.	K2, S3
CO5	Infer the Linux device driver development process for communication interfaces and to develop Linux drivers for basic devices.	K2, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	M	M	M	-	-	L	M	M	H	H	-	L
CO2	L	-	L	-	H	-	-	-	-	-	-	-	L	L
CO3	L	-	L	-	H	-	-	-	-	-	-	-	L	L
CO4	M	-	-	M	H	-	-	L	M	M	H	L	M	M
CO5	L	-	M	M	H	-	-	L	M	M	H	H	-	-

g) Course Content

UNIT I OVERVIEW OF RTOS 9

Introduction to OS, OS structure, system calls, RTOS task and task state, scheduling – preemptive and non-preemptive, process synchronization, inter process communication: message queues, mailboxes, pipes, critical section, semaphores, classical synchronization problem –deadlocks.

UNIT II BOARD SUPPORT PACKAGES 5

Kernel build procedure, inserting Board Support Packages (BSP) in kernel build procedure, boot loader interface, memory map, interrupt management, PCI subsystem: timers - UART-power management.

UNIT III EMBEDDED STORAGE ARCHITECTURE 4

Embedded storage: MTD – MTD architecture - MTD driver for NOR flash - flash mapping driver.

UNIT IV EMBEDDED FILE SYSTEM AND OPTIMIZATION 6

Embedded file system: RAM disk – RAMFS – CRAMFS, journaling flash file systems: JFFS and JFSS2, NFS: PROC file system, optimizing storage space: kernel space optimization - application space optimization, applications for embedded Linux - tuning kernel memory.

UNIT V LINUX DEVICE DRIVERS 6

Embedded drivers: Linux device model, loadable kernel modules, Linux serial driver – function pointers, data flow, ethernet driver - I^2C subsystem on Linux - USB gadgets.

Total: 30 Hours

S. No.	Practical Exercises (30 Hours)	CO
1.	Exploring the features of Keil and RTX51	CO1
2.	Task creation and deletion using RTX51 in Keil	CO1
3.	Task scheduling using RTX51 in Keil	CO1
4.	Processing critical section using RTX51 in Keil	CO1
5.	Task synchronization using RTX51 semaphores in Keil	CO1
6.	Task communication using shared memory in Keil	CO1
7.	Linux installation	CO2
8.	Basic Linux programming	CO2
9.	Boot loader interface	CO2
10.	Make file creation	CO4
11.	Creating Linux loadable kernel modules	CO5
12.	Linux serial driver	CO5

Total : 60 Hours

h) Learning Resources

Text Books

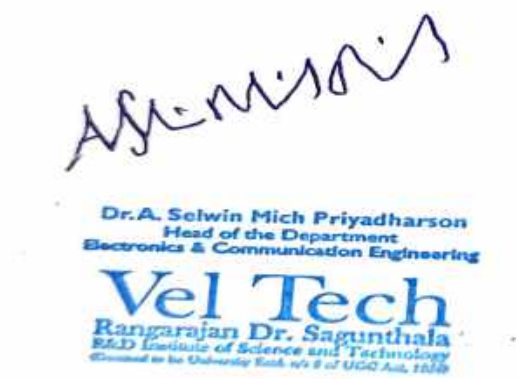
1. Silberschatz, Galvin, Gagne, "Operating System Concepts", 6th edition, John Wiley, 2003.
2. Raj Kamal, "Embedded Systems-Architecture, Programming and Design", Tata McGraw Hill, 2006.
3. P.Raghavan, Amol Lad, Sriram Neelakandan, "Embedded Linux System Design and development", Auerbach Publications 2005

Reference Book

1. Jonathan Corbet, Allesandro Rubini & Greg Kroah-Hartman, "Linux Device Drivers", O'Reilly, 3rdedition, 2005.

Online Resources

1. https://www.youtube.com/watch?v=PEzpOembKNc **-What is a Bootloader?**
2. https://www.youtube.com/watch?v=mCs21yByQqk **- Qlikview Basic Tutorial - Time Comparisons- YTD QTD MTD**



Course Code	Course Title	L	T	P	C
10211EC202	**INTERNET OF THINGS**	**2**	**0**	**2**	**3**

a) Course Category

Programme core

b) Preamble

This introductory course is designed to provide information about the technologies that make up the Internet of Things (IoT) and intents to produce skilled graduates with basic understanding of IoT and how they are applied in different application domains. It will help to know the components of IoT products and services including devices for sensing, actuation, processing, and protocols for data communication and networking.

c) Prerequisite

Data Communication Networks

d) Related Courses

Software Defined Networking

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the fundamental of IoT including architecture, functional blocks and connecting devices.	K2
CO2	Explain the concepts of IoT by interfacing devices using Raspberry Pi/Arduino IDE.	K2
CO3	Extend the various IoT protocols for routing and data acquisition.	K2
CO4	Outline the IoT perceptions for cloud and fog services.	K2
CO5	Summarize the concepts of IoT to solve real time scenario for various smart applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	-	L	-	-	-	-	L	L	-	-	-	-	-
CO2	H	-	L	-	L	-	-	L	L	L	-	L	L	-
CO3	H	M	M	-	L	-	-	L	L	L	-	L	L	L
CO4	H	M	M	L	-	-	-	L	L	L	-	L	L	L
CO5	H	M	M	L	L	L	L	L	L	L	L	L	L	L

g) Course Content

UNIT I FUNDAMENTALS OF IoT 6

Evolution of Internet of Things – Enabling Technologies – IoT Architectures: oneM2M, IoT World Forum (IoTWF) – Simplified IoT Architecture and Core IoT Functional Stack– Functional blocks of an IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects.

UNIT II IoT INTERFACING 6

Introduction to Arduino – Arduino IDE –Basic Commands –Interfacing with Arduino, Introduction to Raspberry Pi – Terminal Commands- Interfacing with Raspberry Pi.

UNIT III IoT COMMUNICATION PROTOCOLS 6

Infrastructure Protocols, Discovery Protocols, Data Protocols- MQTT, CoAP, Web Socket. Identification Protocols, Device Management, Semantic Protocols.

UNIT IV IoT SUPPORTING SERVICES 6

Cloud Computing-Virtualization and its types-Cloud Models-Implementation- Open Stack-AWS, Fog Computing in IoT-Fog Nodes-Deployment Model-Applications.

UNIT V SMART APPLICATIONS 6

Smart and Connected Cities: Smart Grids, Smart Lighting, Smart Parking Architecture and Smart Traffic Control.

Total : 30 Hrs

h) Laboratory **Total : 30 Hrs**

List of experiments

S. No	Practical Exercises	Course Outcome
1	Software installation for Arduino.	CO2
2	Software installation for Raspberry Pi	CO2
3	Design an MCU to control GPIO Pins.	CO2
4	Design an MCU to Interface with Sensors.	CO2
5	Design an MCU to control HTTP Client.	CO3
6	Create an IoT Connected Sensor Network using lightweight protocol.	CO3
7	Create Wireless MCU to connect to a website and search a string.	CO3
8	Design a system to analyse the sensor values in Cloud.	CO4
9	AWS IoT Basic Configuration.	CO4
10	Mini Project.	CO5

Total: 60 Hrs

i) Learning Resources

Text Books

1. David Hanes, Gonzalo Salgueiro, Patrick Grossetete, Rob Barton and Jerome Henry-IoT Fundamentals: Networking Technologies, Protocols and Use Cases for Internet of Things, Cisco Press, 2017. (Unit 1 & Unit 5)

2. Sudip Misra, Anandarup Mukherjee, Arijit Roy - Introduction to IoT , Cambridge University Press, 2021. (Unit 3 & Unit 4)

Reference Books

1. Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh and Mahendra Swain-Internet of Things with Raspberry Pi and Arduino, CRC Press,2020. (Unit 2)

2. Arshdeep Bahga, Vijay Madisetti,-Internet of Things- A Hands-on Approach, Universities Press, 2015.

3. Olivier Hersent, David Boswarthick, Omar Elloumi, -The Internet of Things – Key applications and Protocols, Wiley, 2012 (for Unit 2).

4. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Elsevier, 2014.

5. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things, Springer, 2011.

6. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

Online resources

1. Dr.Sudip Misra, Video lecture on Internet of Things, Centre for Educational Technology, IIT Kharagpur Sponsored by National Programme on Technology Enhance Learning (NPTEL) https://onlinecourses.nptel.ac.in/noc17_cs22/preview.

Course Code	Course Title	L	T	P	C
10211EC301	**ANALOG INTEGRATED CIRCUITS LABORATORY**	**0**	**0**	**4**	**2**

a) Course Category

Programme Core

b) Preamble

The aim of this course is to familiarize students with the analog integrated circuits and design and implementation of application circuits using basic analog integrated circuits using transistor, op-amp and MOS and additionally familiarize students with simulation of basic analog integrated circuits.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Skill Level As per Dave's Taxonomy
CO1	Build and validate the electronic circuits like biasing circuit, emitter follower, amplifier and oscillator using BJT	S3
CO2	Demonstrate the op-amp electronic circuit's viz. filters, comparators and analog signal processing unit.	S3
CO3	Construct the electronic circuits using timer IC and MOS	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	M	M	-	-	-	-	L	-	L	M	-
CO2	H	H	M	M	M	-	-	-	-	L	-	L	M	-
CO3	H	H	M	M	M	-	-	-	-	L	-	L	M	-

g) Course Content List of Experiments

[Design and Testing of the following circuits and simulation using LTSPICE]

Ex.No.	List of Experiments	CO	Skill Level As per Dave's Taxonomy
1.	Design and analyze Voltage Divider Bias and compare its performance with Fixed bias.	CO1	S3
2.	Design and test a Darlington Emitter Follower with and without bootstrapping.	CO1	S3
3.	Generate a desired frequency of LC Phase Shift Oscillator using BJT	CO1	S3
4.	Design a Complementary Symmetry Class B push Pull Amplifier	CO1	S3
5.	Design an Active Low Pass and High Pass Filter using op-amp.	CO2	S3
6.	Design and implement Schmitt Trigger using op-amp	CO2	S3
7.	Design and implement Differentiator and Integrator using op-amp	CO2	S3
8.	Design an Instrumentation Amplifier using op-amp and calculate the CMRR.	CO2	S3
9.	Design an Astable Multivibrator using 555 Timer	CO3	S3
10.	Design a MOSFET as an amplifier with their frequency response	CO3	S3
11.	Design a CMOS inverter and plot its V-I Characteristics	CO3	S3
12.	Design a three stage Ring Oscillator using CMOS	CO3	S3

Total : 60 Hrs

h) Learning Resources

Text Books

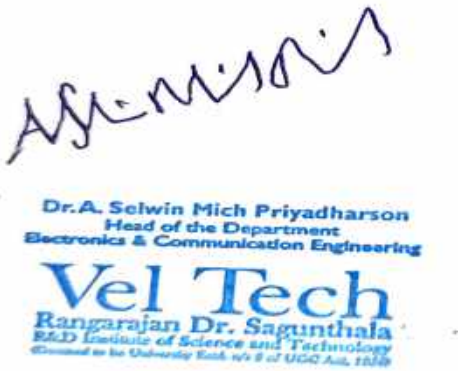
1. M. Morris Mano, Michael D Ciletti, "Digital Design", 5th Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.
2. Donald. P. Leach, "Digital principles and applications", 7th Edition, McGraw-Hill, 2012
3. S.Salivahanan, S. Arivazhagan, " Digital Circuits and Design", 5th Edition, Oxford University Press, 2018
4. W.H. Hayt and I.E.Kemmerley, "Engineering Circuits Analysis", McGraw Hill Education 8th Ed, 2014.

Reference Books

1. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.
2. Thomas L. Floyd, Digital Fundamentals, 8th Edition, Pearson Education Inc, New Delhi, 2003 Donald D.Givone, Digital Principles and Design, TMH
3. William H. Gothmann, Digital Electronics, 2nd Edition, PHI, 1982.

Online Resources

1. http://www.wiley.com/legacy/wileychi/mblin/supp/student/ LN08CombinationalLogic Modules.pdf
2. http://www.learnabout-electronics.org



Course Code	Course Title	L	T	P	C
10211EC302	**DIGITAL ELECTRONICS LABORATORY**	**0**	**0**	**2**	**1**

a) Course Category

Programme Core

b) Preamble

The aim of this course is to understand the fundamental and design of digital circuits using ICs and FPGA. Additionally this course includes design and implementation of combinational and sequential circuits using Verilog HDL and FPGAs.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Dave's Taxonomy)
CO1	Execute the combinational and sequential circuits using Verilog HDL.	S2
CO2	Build the digital circuits using IC's.	S2
CO3	Demonstrate and implement the real time interfacing using FPGAs.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2
CO1	H	M	H	L	H	-	-	-	M	-	-	M	H	L
CO2	H	H	H	M	H	-	-	-	M	-	-	M	H	-
CO3	H	H	H	H	H	L	M	-	M	-	-	M	H	L

g) Course Content

List of Experiments

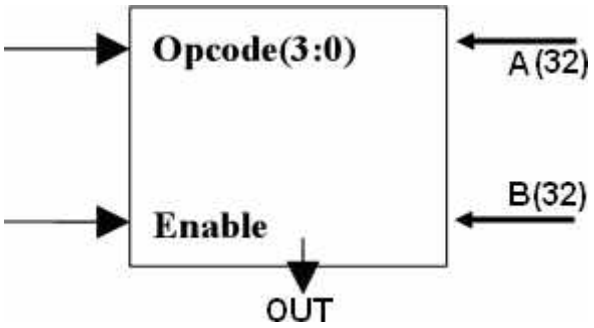
Module 1 – Software (CO1)

1. Write a Verilog program for the following combinational designs (a) Decoder (b) Encoder.

2. Write a Verilog program for the following combinational designs (a) Multiplexer (b) De-multiplexer.

3. Write a HDL code to describe the functions of a full adder using three modeling styles.

4. Write a model for 32 bit ALU using the schematic diagram shown below



   a. ALU should use the combinational logic to calculate an output based on the four bit op-code input.
   b. ALU should pass the result to the out bus when enable line in high, and tri-state the out bus when the enable line is low.
   c. ALU should decode the 4 bit op-code according to the given in example below.

OPCODE	ALU OPERATION
1.	A + B
2.	A – B
3.	A Complement
4.	A * B
5.	A AND B
6.	A OR B
7.	A NAND B
8.	A XOR B

5. Develop the Verilog code for the following flip-flops: SR, D, JK &T.

6. Write a Verilog code for 4 bit binary counter (Synchronous and Asynchronous).

Module 2 – Hardware (CO2)

7. Realization of logic functions with the help of Universal Gates (NAND, NOR)
8. Implementation of comparator using digital logic ICs
9. Implementation of Synchronous Counter using digital logic ICs
10. Implementation of Asynchronous Counter using digital logic ICs

Module 3 – Interfacing (CO3)

11. Write a Verilog code and realize all the logic gates using FPGA
12. Write HDL code to interface hex key pad and display the key code on seven segment display using FPGA.

h) Learning Resources

Text Books:

1. M. Morris Mano, Michael D Ciletti, Digital Design, 5th Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.
2. Zainalabedin Navabi Verilog Digital System Design, II edition, McGraw Hill Electronic Engineering, 2017.

Reference Books:

1. Samir Palnitkar, Verilog HDL - Guide to Digital design and synthesis, III edition, Pearson Education, 2003.
2. John F.Wakerly, Digital Design, Fourth Edition, Pearson/PHI, 2006.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc22_ee55/preview
2. http://asic-world.com/
3. http://www.learnabout-electronics.org

Course Code	Course Title	L	T	P	C
10211EC303	**SIGNAL PROCESSING LABORATORY**	**0**	**0**	**2**	**1**

a) Course Category

Programme Core

b) Preamble

Signal processing laboratory course uses MATLAB simulation software to demonstrate the basic operations on signals and the applications of transformation techniques. Students will also understand the concept of filters and its frequency response through MATLAB simulation and processor implementation.

c) Prerequisite

Signals and Systems

d) Related Courses

Discrete Time Signal Processing, Digital Image and Video Processing

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Dave's Taxonomy)
CO1	Generate basic signals and perform various processing operations on it.	S2
CO2	Demonstrate system properties and also design an IIR and FIR filters.	S2
CO3	Implement discrete time signal processing operations and applications using digital signal processor.	S2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	M	L	M	L	H	-	-	L	H	-	-	M	L	-
CO2	M	H	H	H	H	L	L	L	H	M	-	H	M	-
CO3	M	H	H	H	H	L	L	L	H	M	-	H	H	-

g) Course Content

List of Experiments:

No.	Experiment Title	COs
	MATLAB based experiments	
1.	Generate the continuous time and discrete time signals.	CO1
2.	Perform sampling and reconstruction of the given signal.	CO1
3.	Perform linear and circular convolution for the given two signals.	CO1
4.	Compute the Discrete Fourier Transform of the given signal.	CO1
5.	Verify the properties of the discrete time systems.	CO2
6.	Design an IIR filter and obtain the frequency response using Butterworth and Chebyshev model.	CO2
7.	Design an FIR Filter and obtain the frequency response using windowing technique.	CO2
8.	Perform Interpolation and decimation operations for the given	CO1
	Processor Based experiments	
9.	Perform linear convolution of two signals.	CO3
10.	Compute the Fourier transform of the discrete time signal.	CO3
11.	Design and implement an IIR filter.	CO3
12.	Design and implement an FIR filter.	CO3
13.	Perform Filtering operation on Audio/ECG signal.	CO3

Total : 30 Hrs

h) Learning Resources

Text Books

1. Keonwook Kim, "Conceptual Digital Signal Processing with MATLAB", Springer Nature Singapore, 2020.

Reference Books

2. V. K. Ingle and J. G. Proakis, "Digital Signal Processing using MATLAB," Cengage Learning, 3rd edition, 2012.
3. Li Tan, Jean Jiang ," Digital Signal Processing Fundamentals and Applications"Elsevier Science, 2013.
4. Alex Palamides, Anastasia Veloni, "Signals and Systems Laboratory with MATLAB", CRC Press, Taylor and Francis Group, London, New York, 2010.

Online Resources

1. https://in.mathworks.com/products/signal.html
2. https://grader.mathworks.com/
3. https://in.mathworks.com/products/matlab-grader.html

Course Code	Course Title	L	T	P	C
10211EC304	MICROPROCESSOR AND MICROCONTROLLER LABORATORY	0	0	2	1

a) Course Category

Programme Core

b) Preamble

The course objective is to introduce the basic concepts of microprocessor and to develop students in the assembly language programming skills and real time applications of microprocessor as well as microcontroller.

c) Prerequisite

Digital Electronics

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Develop an assembly language program for performing basic ALU manipulation using 8085 microprocessor.	S3
CO2	Execute an assembly language program to perform peripheral interfacing using 8086 microprocessor.	S3
CO3	Generate an assembly language/ C program for performing bit manipulations and timer, serial port and interrupt programming using 8051 microcontroller.	S3
CO4	Implement C program for performing real time interfacing using 8051and PIC microcontroller.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	-	L	M	-	-	-	-	-	-	-	-	-
CO2	M	M	L	L	M	-	-	-	-	-	-	-	-	-
CO3	H	M	L	L	H	-	-	-	-	-	-	-	M	-
CO4	H	M	L	L	L	-	-	-	-	-	-	-	M	-

g) Course Content

Exp. No.	Experiment Name	CO Mapping
1.	Assembly language program to perform 8-bit ALU operations in 8085 Microprocessor	CO1
2.	Assembly language program to interface the 8255 peripheral devices with 8086.	CO2
3.	Assembly language program to interface the 8279 peripheral devices with 8086.	CO2
4.	Assembly language program to perform 8-bit manipulation and masking in 8051 microcontroller.	CO3
5.	Embedded C program to simulate the different timer modes in 8051 microcontroller using Keil software.	CO3
6.	Embedded C program to simulate the transmitting of character/string using serial port in 8051 microcontroller using Keil software.	CO3
7.	Embedded C program to simulate to perform the various interrupt operations in 8051 microcontroller using Keil software.	CO3
8.	a.) Embedded C program to interface 8051 microcontroller with stepper motor and perform clockwise and anticlockwise rotation using Keil software. b.) Write an embedded C program to interface 8051 microcontroller with DC motor and determine the speed of the motor using Keil software.	CO4
9.	Embedded C program to interface 8051 microcontroller with elevator using Keil software.	CO4
10.	Embedded C program to interface any sensors with PIC microcontroller using MPLAB IDE.	CO4
11.	Embedded C program to interface any actuators with PIC microcontroller using MPLAB IDE.	CO4

Total: 30 Hours

h) Learning Resources

Text Books

1. Ramesh S Gaonkar, Microprocessor Architecture, Programming and application with 8085, 6th Edition, Penram International Publishing, 2013.
2. A.K Ray & K.M. Burchandi, Advanced Microprocessor and peripherals Architectures, Programming and interfacing", Third edition, Tata McGraw-Hill, 2013.
3. Muhammad Ali Mazidi, Janice Gillispie Mazidi and Rolin D McKinlay, The 8051 Microcontroller and embedded systems using assembly and C, second edition Pearson Education Asia, 2006.
4. Danny Causey, Muhammad Ali Mazidi, and Rolin D. McKinlay "PIC Microcontroller and Embedded Systems: Using Assembly and C for PIC18".

Online Resources

1. https://www.youtube.com/watch?v=x_4G3LYqiO4 - 8051 microcontroller experiment for elevator interface.

2. https://www.youtube.com/watch?v=Go8hDHqPqiU - MPLAB IDE with PIC microcontroller and temperature sensor.

Course Code	Course Title	L	T	P	C
10211EC305	**COMMUNICATION LABORATORY**	**0**	**0**	**2**	**1**

a. Course Category:

Programme Core

b. Preamble:

This course provides to demonstrate all types of modulation techniques for both analog and digital communication systems.

c. Pre-requisites:

Analog Electronics

d. Related Courses:

Nil

e. Course Outcomes:

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Perform the analysis of amplitude modulation and frequency modulation along with its demodulation circuits.	S2
CO2	Demonstrate the effects of sampling, error control codes and multiplexing.	S2
CO3	Execute the analysis of various digital modulation techniques, fading channel, and channel coding techniques.	S2
CO4	Design the antenna and test the digital modulation scheme using network and spectrum analyzers.	S2

f. Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	M	-	L	L	L	L	-	L	L	L	-
CO2	M	L	L	L	H	M	M	L	L	-	M	L	L	-
CO3	M	L	L	L	H	M	M	L	L	-	M	L	L	-
CO4	M	-	L	L	M	M	M	L	L	-	M	L	L	-

g. Course Content:

List of Experiments

S. No	Name of the Experiment	Course Outcomes
1	Design and testing of Amplitude Modulation and Demodulation. (Hardware)	CO1
2	Design and testing of Frequency Modulation and Demodulation. (Hardware)	CO1
3	Simulation of Sampling, Quantization, and Reconstruction of the signals.	CO2
4	Analysis of Time Division Multiplexing and De-multiplexing Techniques.	CO2
5	Simulation and Performance analysis of Cyclic Coding	CO2
6	Pulse Code Modulation and Demodulation of a signal.	CO3
7	Simulation and Performance Analysis of Binary Amplitude Shift Key in an AWGN environment.	CO3
8	Design and testing of ASK Modulation and Demodulation. (Hardware)	CO3
9	Simulation and Performance Analysis of Frequency Shift Key in an AWGN environment.	CO3
10	Design and testing of FSK Modulation and Demodulation. (Hardware)	CO3
11	Simulation and Performance Analysis of Binary Phase Shift Key in an AWGN environment.	CO3

12	Simulation and Performance Analysis of Quadrature Amplitude Modulation in an AWGN environment.	CO3
13	Simulation and Performance Analysis of digital modulation technique in fading channel with channel coding.	CO3
14	Performance analysis of monopole antenna using a Network Analyzer. (Hardware)	CO4
15	Design and testing the performance of Binary PSK modulation using Spectrum Analyzer. (Hardware)	CO4

Course Code	Course Title	L	T	P	C
10211EC306	**OPTICAL AND MICROWAVE ENGINEERING LABORATORY**	**0**	**0**	**2**	**1**

a) Course Category

Programme Core

b) Preamble

Optical and Microwave laboratory provides an opportunity to explore the concepts inoptical devices and microwave systems in a laboratory setting with an emphasison measurement techniques. The listed experiment provides the practical analysis of scattering matrix for various microwave components and its properties, operation of solid state based devices.

c) Prerequisite

Nil

d) Related Courses

Optical & Microwave Communication Systems.

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Demonstrate the characteristics of microstrip transmission line, distributed elements and Tee junctions using ANSYS HFSS software.	S2
CO2	Perform characteristics analysis of microwave test benches using reflex klystron and gunn source.	S2
CO3	Execute the characteristics of LED/photodiodes and performance analysis of fibre optic cable with less attenuation and dispersion.	S2
CO4	Test the characteristics of microwave integrated circuits and devices.	S2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	M	H	L	L	L	L	-	L	L	L	-
CO2	M	L	L	L	M	M	M	L	L	-	M	L	L	-
CO3	M	L	L	L	H	L	L	L	L	-	L	L	L	-
CO4	M	-	L	L	M	M	M	L	L	-	M	L	L	-

g) Course Content

List of Experiment

S.No.	Name of the Experiments	CO mapping of Experiments
1	Study of Ansys HFSS simulation tool	CO1
2	Design and analysis of a basic Microstrip transmission line using ANSYS HFSS Simulation Tool	CO1
3	Design and analysis of Rectangular Waveguide using ANSYS HFSS simulation Tool.	CO1
4	Design and Analysis of E-Plane and H-Plane T junctions using ANSYS HFSS simulation Tool.	CO1
5	Mode Characteristics of Reflex Klystron	CO2
6	Measurement of Radiation Pattern and Gain of Microwave Antenna	CO2
7	V-I Characteristics Of Gunn Diode	CO2
8	Measurement of VSWR and Impedance of Unknown Load	CO2
9	Modeling of a basic fiber optic system consisting of a transmitter, fiber and receiver using Optisystem	CO3
10	Design of an attenuation-limited fiber length based on power budget system	CO3
11	Design of dispersion limited fiber length for a fiber optic transport system.	CO3
12	Determination Of Numerical Aperture of an Optical Fiber Cable	CO3

13	V-I Characteristics of LED/Photodiode	CO3
14	Performance Analysis of Monolithic Microwave Integrated Circuit (MMIC) Amplifier Characteristics, measurement of gain, 1dB compression point, and reverse isolation.	CO4

Course Code	Course Title	L	T	P	C
10212EC101	**RF AND MICROWAVE INTEGRATED CIRCUITS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

RF & Microwave Engineering Circuits is a course designed for introducing the field of Microwave Engineering to students, engineers and academics. Practical design issues of microwave circuits will be emphasized and fabrication techniques of microwave integrated circuits will also be treated.

c) Prerequisite

Nil

d) Related Courses

Electromagnetics and Transmission Lines, Antenna Theory

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts of radio frequency circuit design.	K2
CO2	Discuss the different planar transmission lines.	K2
CO3	Describe the basics of microwave integrated circuits	K2
CO4	Summarize the fabrication and measurement techniques of MIC	K2
CO5	Distinguish the MMIC technique for different applications	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	M	H	-	-	-	-	-	-	-	-	-
CO2	H	M	M	M	H	M	L	-	L	L	L	M	L	-
CO3	L	M	M	M	-	L	-	-	M	M	L	H	H	-
CO4	H	M	-	M	L	-	L	-	L	-	L	-	L	-
CO5	L	M	-	M	L	-	-	-	L	M	-	M	H	-

g) Course Content

UNIT I RF CIRCUIT DESIGN 9

Importance of Radio Frequency design – Dimensions and units, Frequency spectrum – RF Behavior of passive components: High frequency resistors, capacitors and inductors - Chip components and circuit board considerations. Review of transmission lines: parameters, Characteristic impedance, Reflection coefficient, Standing waves

UNIT II PLANAR TRANSMISSION LINES 9

Characteristics and design parameters of planar transmission lines – strip line – microstrip Line – coplanar waveguide – coplanar strips slot line – fin line

UNIT III MICROWAVE INTEGRATED CIRCUITS 9

Introduction to MIC – advantages and applications – MMIC technology: Active device Technologies, design approaches- multichip module technology – Hybris MIC- Monolithic MIC

UNIT IV MIC FABRICATION AND MEASUREMENT TECHNIQUES 9

Fabrication technology and Measurement Techniques – test fixture measurements - probe station measurements -thermal and cryogenic measurements- experimental field probing Techniques.

UNIT V SYSTEM DESIGN USING MMIC TECHNOLOGY 9

Analysis of MMIC Technology – micro machined antenna – micro electro-mechanical system antennas - design issues in Phased array radar- Satellite Transponder - Integrated Electronic warfare T/R modules - Avionic systems integration

Total: 45 Hrs

h) Learning Resources

Text Books

1. S.Raghavan, "Microwave Integrated Circuit Components Design Through MATLAB", Taylor and Francis, 2020.
2. Reinhold Ludwig, Gene Bogdanov, "RF Circuit Design Theory and Applications" Prentice Hall Inc. 2009.
3. Habil. MBA Frank Ellinger, "Radio frequency integrated circuits and technologies", Springer- Varlag Berlin Heidelberg, 2007.
4. Leo G. Maloratsky, "RF and Microwave Integrated Circuits: Passive Components and Control Devices" Elsevier, 2004.

Reference Books

1. Gupta. K.C and R. Garg, "Microstrip line and slot line" Artech House, Boston, 1996
2. Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.
3. Robert Caverly, "CMOS RFIC Design Principles" Artech House, 2007.
4. D.M.Pozar, "Microwave Engineering", 3rd edition, John Wiley, 2004.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc23_ee18/preview
2. http://home.sandiego.edu/~ekim/e194rfs01/
3. https://parts.jpl.nasa.gov/mmic/3-IX.PDF

Course Code	Course Title	L	T	P	C
10212EC102	**CELLULAR MOBILE COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course addresses about the fundamentals of cellular mobile communication and provides overview of existing and emerging cellular communication networks. It covers radio frequency propagation and mobile antennas, use of IP and associated technologies for a cellular system, wireless generation technologies-1G, 2G, 2.5G, and 3G. For enhanced performance in system, the knowledge about the next generation cellular technologies like 4G and 5G are essential.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication, Communication Systems

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts of a cellular communication system and standards	K2
CO2	Illustrate radio frequency propagation phenomenon and mobile antenna types	K2
CO3	Demonstrate the significance of internet protocol and associated technologies in a cellular system	K2
CO4	Interpret various wireless communication technologies, including third generation	K2
CO5	Discuss the features of fourth-generation and emerging technologies, including fifth generation technology	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	L	-	-	L	L	-	-	-	-	-	-
CO2	M	M	M	L	L	-	-	L	-	-	-	-	-	-
CO3	H	M	M	-	M	M	-	-	-	-	L	-	L	-
CO4	H	M	H	L	-	L	M	L	L	L	L	L	L	-
CO5	H	M	H	M	M	L	M	M	L	L	-	L	L	-

g) Course Content

UNITI INTRODUCTION TO CELLULAR COMMUNICATION 9

Motivation for cellular communication, History of wireless communications and Birth of cellular system, Overview of cellular system and Duplexing, Types of interference, Evolution of cellular standards, Ecosystem of cellular system, Phases and Performance of a cellular system.

UNITII RADIO FREQUENCY PROPAGATION AND MOBILE ANTENNAS 9

Radio frequency waves and propagation modes, Free-space propagation, Cellular propagation mechanism and Prediction of received signal strength, Antenna for mobile communication and its effects, human body interactions, and specific absorption rate, Cell-site antennas and its effects, Space diversity antennas and base station systems.

UNITIII IP AND ASSOCIATED TECHNOLOGIES FOR A CELLULAR SYSTEM 9

Internet protocol, Protocol stack for the internet, Routing and forwarding of IP packets, Transport of information within the network infrastructure, Voice over the IP related protocols, IP-centric protocols, and Essence of IPv6.

UNITIV CELLULAR TECHNOLOGIES 9

First generation (1G), Second generation (2G), TDMA-based 2G standard, IS-95, Two point five generation (2.5G), Third generation (3G), 3G air interface technology, 3G spectrum, subscriber forecast for 3G in India with Quality of services (QoS) in 3G, Limitations of 3G and rise of the Fourth generation (4G) cellular communication.

UNITV 4G TECHNOLOGY AND BEYOND 9

4G evolution, Objectives of the projected 4G, Advantage of 4G network technology over the 3G, Applications of 4G, 4G Technologies, 4G software, Limitations of 4G, New technologies in the cellular data networks and emergence of new technologies Fifth-generation (5G) communication.

Total: 45 Hours

h) Learning Resources

Text Books

1. N. D. Tripathi and J. H. Reed, "Cellular Communication: A Comprehensive and Practical Guide", 3rd Ed., John Wiley & Sons, Inc., 2014.
2. Gottapu S. Rao, "Mobile Cellular Communication", 2nd Ed., Dorling Kindersley (India) Pvt. Ltd., 2013.

Reference Books

1. A. Goldsmith, "Wireless Communications," 2nd Ed., Cambridge University Press, 2005.
2. William C. Y. Lee, "Wireless and Cellular Communications," 3rd Ed., McGraw-Hill Companies Inc, 2006.

Online Resources

1. https://archive.nptel.ac.in/courses/108/106/106106167/
2. https://www.tutorialspoint.com/wireless communication/wireless_communication cellular_networks.htm

Course Code	Course Title	L	T	P	C
10212EC103	**INFORMATION THEORY AND CODING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The aim of this course will study how information is measured in terms of probability and entropy to get exposed in compression technique, audio & video. This course discusses about the various methods of coding techniques to correct and detect errors and add security solutions. The course will also introduce the principles and applications of information theory.

c) Prerequisite

Digital Electronics

d) Related Courses

Wireless Communication

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basics of information and coding theory	K2
CO2	Illustrate the capacity reduction-based coding techniques for text, audio, and speech data types.	K2
CO3	Compare the capacity reduction-based coding techniques for image and video types of data.	K2
CO4	Discuss the various security-oriented coding techniques for Block codes	K2
CO5	Interpret the different error control techniques for convolutional codes	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	M	L	L	L	-	-	-	L	L	-	L	-	-
CO2	H	L	M	L	L	-	-	-	L	L	-	-	L	-
CO3	H	L	M	L	-	L	-	L	L	L	L	-	L	-
CO4	H	L	M	L	L	-	L	-	L	L	L	L	L	-
CO5	H	L	M	L	L	L	L	L	L	L	L	L	M	-

g) Course Content

UNIT I INFORMATION THEORY 9

Entropy - Information rate - classification of codes - Kraft McMillan inequality- Source coding theorem: Shannon-Fano coding, Huffman coding, Extended Huffman coding- Joint and conditional entropies- Mutual information – Discrete memoryless channels: BSC, BEC, Channel capacity, Shannon limit.

UNIT II SOURCE CODING: TEXT, AUDIO AND SPEECH 9

Text: Adaptive Huffman Coding, Arithmetic Coding, LZW algorithm- Audio: Perceptual coding, Masking techniques: Spectral, Temporal, Psychoacoustic model, MPEG Audio layers I, II, III, Dolby AC3- Speech: Channel Vocoder, Linear Predictive Coding.

UNIT III SOURCE CODING: IMAGE AND VIDEO 9

Image and Video Formats: GIF, TIFF, SIF, CIF, QCIF- Image compression: READ, JPEG Video-Compression: Principles-I, B, P frames, Motion estimation, Motion compensation, H.261, MPEG standard.

UNIT IV ERROR CONTROL CODING: BLOCK CODES 9

Principles of Hamming weight, hamming distance, Minimum distance decoding - Single parity codes-Hamming codes- Repetition codes- Linear block codes- Cyclic codes – Syndrome calculation: Encoder and decoder – CRC.

UNIT V ERROR CONTROL CODING: CONVOLUTION CODES 9

Convolution codes: code tree, trellis diagram, state diagram, Encoding, Decoding-Sequential search and Viterbi Algorithm - Principles of Turbo coding**.**

Total: 45 Hrs

h) Learning Resources

Text Books

1. R Bose, "Information Theory, Coding and Cryptography", TMH, 2008.
2. Fred Halsall, "Multimedia Communications: Applications, Networks, Protocols and Standards", 15th Impression, Pearson, 2013.
3. K Sayood, "Introduction to Data Compression" 3rd Edition, Elsevier 2006.
4. David Salomon, "Data Compression", 3rd Edition, Springer, 2005.

Reference Books

1. S Gravano, "Introduction to Error Control Codes", Oxford University Press 2007.
2. Amitabha Bhattacharya, "Digital Communication", TMH 2006.
3. Imre Csiszar and Jonos Korner, "Information Theory"', 2nd Edition, Cambridge University Press, 2011.

Online Resources

1. https://nptel.ac.in/courses/117101053
2. https://www.coursera.org/learn/information-theory
3. https://www.udemy.com/course/information-theory-and-error-control-coding/
4. https://online.stanford.edu/courses/ee276-information-theory
5. https://unacademy.com/lesson/introduction-to-information-theory-and-coding-itc/RC6XT5IP
6. https://www.cl.cam.ac.uk/teaching/0910/InfoTheory/InfoTheoryLectures.pdf

Course Code	Course Title	L	T	P	C
10212EC104	**RADAR AND ELECTRONIC NAVIGATION SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course Radar and Electronic Navigation Systems provides an introduction to radar systems and to acquire knowledge about various advanced electronic navigation systems.

c) Prerequisite

Nil

d) Related Courses

Optical and Microwave Communication Systems, Antenna Theory

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the principles and characteristics of basic radar systems and applications.	K2
CO2	Infer the principles of the MTI radar system, CW pulse doppler radar, and FMCW radar	K2
CO3	Discuss the principles of various tracking techniques and radar	K2
CO4	Summarize the characteristics of radar clutter and conventional navigational methods	K2
CO5	Illustrate the various advanced navigation techniques and systems	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO 12	PSO1	PSO2
CO1	M	M	M	L	L	-	L	-	L	-	-	-	L	-
CO2	M	M	L	M	-	L	-	L	-	L	-	L	-	-
CO3	M	M	L	L	L	-	L	-	-	-	L	-	-	L
CO4	M	M	M	L	L	L	-	L	H	M	L	-	-	-
CO5	M	M	M	H	M	-	L	-	-	L-	-	L	L	-

g) Course Content

UNIT I BASIC CONCEPTS AND RADAR EQUATIONS 9

Introduction to Radar – Radar equation – Radar Block diagram and Operation – Radar Frequencies – Millimeter and sub millimeter waves – Range performance of radars – System losses and propagation effects – Application of Radars.

UNIT II CW, FMCW AND MTI RADAR 9

Introduction to MTI and Doppler radar – Delay Line canceller – Moving Target Detector – Pulse Doppler Radar – CW Radar – FMCW – Radar Multiple or staggered Pulse Repetition frequencies – MTI radar Processor – Types of MTI – Airborne Radar.

UNIT III TRACKING RADAR 9

Tracking Radar and its types – Mono pulse Tracking – Conical scan and Sequential Lobbing - Low Angle Tracking – Synthetic Aperture Radar (SAR) – Tracking in range – Automatic tracking with surveillance Radar (ADT)

UNIT IV RADAR CLUTTER AND BASIC NAVIGATIONAL RADAR SYSTEM 9

Introduction to Radar Clutter – Surface clutter – Land Clutter – Sea Clutter and weather Clutter – Navigation: Introduction, Four Methods of navigation – Radio direction Finding – Types of Radar Antenna – Automatic directional finders – VHF Omni directional Range and VOR receiving equipment.

UNIT V ADVANCED NAVIGATIONAL SYSTEM 9

Hyperbolic system of Navigation – LORAN (Long Range Navigation) – Decca navigation system – DME (Distance Measurement Equipment) – TACAN (Tactical Air Navigation) – Navistar Global positioning system

Total: 45 Hrs

h) Learning Resources

Text Books

1. Skolnik,M., "Introduction to Radar Systems", 3rd Edition, Tata McGraw-Hill,2001.
2. GSN Raju, "Radar Engineering and Fundamentals of Navigational Aids" 2nd Edition, IK International Publishers,2008.
3. N. S. Nagaraju, "Elements of Electronic Navigation Systems", 2nd Edition, Tata McGraw-Hill, 2000.

Reference Books

1. Peyton Z. Peebles, "Radar Principles", JohnWiley, 2004.
2. J.CToomay, "Principles of Radar", 2nd Edition , PHI, 2004.
3. Nadow Levanon, "Radar Principles", John Wiley and Sons, 1989.
4. Brookener,"Radar Technology",Artech Hons,1986
5. Sen,A.K.& Bhattacharya,A.B."Radar System and Radar Aids to Navigation", Khanna Publishers, 1988.
6. Slater, J.M. Donnel, C.F.O and others, "Inertial Navigation Analysis and Design", McGraw-Hill Book Company, NewYork, 1964.

Online Resources

1. https://ocw.mit.edu/resources/res-ll-001-introduction-to-radar-systems
2. https://archive.nptel.ac.in/courses/108/105/108105154/
3. www.radartutorial.eu/index.en.html
4. https://pe.gatech.edu/courses/basic-radar-concepts

Course Code	Course Title	L	T	P	C
10212EC105	**SATELLITE COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the student to understand the necessity for satellite based communication, elements involved, transmission methodologies and different interferences, attenuation mechanisms affecting the satellite link design. And also the students get an idea of advances in satellite based navigation, GPS and the different application scenarios.

c) Prerequisite

Communication Systems

d) Related Courses

Cellular Mobile Communication

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts of orbit mechanics and satellite subsystem	K2
CO2	Infer the link design between the earth station and the satellite.	K2
CO3	Classify various access methods in the space segment and explain onboard processing.	K2
CO4	Illustrate direct broadcast satellite television, radio systems, and earth station technology.	K2
CO5	Discuss the services rendered by the satellite and its future applications	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	M	M	M	L	L	L	L	-	-	-	-	M	-
CO2	M	M	L	L	L	L	L	-	-	L	-	-	L	-
CO3	L	L	L	L	L	M	L	-	-	-	M	-	L	-
CO4	M	M	L	L	L -	M	L	-	-	-	L	-	M	-
CO5	M	L	L	L	L	M	L	-	-	-	L	-	M	-

g) Course Content

UNIT I INTRODUCTION TO SATELLITE COMMUNICATION 9

Orbital mechanisms: Origin and Brief History - Kepler's law & Newton's law, Orbital mechanics: Equation of Orbit- Geostationary Orbit- Location of Satellite in Orbit- Orbital Elements, Orbital perturbation, Look Angle determination, Satellite subsystems: Attitude and orbit control subsystem, power subsystem, telemetry tracking and command systems, communication subsystems

UNIT II SATELLITE LINK DESIGN 9

Basic transmission theory, Equivalent isotropic radiated power – Transmission losses – Free-space transmission – Feeder losses – Antenna misalignment losses – Fixed atmospheric and ionospheric losses – Link power budget equation, Downlink and uplink system design, Design of satellite links for specified C/N

UNIT III SATELLITE ACCESS 9

Analog – digital transmission system- Modulation and Multiplexing, Digital video Broadcast, Types of multiple access: FDMA concepts - Inter modulation and back off - SPADE system- TDMA concept- frame and burst structure - CDMA concept, Comparison of multiple access schemes, Satellite onboard processing

UNIT IV DIRECT BROADCAST SATELLITE TELEVISION AND RADIO 9

Introduction-C-Band and Ku-Band Home Satellite TV, Digital DBS TV, DBSTV System Design and Installation, Satellite Radio Broadcasting, Digital Video Broadcast (DVB) Standards, receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV. MATV,CATV, Transmit and Receive earth stations

UNIT V SATELLITE APPLICATIONS 9

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. Direct to home Broadcast (DTH), Digital audio broadcast (DAB)- World space services, Business TV(BTV), GRAMSAT, IRS satellites – PSLVs – GSLVs.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Dennis Roddy, "Satellite Communication", McGraw Hill, Fourth Edition, 2006
2. Pratt and Bostian, "Satellite communication", John Wiley and Sons, 2007

Reference Books

1. Tri. T. Ha, "Digital satellite communication system", McGraw Hill. 2017
2. Pritchend and Sciulli, "Satellite communication systems engineering", PHI Learning, 1986.
3. Robert M. Gagliendi, "Satellite communication", John Wiley and Sons, 1988.
4. M. Richharia, "Satellite communication system design and analysis", Mc-Millan, 1996

Online Resources

1. https://onlinecourses.nptel.ac.in/noc17_ec14
2. https://www.coursera.org/learn/satellite-communications
3. https://www.class-central.com/tag/satellite%20communications
4. https://ep.jhu.edu/programs-and-courses/525.440-satellite-communications-systems

Course Code	Course Title	L	T	P	C
10212EC106	**ADVANCED OPTICAL COMMUNICATION SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

To introduce the advances optical communication systems and coding techniques and understanding the concepts of optical network architecture and multiplexing along with Physical layer concepts.

c) Prerequisite

Nil

d) Related Courses

Optical and Microwave Communication Systems

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the concepts of optical transmission systems and principle.	K2
CO2	Discuss the coherent detection techniques.	K2
CO3	Illustrate the concepts of optical network architectures.	K2
CO4	Infer the concepts of optical TDM and soliton	K2
CO5	Interpret the physical layer concepts in optical communication	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	-	-	-	L	L	-	L	-	-	-	-	-
CO2	H	M	M	-	-	-	-	L	L	-	L	-	-	-
CO3	M	H	-	-	-	-	-	-	L	-	-	-	-	-
CO4	H	H	L	L	M	-	-	-	L	-	-	L	L	-
CO5	L	H	-	-	-	-	-	-	L	-	-	M	L	-

g) Course Content

UNIT I OPTICAL TRANSMISSION SYSTEM DESIGN PRINCIPLES 9

Noise sources-channel impairments and optical transmission system-design principles Advanced modulation formats- polarization multiplexing-constrained coding-Multilevel modulation schemes - Orthogonal frequency-division multiplexing-Polarization multiplexing, Constrained coding and Coherent detection.

UNIT II COHERENT SYSTEMS 9

Basic principles of Coherent detections – Practical constraints – Injection laser line width state of polarization, local oscillator power, fiber limitations; Modulation formats – ASK-FSK-PSK-DPSK and polarization shift keying (POL SK); Demodulation schemes – Homodyne, Heterodyne – Synchronous and Non synchronous detection-Comparison-Carrier recovery in Coherent detection.

UNIT III OPTICAL NETWORK ARCHITECTURES 9

Introduction: First Generation optical networks–SONET / SDH Network. Second Generation (WDM) Optical Networks: Broad Cast and select - wavelength routing architectures – Media – Access Control protocols.

UNIT IV OPTICAL TDM AND SOLITON 9

Optical Time division Multiplexing – Int Interleaving – Packet Interleaving – Multiplexer and Demultiplexers – AND Gates – Non-linear optical loop Mirror – Soliton – trapping AND Gate – Synchronization.

UNIT V PHYSICAL LAYER 9

Physical layer: optical communication phenomena – system and network – fiber and optical transmission – advanced fiber design (Inc. holey fiber) – dispersion effects and compensation – polarization effects (PMD) and compensation – nonlinearities in system design – high-bit-rate transmission systems-light wave systems and network

Total: 45 Hrs

h) Learning Resources

Text Books

1. G.P Aggrawal, "Fiber-Optic Communication Systems", Wiley-inter science,5th Edition, June 2021.
2. G. Keiser, "Optical Fiber Communication", Tata –McGraw Hill, 3rd edition, 2000.
3. John Gowar , "Optical communication system", PHI, 2nd edition,1993.

Reference Books

1. Max Ming-Kang Liu, "Principles and Applications of Optical Communication", Tata McGraw Hill Education Pvt., Ltd., New Delhi, 2010.
2. Le Ngyyen Binh, "Digital Optical Communications", CRC Press – Taylor and Francis Group – Indian reprint 2012.
3. Rajiv Ramaswami and Kumar N. Sivarajan, "Optical Networks: A Practical Perspective", Harcourt Asia Pte Ltd., Second Edition 2006.
4. P.E. Green, "Fiber Optic Networks", Prentice Hall, 1993.
5. Guu-Chang Yang ,"Prime Codes with Application to Optical and Wireless Networks" , Artech House, Inc., 2002.

Online Resources

1. https://nptel.ac.in/courses/117101002
2. https://ece.engineering.arizona.edu/grad-programs/courses/advanced-optical-communication-systems

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CourseCode	CourseTitle	L	T	P	C
10212EC107	**DIGITAL TV ENGINEERING**	**3**	**0**	**0**	**3**

a) CourseCategory

Programme Elective

b) Preamble

Television Technology has become a vital tool to the information revolution that is sweeping across the globe. This syllabus aims at a comprehensive coverage of Television Systems with all the latest developments in Television Engineering especially in the digital technology

c) Prerequisite

Nil

d) RelatedCourses

Communication Theory

e) CourseOutcomes

Upon the successful completion of the course, students will be able to

CONos.	CourseOutcomes	Knowledge Level (BasedonRevised Bloom's Taxonomy)
CO1	Explain digital TV transmission and reception, audio, and video processors.	K2
CO2	Discuss the various picture tubes such as camera tubes, cam coder, image orthicon, vidicon etc.	K2
CO3	Summarize the concepts of digital transmission and reception and Digital Video Broadcasting.	K2
CO4	Relate the elements of the digital TV system.	K2
CO5	Illustrate the high-definition TV standards and its Components.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	-	M	M	-	L	L	L	-	L	L	L	-
CO2	M	-	-	L	-	L	L	-	L	-	-	L	L	-
CO3	M	M	L	L	-	-	L	-	L	L	L	L	-	-
CO4	H	L	-	M	L	-	L	L	L	-	M	-	-	-
CO5	H	L	L	L	-	L	M	-	M	L	-	M	-	-

g) Course Content

UNIT I DIGITAL TELEVISION **9**

Analog to digital TV - Merits of Digital technology - Digital TV signals -Digitized video parameters - digital transmission and reception - codec Functions - codec MAA2100 -Video processor - MAA2300 - Audio processor - Performance Objectives for Digital Television: System noise - external noise sources - transmission errors - error vector magnitude - eye pattern - interference - co-channel interference - adjacent channel interference.

UNIT II TV CAMERA AND PICTURE TUBES **9**

Principle of camera tubes – camcorder - image orthicon- vidicon – plumbicon – solid state image scanners - elements of a picture tube - focusing and deflection – EHT - picture tube controls - Delta gun – PIL – Trinitron - color camera - picture tubes purity – convergence - automatic degaussing. Display Technologies - basic working of Plasma - LCD and LED Displays.

UNIT III DIGITAL TRANSMISSION AND RECEPTION **9**

Digital TV: Digitized Video, Source coding of Digitized Video - Compression of Frames - DCT based - (JPEG) - Compression of Moving Pictures (MPEG) - Basic blocks of MPEG2 and MPE4 - Digital Video Broadcasting (DVB). Modulation: QAM - (DVB-S, DVB-C), OFDM for Terrestrial Digital TV (DVB–T). Reception of Digital TV Signals (Cable, Satellite and terrestrial) - Digital TV over IP, Digital terrestrial TV for mobile.

UNIT IV ELEMENTS OF A DIGITAL TELEVISION SYSTEM 9

Television: Scanning - Blanking and synchronization - Picture signal - composite video signal- Vestigial sideband transmission - Principle of CCD Camera - Monochrome picture tube- Monochrome TV receivers - RF tuner, VHF tuner - Video amplifier - IF section - Vestigial sideband correction - Video detectors - Sound signal separation - AGC - sync separation- horizontal and vertical deflection circuits - EHT generation. Principle of color signal transmission and reception.

UNIT V HIGH DEFINITION TV 9

HDTV Standards & compatibility - colorimetric characteristics & parameters of HDTV LCD TVSystem - LCD Technology - LCD Matrix types & operations - LCD screen for TV. LCD color Receiver Plasma TVSystem: Plasma & conduction of charge - Plasma TV screen -Signal processing in Plasma TV - Plasma Colour Receiver Satellite TV - DTH Receiver System - CCTV – CATV - working of block converter- IR Remote control.

Total : 45 Hrs

h) Learning Resources

TextBooks

1. R.R. Gulati, "Modern Television Practice: Principles, Technology & Servicing Transmission, Reception and Applications", NewAgeInternational Publication, 4th revised edition, 2002
2. R.R. Gulati, "Monochrome And Colour Television", New Age International Publication, 3rd edition, 2002.

Reference Books

1. S.P. Bali, "Colour Television Theory and Practice", TMH, 2nd edition, 1994.
2. A.M. Dhake, "Television and Video Engineering",2nd Edition, - 16th Reprint, 2006

Online Resources

1. http://www.faadooengineers.com/online-study/post/ece/tv-engineering/409/digital-television

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Course Code	Course Title	L	T	P	C
10212EC108	**SOFTWARE DEFINED RADIO**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

With the rapid emergence of new standards and protocols in wireless communication, many functions of traditional radio receivers are being implemented in software. This course provides an overview of software defined radio systems and the technologies necessary for their successful implementation.

c) Prerequisite

Wireless Communication

d) Related Courses

NIL

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the benefits and challenges in software defined radio	K2
CO2	Illustrate the various functional blocks of software defined radio architecture.	K2
CO3	Interpret the various signal processing components in software architecture	K2
CO4	Infer the knowledge of wireless communication systems in software defined radio.	K2
CO5	Summarize the SDR concepts in various applications through case studies.	K2

f) Correlation of Cos with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	L	-	-	-	-	-	-	L	-	-	-	-
CO2	L	L	L	-	-	-	-	-	-	L	-	-	-	-
CO3	L	L	L	L	M	L	-	-	L	L	-	-	L	-
CO4	L	H	L	L	M	L	-	-	L	L	-	-	L	-
CO5	L	L	L	M	M	M	-	L	L	L	M	M	M	-

g) Course Content

UNIT I INTRODUCTION TO SOFTWARE DEFINED RADIO 9

Components of Software Defined Radio, Need, Characteristics and Benefits of a SDR, Challenges and issues for the implementation of SDR, Design Principles, Specific Architecture and standards for SDR, Technology Tradeoff

UNIT II FUNCTIONAL BLOCKS IN SDR ARCHITECTURE 9

RF Front end Topologies, Power Amplifier, Band pass Signal Generation, Parameters of Data converters, ADC and DAC architectures, Direct Digital synthesis, PLL, Digital Hardware Choices – DSPs, ASICs, and FPGAs.

UNIT III SIGNAL PROCESSING IN SDR 9

Digital Signal Processing techniques for SDR, Reconfigurable processors, Multirate signal Processing: Sample Rate Conversion, Digital Filter banks, Polyphase Filters, Quadrature Mirror Filters (QMF) – Theory and Application – Wavelet for multirate signal processing. Timing recovery in digital receivers

UNIT IV SDR FOR WIRELESS COMMUNICATION 9

Characteristics of SDR in terms of baseband processing, Pulse Shaping, Matched Filtering, Baseband Modulation, Synchronization, and Multicarrier Communication: OFDM Transceiver, FBMC transceiver. RF implementation issues, Noise and nonlinear PreDistortion.

UNIT V APPLICATIONS OF SDR 9

5G services, Evolution of Cognitive Radio, Smart Antennas, Beam forming and MIMO. Case studies - Wireless Information Transfer System, JTRS, Spectrum Ware, SDR-3000 digital transceiver subsystem.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Jeffrey H. Reed, "Software Radio: A Modern Approach to Radio Engineering" Pearson Education, 2002
2. Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinski, "Software-Defined Radio for Engineers", Artech House Publishers 2018.
3. Paul Burns, "Software Defined Radio for 3G", Artech House, 2002.

Reference Books

1 Ramesh Garg, "Analytical and Computational Methods in Electromagnetics" Artech House, 2008
2 J.H. Reed, Software-Defined Radio, Prentice-Hall, 2002

3 Ravender Goyal, "Monolithic MIC; Technology & Design", Artech House, 1989.
4 Robert Caverly, "CMOS RFIC Design Principles" Artech House, 2007.
5 P.Kennington, "RF and Baseband Techniques for Software Defined Radio," Artech House, 2005.
6 Robert M.Heath "Digital Communication, Physical Layer Exploration Lab using the NI USRP" National Technology and Science Press, 2012

Online Resources

1. http://morse.colorado.edu/sdr/
2. http://gnuradio.org/
3. http://openhpsdr.org/
4. https://nptel.ac.in/noc/courses/noc19/SEM1/noc19-ee22/
5. https://www.ni.com/de-de/innovations/white-papers/14/overview-of-the-ni-usrp-rio-software-defined-radio.html

Course Code	Course Title	L	T	P	C
10212EC201	**ELECTROMAGNETIC INTERFERENCE AND COMPATIBILITY**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides basic information on the different electromagnetic Interference problems occurring in Intersystem, their possible mitigation techniques in Electronic design, also to understand EMI sources, EMI problems, their solutions at PCB level, as well as to understand sub system level design and to measure the emission, immunity level from different systems to couple with the prescribed EMC standards.

c) Prerequisite

Electromagnetics and Transmission Lines

d) Related Courses

NIL

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basics of EMI/EMC and types of interference	K2
CO2	Discuss different types of EM coupling and their principles	K2
CO3	Infer the electromagnetic interference susceptibility and immunity techniques.	K2
CO4	Summarize various EM compatibility issues in the PCB design process	K2
CO5	Interpret various EM measurement techniques and universal standards	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	L	L	L	-	L	-	-	-	-	-	-
CO2	H	M	M	M	L	L	-	M	-	-	-	-	-	-
CO3	M	M	L	M	L	-	L	L	-	L	L	-	L	-
CO4	M	H	M	M	L	-	L	M	L	-	L	L	L	-
CO5	M	M	M	L	M	L	-	L	L	L	-	L	L	-

g) Course Content

UNITI EMI/EMC CONCEPTS 6

EMI-EMC definitions and Units of Parameters; Sources and Victim of EMI; Conducted and Radiated EMI Emission and Susceptibility; Transient EMI, ESD; Radiation Hazards.

UNITII EMI COUPLING PRINCIPLES 6

Conducted, Radiated and Transient coupling; Common ground impedance coupling; Common mode and Ground loop coupling; Differential mode coupling; Near field cable to Cable coupling, Cross talk; Field to Cable coupling; Power mains and Power supply coupling.

UNITIII EMI CONTROL TECHNIQUES 6

Shielding Material- Characteristics of Filters-Impedance and Lumped element filters-Filter installation and Evaluation; Grounding, Bonding, Isolation transformer, Transient suppressors, EMC Gaskets.

UNITIV EMC DESIGN OF PCBS 6

EMI Suppression Cables-Devices-Transient protection hybrid circuits; PCB Trace impedance; Routing; - Electromagnetic Pulse-Noise from Relays and Switches, Power distribution decoupling; Zoning; Grounding; Vias connection; Terminations.

UNITV EMI MEASUREMENTS AND STANDARDS 6

Open area test site; TEM cell; EMI Test Shielded chamber and Shielded Ferrite Line anechoic chamber; Tx/Rx Antennas, Sensors, Injectors / Couplers, and Coupling factors; EMI Rx and Spectrum analyzer; Civilian Standards-CISPR,FCC, IEC, EN; Military Standards –Frequency Allocation and Spectrum Utilization comparisons.

Total : 30 hrs

List of Experiments

S. No	Practical Exercises (30 Hours)	COs
1.	Concept of Self-Induction Board	CO1
2.	Concept of Lenz Law	CO1
3.	EMI effects on Co-axial Cable	CO2,CO3
4.	Concept of Cross Talk Basic Phenomena	CO2,CO4
5.	EMI effects on Cross Talk problem	CO2,CO4
6.	EMI effects on Inductance and Capacitance with various VIAs and Terminations	CO4
7.	EMI effects on Inductance and Capacitance with Radial and SMD components	CO4
8.	EMI effects on Ground Bounce for Symmetric IC Power Pins	CO4
9.	EMI effects on Ground Bounce with Difference Between Symmetric and Asymmetric IC Power Pins	CO4
10.	Study of EMI test chambers	CO5

Total 60 Hours

h) Learning Resources

Text Books

1. V.P.Kodali, Engineering EMC Principles, Measurements and Technologies, 2nd Ed., IEEE Press, 1996.
2. Henry W Ott, Noise Reduction Techniques in Electronic Systems, 2nd Ed., Wiley Inter Science, 1998.

Reference Books

1. Bemhard Keiser, principles of Electromagnetic Compatibility, 2rd Ed., Artech House, 1996.
2. C R Paul, Introduction to Electromagnetic Compatibility, 2nd Ed., Wiley and Sons, 1998.

Online Resources

1. http://www.metlabs.com/blog/emc/electromagnetic-compatibility-compliance-engineers-use-these-emc-resources/
2. http://www.intertek.com/emc/

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Course Code	Course Title	L	T	P	C
10212EC202	**MIMO WIRELESS COMMUNICATION**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course covers the fundamentals of Multiple Input Multiple Output (MIMO) antenna based wireless communication systems. With multiple antennas at the transmitter and receiver it helps to design wireless communication systems that can be used with additional spatial dimensions over and above the well investigated time frequency dimensions.

c) Prerequisite

Nil

d) Related Courses

Communication Systems

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the diversity involved in MIMO fading Channel model with error/outage probability and power allocation	K2
CO2	Interpret the capacity of deterministic and random, non-coherent MIMO fading channels	K2
CO3	Discuss the different space-time coding techniques and BLAST architectures for multiple antenna systems.	K2
CO4	Summarize the various algorithms for the MIMO detection techniques.	K2
CO5	Infer the advances of MIMO communication systems.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	M	M	L	L	M	L	L	L	M	L	-	L	L	-
CO2	M	M	L	L	M	-	L	L	M	M	-	M	-	-
CO3	M	M	L	L	H	-	-	L	M	L	-	M	-	-
CO4	M	M	M	L	H	-	-	L	H	L	-	M	-	-
CO5	M	M	M	L	H	L	-	L	L	L	M	M	L	-

g) Course Content

UNIT I MIMO CHANNEL MODELS 6

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, Error/Outage probability over fading channels.

UNIT II MIMO CHANNEL CAPACITY 6

Capacity and Information rates of AWGN and fading channels, deterministic, random MIMO channels, independent identically distributed channels, separately correlated Rayleigh fading MIMO channels, Capacity of non-coherent MIMO channels, keyhole Rayleigh fading MIMO channel

UNIT III SPACE-TIME BLOCK AND TRELLIS CODES 6

Alamouti scheme: Transmission scheme-Optimal receiver for Alamouti scheme, Performance analysis of Alamouti scheme. Orthogonal space-time block codes: Linear orthogonal design-Decoding of linear orthogonal design- Performance analysis of Space-time block codes. Space-time trellis codes: Performance analysis for Space-time trellis codes.

UNIT IV MIMO DETECTION TECHNIQUES 6

Maximum Likelihood, Zero Forcing, Minimum Mean Square Error, Successive Interference Cancellation, Lattice Reduction based detection, Iterative Decoding: Turbo coded modulation for MIMO channel.

UNIT V ADVANCED MIMO SYSTEM 6

Spatial modulation, MIMO based cooperative communication and cognitive radio, multiuser MIMO, cognitive-femtocells and large MIMO systems for 5G wireless, Wi-Fi, Multiuser and Hybrid beamforming in Massive MIMO**.**

List of Experiments

S. No	Practical Exercises (30 Hours)	CO's
1	Simulate MIMO channel and estimate BER and SNR	CO1
2	Performance analysis of 2 x 2 MIMO system using different modulation techniques	CO1
3	Design OFDM System with 2x2 MIMO System.	CO1
4.	Performance analysis of 2 x 2 MIMO system using separately correlated Rayleigh fading MIMO channels	CO2
5.	Analyze the capacity of MIMO channel with n transmit and Receive antennas	CO2
6.	Performance analysis of 2 x 2 MIMO system using different space time coding techniques.	CO3
7	Performance analysis of 2 x 2 MIMO system using different space time coding techniques with V-Blast detection algorithm	CO3
8	Performance analysis of 2 x 2 MIMO system using different modulation techniques with ML detection algorithms in uncorrelated channel conditions	CO4
9	Performance analysis of 2 x 2 MIMO system using Iterative Decoding	CO4
10	simulation for lattice reduction algorithms used for MIMO detection	CO4
11	Simulation of Bemforming for a MIMO OFDM system.	CO5
12	Simulation of Massive MIMO system for 5G applications	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Tolga M.Duman and Ali Ghrayeb, "Coding for MIMO Communication Systems", John Wiley & Sons Ltd.,2007.

2. EzioBiglieri, Robert Calderbank and Anthony Constantinides. "MIMO Wireless Communications" Cambridge University Press,2007.

3. R. S. Kshetrimayum, "Fundamentals of MIMO Wireless Communications", Cambridge University Press, 2017

Reference Books

1. B. Kumbhani and R. S. Kshetrimayum, "MIMO Wireless Communications over Generalized Fading Channels", CRC Press, 2017
2. T. L. Marze_a, E. G. Larsson, H. Yang and H. Q. Ngo, "Fundamentals of Massive MIMO", Cambridge University Press, 2016

Online Resources

1. http://nptel.ac.in/courses/117105132

Course Code	Course Title	L	T	P	C
10212EC203	**ANTENNA DESIGN AND APPLICATION**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides detailed concepts on antennas and arrays. And also the students will be able to understand the design principles involves in modeling modern antennas for industrial scientific and medical applications.

c) Prerequisite

Antenna Theory

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the physical concept of loop antennas.	K2
CO2	Classify the design concepts in antenna arrays and beamforming antennas.	K2
CO3	Identify the various feeding techniques of microstrip patch antennas and their types.	K3
CO4	Discuss the various printed antennas and metamaterials used in modern applications.	K2
CO5	Compare the various applications of SIW, RFID, and RNSS antennas.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	H	H	H	H	-	-	M	M	L	L	M	L	-
CO2	M	L	H	L	L	-	-	-	L	-	-	L	-	-
CO3	L	M	H	L	L	-	L	L	M	L	L	L	M	-
CO4	L	M	H	H	H	-	L	L	M	L	-	M	M	-
CO5	H	L	-	-	L	L	M	M	-	-	-	-	-	-

g) Course Content

UNIT I LOOP ANTENNAS 6

Small Circular Loop - Circular Loop of Constant Current - Circular Loop with Nonuniform Current - Ground and Earth Curvature Effects for Circular Loops - Polygonal Loop Antennas - Ferrite Loop - Mobile Communication Systems Applications.

UNIT II ANTENNAS ARRAYS 6

Array pattern synthesis, Fourier series method, Chebyshev arrays, super directive arrays - Feed networks for arrays - Butler Matrix, Parasitic Arrays - Phased Arrays - retrodirective arrays - adaptive arrays

UNIT III MICROSTRIP ANTENNA 6

MSA: Basic characteristics, Feeding methods, method of analysis – Design of rectangular and circular patch antenna – Tapered slot antennas – Leaky wave structures – elliptically polarized antennas.

UNIT IV MODERN PRINTED ANTENNAS AND MATERIALS 6

Broadband antennas - Antenna design - Meta materials- Electromagnetic band gap – Artificial Magnetic surface – Frequency selective surface – Photonic band gap – Fractal antennas.

UNIT V APPLICATIONS 6

SIW Micro strip antennas for RADAR applications – UWB antenna for surface and Ground penetrating radars – RFID antenna: Working principles, Frequency band and its Design –Radio navigation satellite system antenna: Frequency bands – IoT antennas.

LIST OF EXPERIMENTS

S. No.	Practical Exercise (30 Hours)	Cos
1.	Design and simulate circular loop antenna using HFSS	CO1
2.	Design of Broad Side and End fire array antennas using HFSS	CO2
3.	Analyze MUSIC AoA estimation algorithm using MATLAB	CO2
4.	Analyze various feeding methods using HFSS	CO3
5.	Design of Microstrip patch antenna for mobile applications	CO3
6.	Design of Rectangular Patch antenna using HFSS	CO3
7.	Design of Circular Patch antenna using HFSS	CO3
8.	Design of frequency selective surface structure using HFSS	CO4
9.	Design of Artificial magnetic conductor surface structure using HFSS	CO4
10.	Design and develop an antenna to receive AM radio	CO4
11.	Design and develop an antenna to receive FM radio	CO4
12.	Design Yagi-Uda Antenna at very high frequency band	CO4
13.	Design of sierpinski gasket monopole antenna using HFSS	CO4
14.	Design of substrate integrated waveguide for a given operating frequency using HFSS	CO5
15.	Design of SIW based leaky wave Antenna using HFSS	CO5
16.	Design of SIW based H-Plane Horn Antenna using HFSS	CO5

Total: 60 Hours

h) Learning Resources

Text Books

1. Constantine A. Balanis, "Antenna Theory: Analysis and Design", 4th Ed., Wiley, 2016.
2. Collin, Robert E. "Antennas and radio wave propagation",1st Ed., McGraw-Hill, 1985.
3. Thomas A. Milligan, "Modern Antenna Design", 2nd Ed., Wiley, 2005.

Reference Books

1. Anil Pandey "Practical Microstrip and Printed Antenna Design" Artech House, 2019.
2. Douglas H. Werner, "Broadband Metamaterials in Electromagnetics: Technology and Applications", 1st Ed, Jenny Stanford Publishing, 2017.
3. Frank Gross, Smart Antennas for Wireless Communications, McGraw-Hill Education - Europe, ISBN 9780071447898, 2005
4. Xiaodong Chen, Clive G. Parini, Brian Collins, Yuan Yao, Masood Ur Rehman, Antennas for Global Navigation Satellite Systems, Wiley April 2012

Online Resources

1. https://asu.pure.elsevier.com/en/publications/introduction-to-smart-antennas

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Course Code	Course Title	L	T	P	C
10212EC196	**ELECTRONIC WARFARE RADAR ANTENNA SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course covers the principles, techniques and advancements in radar and antenna for Electronic Warefare (EW) systems including target detection, tracking, signal processing, stealth and spectrum management. It helps learners with the skills to understand the concepts and design principles of EW radar and antenna systems in defence and tactical operations.

c) Prerequisite

Nil

d) Related Courses

Antenna Theory, Radar and Electronic Navigation Systems, Optical and Microwave Communication Systems

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the fundamentals of conventional radar systems and their role in EW systems.	K2
CO2	Explain the principles of surveillance and tracking radars employed in EW systems.	K2
CO3	Interpret the advanced radar systems used for the detection and tracking of objects.	K2
CO4	Infer the principles of EW antennas and their applications in electronic warfare systems and signal intelligence.	K2
CO5	Outline the concept and design principles of modern antennas in electronic warfare systems.	K2

f) Correlation of COs, POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	M	L	L	L	-	L	-	-	-	L	-
CO2	M	M	L	M	-	L	L	-	L	-	L	-	-
CO3	M	M	L	L	L	L	-	-	-	L	-	-	L
CO4	M	M	M	L	L	L	L	H	M	L	-	-	-
CO5	M	M	M	H	M	L	-	-	L	-	L	L	-

g) Course Content

UNIT I BASICS OF RADAR AND EW SYSTEMS 9

Fundamentals of radar: Basic T/R module, range performance, Radar Cross Section(RCS) of targets - Radar detection: Bayes's concept and detection of multiple targets - Stealth target detection: early warning systems, detection and classification - Doppler radar transmitter and receiver operation, MTI and Pulse Doppler Radar- Radar performance in EW systems:ECM, ESM, ECCM.

UNIT II SURVEILLANCE AND TRACKING RADAR FOR EW SYSTEMS 9

Ground moving target radar - synthetic aperture radar- miniaturized radars for surveillance and imaging - Electronic scanning - angle measurement and tracking by conical scan and monopulse radar - Moving Target Tracking (MTT) - Synthetic Aperture Radar (SAR) imaging - Coherent Change Detection (CCD) and synthetic monopulse.

UNIT III ADVANCED RADAR SYSTEMS 9

Low Probability of Intercept (LPl) Radars: LPI radar concepts, LPI early warning systems, detection and avoidance techniques - Quantum Radar: detection and tracking of stealth targets - Cognitive Radar: radar signal processing and adaptive waveform - Foliage Penetration Radar: detection of objects, vehicle and other objects inside foliage.

UNIT IV EW ANTENNAS 9

Broadband blade monopole and dipole antennas: structure and working, design techniques and applications in monitoring and direction finding systems - HF DF loop array active antenna - Active VHF/UHF Antenna: concept, performance metrics- Polarization agile sinuous antenna: principles, applications in electronic warfare and signal intelligence.

UNIT V MODERN ANTENNAS FOR EW SYSTEMS 9

Metamaterial (MM) based antenna: design principle and advanced concepts, MM antenna for RCS reduction - Shared Aperture Antenna: array configurations and beamforming techniques- Reflect Array antennas - multiband antenna and reconfigurable antenna for multifunction radars.

Total: 45 Hours

h) Learning Resources

Text Books

1. Electronic Warfare and Radar Systems Engineering Handbook, Naval Air Warfare Center Weapons Division, CA, Fourth Edition, 2013.
2. Antenna Systems and Electronic Warfare Applications.Edited by Richard A. Poisel, Artech House, 2012.
3. Skolnik,M., Introduction to Radar Systems, 3rd Edition, Tata McGraw-Hill, 2001.

Reference Books

1. Peyton Z. Peebles, “Radar Principles", John Wiley, 2004.
2. Mark E. Davis, Ultra-Wideband Surveillance Radar (Radar, Sonar and Navigation), Institution of Engineering and Technology, 2021.
3. Brookener, Radar Technology,Artech Hons,1986

Online Resources

1. https://ocw.mit.edu/resources/res-ll-001-introduction-to-radar-systems
2. https://archive.nptel.ac.in/courses/108/105/108105154/ - Principles and Techniques of Modern Radar Systems
3. www.radartutorial.eu/index.en.html
4. https://pe.gatech.edu/courses/basic-radar-concepts

Course Code	Course Title	L	T	P	C
10212EC109	**EMBEDDED SYSTEM DESIGN**	**3**	**0**	**0**	**3**

a) Course Category:
Programme Elective

b) Preamble:
The objective is to impart the concepts and architecture of embedded systems and to make the students capable of designing embedded systems. The course examines contemporary issues and problems in the design, development, and test of contemporary real-time embedded systems while emphasizing solid design practices to ensure safety and reliability.

c) Prerequisite Courses:
Microprocessor & Microcontroller

d) Related Courses:
Nil

e) Course Outcomes:
Upon the successful completion of the course, students will be able to:

CO Nos	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the functional blocks of an embedded system and its software development processes.	K2
CO2	Relate the safety, security, reliability, and robust design of an embedded system	K2
CO3	Outline the embedded system design failure analysis.	K2
CO4	Summarize the embedded system design life cycle models.	K2
CO5	Infer the co synthesis, co- simulation and co-verification process.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	L	H	-	-	-	L	L	L	M	L	M
CO2	L	M	H	L	M	-	-	-	M	L	-	M	-	-
CO3	-	L	-	M	-	H	-	-	-	L	-	-	M	L
CO4	L	M	H	-	-	-	-	-	-	L	-	-	M	-
CO5	-	-	M	-	H	-	-	-	-	L	-	M	M	L

g) Course Content:

UNIT-I FUNDAMENTALS OF EMBEDDED SYSTEM 9

Overview of Embedded System– Processor-Memory-Peripherals- Software-Algorithms-Microcontroller-Microprocessor based – Board based.
Compilation Process in Embedded System –Compiling code-preprocessor-compilation, linking and Loading-Symbols, references and relocation-linker/loader.
Debugging Techniques: High Level language simulation – low level simulation – onboard debugger – task level debugging – symbolic Debug-Emulation.

UNIT-II SAFETY, SECURITY, RELIABILITY, AND ROBUST DESIGN 9

Safety- Reliability- Faults, Errors, and Failures- Safe, Secure, and Robust Designs- System Functional Level Considerations- System Architecture Level Considerations- Busses – The Subsystem Interconnect- Data and Control Faults – Data Boundary Values- Data and Control Faults – The Communications Subsystem

UNIT-III FAILURE ANALYSIS 9

The Power Subsystem- Peripheral Devices – Built-In Self-Test (BIST)- Failure Modes and Effects Analysis- Understanding The Problem – Analyzing the Problem – Looking At Potential Vulnerabilities- Looking At The Attacks- Protecting Against The Attacks**.**

UNIT-IV LIFE-CYCLE MODELS 9

Waterfall Model- V Cycle Model- Spiral Model- Rapid Prototyping Incremental- Problem Solving Six Steps to Design- Traditional Embedded Systems Development- Co-Design Process.

UNIT-V CO-SYNTHESIS, SIMULATION AND VERIFICATION 9

Co-Synthesis: Software Synthesis –System Characterization, Scheduling and Synthesis methods, Analyzing the System Design – Static and Dynamic analysis

Co-Simulation: Types of Simulations, Approaches –detailed processor model, Bus model, compiled model, hardware model, master slave model and distributed Co simulation

Co-verification: Hardware Software Co-verification, Tools supporting and verification, capitalization and reuse, requirements traceability and management and Archiving the project.

Total-45 Hours

h) Learning Resources:

Text Books:

1.Steve Heath "Embedded Systems Design" Second Edition, Elsevier. 2022.

2.James K.Precol, "Embedded Systems-A Contemporary Design Tool", John Wiley & Sons, Inc-2008.

Reference Books:

1.Frank Vahid & Tony Givargis, "Embedded System Design-A Unified Hardware/Software

Introduction", Third Edition, John Wiley & Sons Inc., Reprint 2010.

2. Michael Barr & Anthony Massa, "Programming Embedded Systems-with C & GNU Development tools", Second Edition, O'REILLY, Reprint-2007.

3. Arnold S.Berger, "Embedded Systems Design", CMP Books,2002

4. David E.Simon "An Embedded Software primer" Pearson Publication,2005.

Online Resources:

1.https://www.youtube.com/watch?v=4CPIjYGIYqc

2.https://www.youtube.com/watch?v=y70V0qHAFNQ

3.https://www.youtube.com/watch?v=yAOfqK1kQso

Course Code	Course Title	L	T	P	C
10212EC110	**ROBOTICS AND ITS APPLICATIONS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The course provides introduction to robotics architecture and components as embedded system, sensors, actuators, kinematics of robotics also applications of robotics. It also provides an overview into control, dynamics of robots and its use in automation

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the functional elements of Robotics	K2
CO2	Compare the types of sensors and actuators.	K2
CO3	Relate the kinematics, movement and joints of robots	K2
CO4	Interpret Robot Programming and Robot Controllers	K2
CO5	Summarize various types of robot application	K2

f) **Correlation of COs with POs and PSOs**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	-	M	-	L	L	-	-	-	-	-	-	-
CO2	M	M	M	-	L	-	-	-	L	-	-	-	-	-
CO3	L	L	M	-	M	L	L	L	-	L	L	-	L	-
CO4	L	M	M	-	-	L	L	-	-	-	-	-	-	-
CO5	L	M	M	-	-	-	-	-	L	-	-	L	L	-

g) Course Content

UNIT I FUNDAMENTALS OF ROBOTICS 9

Brief history-Types of Robots–Technology-Robot classifications and specifications , Evolution of robotics ,Design and control issues, Cartesian, Cylindrical, Spherical Work Envelope, Types of joints, Prismatic, Revolute, Ball and socket, Number of Axes, Degree of freedom, Joint variables, Grippers - Mechanical Grippers, Pneumatic and Hydraulic Grippers, Magnetic Grippers, Vacuum Grippers

UNIT II SENSORS AND ACTUATORS 10

Sensors:
Measurement characteristics: Range, response time, Accuracy, Precision, Sensitivity, resolution, linearity, error, Dead time, costs and uncertainty. Position and Odometry Sensors. Beacons and Range Sensors: Doppler Sensors, Haptic sensors. Touch Screen/ Touch Panel.
Actuators:
Solenoids, DC motor, AC motor, Servomotors, Stepper motor, BLDC Motors, speed control, Pulse width modulation (PWM) frequency drive, Pneumatics & Hydraulic Systems, directional & pressure control valves, Drive mechanisms: Lead screw, Ball screw, Chain linkage, belt drive and gear drives

UNIT III ROBOT KINEMATICS **9**

Robot anatomy, Design and control issues, Manipulation and Control. Direct Kinematic Model - Denavit-Hartenberg Notation, Kinematic Relationship between adjacent links, Manipulator Transformation Matrix; Inverse Kinematic Model

UNIT IV ROBOT PROGRAMMING & ROBOT CONTROLLERS **9**

Robot Programming & Robot Controllers: Teach-in, Teach-Through, High-Level languages –

robot talk, programming methods, Software speedup, Robot Controllers – essential components, joint actuation and Sensing, Overload, over current and stall detection methods, Position, Speed, Direction Sensing. Programming Language: Variable Assembly Language (VAL), RAIL, A Manufacturing Language (AML).

UNIT V APPLICATIONS OF ROBOTICS **8**

Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications, Mobile robots, walking devices, Robot reasoning.

Total:45 Hrs

h) Learning Resources:

Text Books

1. Thomas Bräunl, "Embedded Robotics: Mobile Robot Design and Applications with Embedded Systems", Third Edition, Springer-Verlag Berlin Heidelberg, 2008.
2. Mikell P. Groover, "Industrial Robotics", McGraw Hill, 2nd edition, 2012

Reference Books

1.K.S. Fu, R.C. Gonzalez and C.S.G. Lee, "Robotics: Control, Sensing, Vision, and Intelligence", McGraw-Hill, New York, 1987.
2. Fu,K.S. ,et al "Robotics- Control, Sensing, Vision and Intelligence ", McGraw – Hill. Inc., Singapore,1987.
3. H.R.Everett, "Sensors for Mobile Robots – Theory and Applications", A.K.Peteres Ltd. 1995.
4. Yorem Koren, "Robotics for Engineers", McGraw-Hill Book Co., 1992.
5.Groover M.P et al., "Industrial Robotics – Technology, Programming & Applications", McGraw-Hill. 1986.

Online Resources:

1. https://www.youtube.com/watch?v=P_PP76flZfw&list=PLyqSpQzTE6M_XM9cvjLLO_Azt1FkgPhpH&index=2
2. https://www.coursera.org/learn/robotics-flight
3. https://robotacademy.net.au/masterclass/introduction-to-robotics/

Course Code	Course Title	L	T	P	C
10212EC111	EMBEDDED COMMUNICATION PROTOCOLS	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course introduces the embedded communication protocol.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, student will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Compare the serial and parallel communication protocol to embedded networking.	K2
CO2	Explain USB Bus for embedded systems.	K2
CO3	Illustrate the CAN Bus for embedded systems.	K2
CO4	Outline the concepts of Ethernet communication.	K2
CO5	Summarize Ethernet communication to embedded applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	L	-	-	-	-	-	-	-	-	M	-	L
CO2	L	L	L	-	-	-	-	-	-	-	-	H	-	L
CO3	L	L	L	-	-	-	-	-	-	-	-	H	-	L
CO4	L	L	L	-	-	-	-	-	-	-	-	H	-	L
CO5	M	M	M	-	H	-	-	-	-	-	-	H	H	H

g) Course Content

UNIT I SERIAL AND PARALLEL COMMUNICATION 9

Communication Basics, Serial/Parallel communication: Serial communication protocols – RS232, Synchronous Serial Protocols: Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), PC Parallel port communication: ISA/PCI Bus protocols.

UNIT II USB BUS 9

Introduction to USB – Bus components – USB communication model and framework – Physical and signalling environment – USB Transfer types – USB transactions – error recovery –USB device configuration.

UNIT III CAN BUS 9

Introduction to CAN bus – CAN standard – CAN controller and bus adapter – device drivers – interaction layer – Protocol Stack implementation and Configuration – CANopen architecture and standards.

UNIT IV ETHERNET BASICS 9

Elements of a network – Inside Ethernet – Building a Network: Hardware options – Cables, Connections and network speed – Design choices: Selecting components –Ethernet Controllers – Using the internet in local and internet communications – Inside the Internet protocol.

UNIT V EMBEDDED ETHERNET 9

Exchanging messages using UDP and TCP, Serving web pages with Dynamic Data, Serving web pages that respond to user Input , Email for Embedded Systems, Using FTP, Keeping Devices and Network secure.

Total 45 Hours

h) Learning Resources

Text Books

1. Frank Vahid, Givargis, "Embedded Systems Design: A Unified Hardware / Software Introduction", Wiley Publications, 2006.
2. Don Anderson, "Universal Serial Bus System Architecture", Addison Wesley, 2007.
3. M.Natale, A.Ghosal, "Understanding the CAN Communication Protocol", Springer, 2012.
4. Jan Axelson, "Embedded Ethernet and Internet Complete", Lakeview Research Publisher, 2003.

Reference Books

1. Jan Axelson, "USB Complete", Lakeview Research Publisher, 2015.
2. Edward Insam, "TCP/IP Embedded Internet Applications", Newnes Publication, 2003.
3. D.Paret, "Multiplexed Networks for Embedded Systems", Wiley Publications, 2007.

Online Resources

1. www.nptel.ac.in/courses/108105057
2. https://www.seeedstudio.com/blog/2019/07/03/basic-electronics-wired-communication-protocols-in-embedded-design/
3. https://www.gadgetronicx.com/popular-communication-protocols-embedded-systems/

Course Code	Course Title	L	T	P	C
10212EC112	**VIDEO ANALYTICS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course delivers camera classification, hardware, video management system, and video networking and CCTV systems

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Compare the types of camera used in indoor and outdoor surveillance system.	K2
CO2	Illustrate the camera selection step by step process and camera hardware setup with foreground extraction.	K2
CO3	Explain video management system of video analytics, trouble shooting, recording, storage and video analytic security.	K2
CO4	Outline the video networking concepts, delivery methods and trouble shooting.	K2
CO5	Summarize CCTV characteristics, components and case study of ATM and vehicle parking system with case study.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	H	-	L	-	-	-	-	-	-	-	L	L	M	M
CO 2	M	L	L	-	L	-	L	M	-	-	-	-	-	L
CO 3	M	L	L	M	M	L	-	-	-	-	L	L	L	-
CO 4	M	L	-	-	L	L	-	-	-	-	-	M	M	-
CO 5	M	M	L	-	L	-	-	-	-	-	-	-	M	M

g) Course Content

UNIT I CAMERA CLASSIFICATION 9

Introduction, Analog camera, Digital Camera, Wired Camera, Wireless camera, HD Camera, IP/Network Cameras, Indoor/Outdoor Cameras, Pan/Tilt/Zoom Cameras and smart cameras.

UNIT II DIGITAL VIDEO HARDWARE AND FOREGROUND EXTRACTION 9

Evolution of Video Surveillance Hardware, selection of Right Cameras, PTZ Protocols and Communications, Two-Way Audio, Configuring and Commissioning Digital Video Encoders, Digital Video Cables and Connectors. Foreground Extraction- Background estimation, Averaging, Gaussian Mixture Model, Optical Flow based, Image Segmentation.

UNIT III VIDEO MANAGEMENT SYSTEMS (VMS) AND SECURITY 9

Introduction to VMS, Dual VMS, Video Analytics, Troubleshooting VMS Requirements, Portable Observation Device (POD), Edge Recording, storage and Security. Video Analytics for Security - Abandoned object detection, human behavioral analysis, human action recognition, perimeter security.

UNIT IV VIDEO NETWORKING 9

Introduction, Power of the Network, Networked Video Delivery Methods, Interference, Line of Sight (LOS), Wireless Mesh Networking.

UNIT V CLOSED-CIRCUIT TELEVISION (CCTV) SYSTEMS 9

Characteristics of CCTV System Design, Components of CCTV, CCTV system design, case studies of ATM and Vehicle parking system. Video Analytics for Traffic Monitoring and Assistance – Case Study.

Total:45 Hours

h) Learning Resources

Text Books

1. Anthony Caputo,"Digital Video Surveillance and Security IInd edition" , Elsevier 2014
2. Q. Huihuan, X. Wu, Y. Xu, "Intelligent Surveillance Systems", Springer Publication, 2011.

Reference Books

1. Murat A. Tekalp, "Digital Video Processing", Prentice Hall, 1995.
2. Graeme A. Jones , Nikos Paragios, Carlo S. Regazzoni, 'Video-Based Surveillance Systems: Computer Vision and Distributed Processing', Kluwer academic publisher, 2001
3. Nilanjan Dey, Amira Ashour and Suvojit Acharjee, 'Applied Video Processing in Surveillance and Monitoring Systems', IGI global 2016.
4. Zhihao Chen, Ye Yang, Jingyu Xue, Liping Ye, Feng Guo, 'The Next Generation of Video Surveillance and Video Analytics: The Unified Intelligent Video Analytics Suite', Create Space Independent Publishing Platform, 2014

Online Resources

1. https://www.businessnewsdaily.com/9067-choosing-a-surveillance-system.html
2. https://blog.koorsen.com/what-is-a-video-surveillance-system
3. https://www.youtube.com/watch?v=AQ1EPl_4O2w
4. https://www.youtube.com/watch?v=mhrRjgzRfh0

Course Code	Course Title	L	T	P	C
10212EC113	**WEARABLE DEVICES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces students to the exciting field of wearable devices, exploring the design, development, and applications of wearable technology. Students will learn about different types of wearable sensors, their integration into wearable devices, and their role in various industry sectors. The course will cover topics such as wearable inertial sensors, wearable devices for healthcare, other wearable sensors, and the scope of wearable technology in modern applications.

c) Prerequisite

Nil

d) Related Courses

Linear Integrated Circuits

e) Course Outcomes

On successful completion of this course, students will be able to gain knowledge about various types of sensors and their real time applications.

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the emergence of wearable computing and wearable electronics, and their integration into daily life and diverse sectors.	K2
CO2	Compare the various types of wearable sensors and their applications and utilization of wearable.	K2
CO3	Relate the biomedical wearables for healthcare measurements and physical activity monitoring.	K2
CO4	Illustrate the wearable devices with GPS integration and optical sensors for tracking, navigation, and environmental monitoring.	K2
CO5	Summarize the social aspects, challenges, and future trends in wearable technology.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	-	-	-	-	M	-	-	-	L	L	M	L
CO2	M	L	M	L	L	-	-	L	-	-	-	L	M	L
CO3	M	L	-	M	-	-	L	-	L	L	-	-	L	L
CO4	M	L	L	M	M	-	-	L	L	L	-	-	M	L
CO5	M	L	M	M	M	-	-	L	-	-	-	L	M	L

g) Course Content

UNIT I INTRODUCTION TO WEARABLE DEVICES 9

Motivation for development of Wearable Devices, The emergence of wearable computing and wearable electronics, Types of wearable sensors: Invasive, Non-invasive; Intelligent clothing, Industry sectors' overview – sports, healthcare, Fashion and entertainment, military, environment monitoring, mining industry, public sector, and safety

UNIT II INERTIAL SENSORS AND APPLICATIONS 9

Wearable Inertial Sensors - Accelerometers, Gyroscopic sensors, and Magnetic sensors; Modality of Measurement- Wearable Sensors, Invisible Sensors, In-Shoe Force and Pressure Measurement; Applications: Fall Risk Assessment, Fall Detection, Gait Analysis, Quantitative Evaluation of Hemiplegic and Parkinson's Disease patients. Physical Activity monitoring: Human Kinetics, Cardiac Activity, Energy Expenditure measurement: Pedometers, Actigraphs.

UNIT III BIOMEDICAL SENSORS FOR HEALTH CARE 9

Wearable ECG devices: Basics of ECG and its design, Electrodes, and the Electrode–Skin Interface; Wearable EEG devices: Principle and origin of EEG, Basic Measurement set-up, electrodes, and instrumentation; Wearable EMG devices: EMG/ SEMG Signals, EMG Measurement – wearable surface electrodes, SEMG Signal Conditioning. Wearable Blood Pressure (BP) Measurement, Body Temperature sensor.

UNIT IV TRACKING, NAVIGATION, AND ENVIRONMENTAL MONITORING 9

Wearable devices with Global Positioning System (GPS) integration for tracking and navigation. Wearable Optical Sensors -chemical sensors, optical glucose sensors, UV exposure indicators, speech recognition using lasers; Photoplethysmography (PPG), 3D imaging and motion capture.

UNIT V ROLE OF WEARABLE SENSORS IN META WEARABLES, SOCIAL ASPECTS AND HEALTH MONITORING 9

Role of Wearable sensors, Attributes of Wearable sensors, The Meta Wearables – Textiles and clothing, Social Aspects: Interpretation of Aesthetics, Adoption of Innovation, On-Body Interaction, Google Glass, health monitoring.

Total:45 Hours

h) Learning Resources

Text Books

1. B. C. Nakra, K.K. Choudhury, "Instrumentation, Measurement and Analysis" -4th Edition, Tata McGraw, McGraw Hill India, 2016
2. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications" Elsevier, 2014
3. Toshiyo Tamura and Wenxi Chen , "Seamless Healthcare Monitoring", Springer 2018
4. Edward Sazonov and Michael R. Neuman, "Wearable Sensors -Fundamentals, Implementation and Applications", Elsevier Inc., 2014.

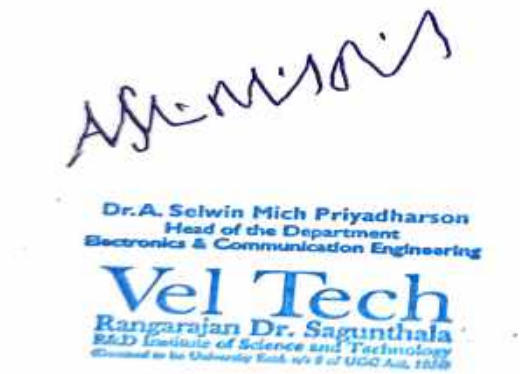
Reference Books

1. A.K. Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpatRai, Educational and Technical Publisher 2021.
2. Mr. Michael J. Kirwan, "Closing the Care Gap with Wearable Devices: Innovating Healthcare with Wearable Patient Monitoring (Intelligent Health Series)",Taylor & Francis Ltd, 1st edition, 2022
3. Vinod Kumar Singh, "Design and Optimization of Sensors and Antennas for Wearable Devices: [emerging Research and Opportunities] (Advances in Mechatronics and Mechanical Engineering)", IGI Global 2019
4. Martin Gitlin, "Smart Wearable Devices (21st Century Skills Innovation Library: Exploring the Internet of Things)", Cherry Lake Pub 2020
5. Nicola Carbonaro, Alessandro Tognetti, "Wearable Technologies", MDPI AG 2019
6. Qammer H Abbasi, Hadi Heidari, Akram Alomainy, "Wearable Wireless Devices", MDPI AG 2020

Online Resources:

1 https://www.sciencedirect.com/science/article/pii/S2211285518306335
2 https://books.google.co.in/books?hl=en&lr=&id=F9PVDwAAQBAJ&oi=fnd&pg=PP1&dq=Book:+%22Wearable+Sensors:+Fundamentals,+Implementation+and+Applications%22+by+Edward+Sazonov+and+Michael+R.+Neuman&ots=WrXY6BHkFa&sig=7zRPZJE1pat272ANIrAVzGV7mTg#v=onepage&q&f=false
3 https://www.mdpi.com/1424-8220/14/7/11957
4 https://scholar.google.co.in/scholar?q=Book:+Inertial+Sensors:+Principles+and+Applications+by+H.+Koivo&hl=en&as_sdt=0&as_vis=1&oi=scholart

5 https://scholar.google.co.in/scholar?q=A+Review+of+Wearable+Inertial+Sensors+for+Human+Body+Motion+Monitoring+by+Angelo+M.+Sabatini+(Sensors,+2014)&hl=en&as_sdt=0&as_vis=1&oi=scholart
6 https://onlinelibrary.wiley.com/doi/abs/10.1002/adfm.201400379
7 https://books.google.co.in/books?hl=en&lr=&id=dNitDwAAQBAJ&oi=fnd&pg=PP1&dq=Wearable+and+Implantable+Medical+Devices:+Applications+and+Challenges&ots=hyA50mp144&sig=Fx2UdXyLWwFa-
8 4XbnV9y7wEzK8E#v=onepage&q=Wearable%20and%20Implantable%20Medical%20Devices%3A%20Applications%20and%20Challenges&f=false
9 https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7683248/
10 https://onlinelibrary.wiley.com/doi/book/10.1002/9781119018612
11 https://www.researchgate.net/publication/325247885_Wearable_Technologies_Concepts_Methodologies_Tools_and_Applications
12 https://shop.elsevier.com/books/wearable-technology-in-medicine-and-health-care/tong/978-0-12-811810-8



Course Code	Course Title	L	T	P	C
10212EC114	**PROCESS CONTROL**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course aims to provide basic knowledge on various process control elements and controllers to solve real world engineering problems in an efficient manner. The course also aims to give an insight into industrial process modelling for level, flow, pressure, and temperature processes. It also discusses various control schemes, controller tuning, process control instrumentation, industrial communication protocols and industrial control schemes.

c) Prerequisite

Control Systems

d) Related Courses

Analog Electronics, Linear Integrated Circuits and Data Communication Networks.

e) Course Outcomes

On successful completion of this course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the fundamental concepts of process control and mathematical modelling of industrial processes.	K2
CO2	Outline the basic control actions, continuous controllers and composite controllers.	K2
CO3	Illustrate the performance criteria and controller tuning methods for feedback controllers.	K2
CO4	Summarize the various industrial sensors, final control elements and communication protocols in process control instrumentation.	K2
CO5	Compare the various industrial control schemes and their applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO 1	M	L	L	-	-	M	H	-	-	-	-	L	-	-
CO 2	M	L	-	-	-	L	L	-	-	-	L	L	-	-
CO 3	M	M	L	L	L	L	M	L	L	L	-	M	L	-
CO 4	M	L	-	-	-	M	M	L	-	L	-	L	-	-
CO 5	H	L	L	L	-	H	M	L	L	M	L	M	L	-

g) Course Content

UNIT I **INTRODUCTION TO PROCESS CONTROL AND PROCESS MODELLING** **9**

Review of Control System Block diagram - Need for process control – Terms and Objectives - Interacting and non-interacting systems – Continuous and batch processes – Self regulation – Servo and regulatory operations- Process lag, load disturbance and their effect on processes - Mathematical model of flow, Level, Pressure and Thermal processes

UNIT II **FEEDBACK CONTROLLERS** **9**

Basic control actions: two position (ON/OFF), multi-position control - Continuous controller modes: proportional, integral, and derivative – P, PI, PID: Composite controller modes, electronic controllers - Advantages and limitations of various control strategies - Measures to overcome the limitations.

UNIT III **TUNING OF CONTROLLERS** **9**

Need for controller tuning – Performance criteria for controllers: Quarter Decay Ratio, IAE, ISE and ITAE - Types of controller tuning: Process reaction curve method, Continuous cycling method and Damped oscillation method.

UNIT IV **PROCESS CONTROL INSTRUMENTATION IN PLANT DESIGN** **9**

Sensors and transducers for Industrial Variables: pressure, flow, level and temperature - Final control elements: I/P converter, P/I converter, Pneumatic and electric actuators, Control Valves - Industrial Communication Protocols.

UNIT V **INDUSTRIAL CONTROL SCHEMES** **9**

Cascade control – Feed forward control- Ratio control – Interference control – Adaptive Control - Process Automation: Role of Digital Computer in process control - Distributed Instrumentation and control system: PLC, DCS and SCADA.

Total:45 Hours

h) Learning Resources

Text Books

1. Stephanopoulos, G., "Chemical Process Control - An Introduction to Theory and practice", Pearson 2015.
2. Curtis D. Johnson, "Process Control Instrumentation Technology", Pearson, 8th edition, 2017.

Reference Books

1. J. Magrath and M. Gopal," Control System Engineering", New Age International Publishers, 5th Edition, 2007.
2. Ernest O. Doebelin "Measurement systems application and design", McGraw Hill International Editions, McGraw Hill Publishing Company, 2004
3. B. Wayne Bequette, "Process control, modeling, Design and simulation", Prentice Hall of India (P) Ltd., 2nd edition, 2010.Steve Mackay, Edwin Wright, John Park, "Practical Data Communications for Instrumentation and Control", Newness Publications, UK, 2003.

Online Resources:

1. https://nptel.ac.in/courses/103103037

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC204	EMBEDDED C PROGRAMMING	2	0	2	3

a) Course Category:

Programme Elective

b) Preamble

The main aim of this course is to provide learners with practical skills and a strong foundation that they can build upon to start producing well written code from the scratch. This course assumes prior knowledge of neither cortex-m nor embedded-c programming. This Course will provide an ideal platform for the applications, and has been developed to be fully programmable in C making it widely accessible to embedded software engineers.

c) Prerequisite Courses

Microprocessor and Microcontroller

d) Related Courses

Embedded OS and Device Drivers,
System on Chip
Internet of Things

e) Course Outcome:

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcome	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain the Embedded System development life cycle and ARM Cortex architecture.	K2
CO2	Outline Embedded C programming components and concepts.	K2
CO3	Apply Embedded C programming concepts to interface peripherals with ARM CORTEX M4 series	K3
CO4	Illustrate Embedded C programming concepts to interface Communication peripherals of ARM CORTEX M4.	K2
CO5	Construct the real time applications using ARM CORTEX M4.	K3

f) Correlation of COs with POs and PSO's:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	L	L	L	L	L	-
CO2	M	M	M	-	-	-	-	-	L	L	L	L	M	-
CO3	M	-	L	-	-	-	-	-	L	L	L	L	M	-
CO4	M	-	L	-	-	-	-	-	L	L	L	L	M	-
CO5	L	L	L	M	-	-	-	-	L	L	L	M	M	-

g) Course Content:

UNIT 1 BASICS OF EMBEDDED SYSTEM 6

Embedded System Overview: Design flow, Introduction to C, Software development process – **ARM Hardware architecture overview and Selection:** ARM Classic, Secure Core, Cortex M Series, Cortex R Series, Cortex A Series. Introduction to Cortex M4.

UNIT 2 EMBEDDED C PROGRAM STRUCTURE AND COMPONENTS 6

Basic Structure, Data Types, Operators and Expressions, Identifiers, Name space & Scope, Flow controls, Loops – **Components:** Comments, Global Variables, Local Variables, Main Function.

UNIT 3 PERIPHERAL PROGRAMMING 6

Interrupt programming, General Purpose Digital Interfacing, General Purpose Analog Interfacing: A-D interfacing, D-A interfacing, Timers control, Signal generators, PWM.

UNIT 4 COMMUNICATION PROTOCOL PROGRAMMING 6

Serial Communication: Universal Asynchronous Receiver Transmitter (UART), Serial Peripheralinterface (SPI), Inter Integrated Circuits (I2C), Direct Memory Addressing (DMA).

UNIT 5 APPLICATIONS 6

Tone Generation, Pseudo Code Generation, Event Recorder, Watchdog timer, Interfacing Digital & Analog Sensor, Actuator Control.

Total:30 Hours

h) Learning Resources:

Text Books

1. Jonathan W Valvano "Introduction to ARM Cortex M microcontroller" Fifth Edition2014. ISBN-13: 978-1477508992.
2. Fisher, M. ARM® Cortex® M4 Cookbook. United Kingdom: Packt Publishing, 2016.

Reference Books

1. Cortex-M4 Devices Generic User Guide, ARM Limited.
2. Cortex-M4 Technical Reference Manual, ARM Limited.

Online Resources:

1. Keil uVision MDK : http://www.keil.com/arm/mdk.asp
2. Getting started with Keil uVision: http://www.keil.com/product/brochures/uv4.pdf
3. Useful links to other user manuals: http://www.keil.com/arm/man/arm.htm

LIST OF EXPERIMENTS

Write an embedded C code using ARM CORTEX M4 development board

1. Toggle the GPIO with delay.
2. Display the alpha numeric characters in LCD
3. Matrix keypad Interfacing
4. Stepper Motor Interfacing
5. Characters Display in UART terminal
6. Analog to Digital Conversion
7. Digital to Analog Conversion
8. Audio signal generation
9. Watch dog timer
10. Real time Clock

Total:30 Hours

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Head of the Department
Electronics & Communication Engineering
Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology

Course Code	Course Title	L	T	P	C
10212EC205	EMBEDDED LINUX AND DEVICE DRIVERS	1	0	4	3

a) Course Category

Programme Elective

b) Preamble

This course introduces the fundamentals of embedded Linux, tool chain development and device driver development principles for real time embedded applications.

c) Prerequisite

Microprocessor and Microcontroller

d) Related Courses

Embedded OS and Device Drivers

e) Course Outcome

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Demonstrate an embedded Linux system.	K2, S3
CO2	Simulate an embedded Linux device driver application.	K2, S3
CO3	Develop an embedded Linux based system or device driver to demonstrate a sustainable system incorporating the legal and safety standards while handling open source tools.	K2, S3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	-	L	-	-	-	-	M	-	-
CO2	M	M	H	H	H	-	-	L	L	L	-	H	H	H
CO3	M	M	H	H	H	-	-	L	L	L	-	H	H	H

g) Course Content:

Theory **15 Hours**

Operating system basics, difference between OS, Embedded OS and RTOS, Linux features, Linux hardware support, build system, host system and target system. Linux development toolchain, kernel compilation, file system types, boot loader. Loadable kernel modules, makefile, character device driver.

h) List of experiments

S. No.	Practical Exercises (60 Hours)	CO
1.	Understand basic Linux commands	CO1
2.	Build native toolchain	CO1
3.	Develop a host system	CO1
4.	makefile creation	CO1
5.	Native Compile Linux kernel and its C programming	CO2
6.	Build cross toolchain	CO2
7.	Cross compile Linux Kernel	CO2
8.	Configure target system bootloader	CO2
9.	Cross Linux C programming	CO2
10.	Emulate and deploy target Linux system	CO2
11.	Loadable Kernel module programming with makefile and argument passing	CO3
12.	GPIO device driver development	CO3
13.	LCD device driver development.	CO3
14.	Serial port device driver development.	CO3
		Total: 75 Hours

i) Learning Resources

Textbooks:

1. Silberschatz, Galvin, Gagne, "Operating System Concepts", 6th edition, John Wiley, 2003.
2. K.Yaghmour, Jon, Gilad and P.Gerum, "Building Embedded Linux Systems", O'Reilly, 2008.
3. Gene Sally, "Pro Linux Embedded Systems", Apress, 2010.
4. J.Corbet, A. Rubini, G.K.Hartman, "Linux Device Drivers", O'Reilly, 2005.

Online Resources:

1. https://www.youtube.com/watch?v=YR_vYTh8CmY&list=PLERTijJOmYrAtfl5U_TAbCOisCNb7XEbb - Linux device driver programming
2. https://www.youtube.com/watch?v=PEzpOembKNc -What is a Bootloader?
3. https://www.youtube.com/watch?v=U7QFcpVh248&list=PL1zwAXk5ZrWKxLyCq73lzFn3oSLruM750 - Role of Linux Device Driver

Course Code	Course Title	L	T	P	C
10212EC206	**EMBEDDED SYSTEMS AND ROBOTICS**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces the embedded hardware design, programming and introduction of robotics, electronic components, electronic processors and controllers, circuit development with practical knowledge of each modules to give our student the best of robotics training for real-time applications

c) Prerequisite

Microprocessor and Microcontroller

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Demonstrate PIC based embedded systems.	S3
CO2	Design a real time systems using arduino.	S3
CO3	Develop robots using webots based on e-puck for the given specification and demonstrate it.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	-	-	L	H	-	L	-	M	L	-	M	H	H
CO2	M	-	H	H	H	-	L	-	H	L	M	H	H	H
CO3	-	-	H	H	H	L	L	L	H	L	-	H	H	H

h) Course Content:

Theory **15 Hrs**

PIC - Architecture, pin diagram, ports, on chip peripherals. Embedded C programming – General Structure, Data types. Arduino- Introduction, IDE, different Arduino Boards & shields. Analog I/O Serial and Parallel Communication. Microcontroller ATMEGA 328. Seven Segment and LCD DisplayDriving motors. Manual Robots and Autonomous Robots - fundamentals and its applicationsGear assembly and calculations Different types of chassis designing.

List of experiments

S. No	CO Mapping	Practical Exercises (60 Hours)
1.	CO1	Exploring the features of MPLAB X IDE
2.	CO1	Exploring the features of Proteus
3.	CO1	LED and seven segment display using PIC
4.	CO1	Keypad interface using PIC
5.	CO1	Serial communication using PIC
6.	CO1	Motor speed control using PIC
7.	CO2	Exploring the features of Arduino IDE and Boards
8.	CO2	LED Interfacing using Arduino
9.	CO2	RGB LED interface using Arduino
10.	CO2	LCD Interfacing using Arduino.
11.	CO2	LDR Interfacing using Arduino.
12.	CO2	IR sensor interfacing using Arduino
13.	CO2	Ultrasonic sensor interface using Arduino
14.	CO2	Temperature sensor interfacing using Arduino.
15.	CO2	Motor interface using Arduino

16.	CO2	Bluetooth Interfacing using Arduino
17.	CO2	GSM module Interfacing using Arduino
18.	CO2	WiFi Interfacing using Arduino
19.	CO3	Building a Robot Car
20.	CO3	Programming the Robot Car using Arduino
21.	CO3	Exploring the features of Webots
22.	CO3	LED Control of e-puck Robot in Webots
23.	CO3	Motor Control of e-puck Robot in Webots
24.	CO3	Line Follower e-puck Robot in Webots
25.	CO2, CO3	Mini Project

Total: 75 Hrs

j) Learning Resources

Text Books

1. Massimo Banzi, “Getting Started with Arduino” 3 rd edition. O’Reilly, 2014.
2. Udayakumar, G.Kulkarni, “ Arduino: A Begineer's Guide” 2017
3. DoganIbrahi, “Advanced PIC Microcontroller Projects in C”, Newnes, 2008.
4. MykePredko, “Programming and customizing the PIC”, 3 rd edition, 2007.
5. Parab, V.G.Shelake and R.K.Kamat-“Exploring C for Microcontrollers: A Hands on Approach”- Springer-2007.
6. M. ShohamA Textbook of Robotics 1: Basic Concepts Springer-2012.
7. By Kevin M. Lynch, Frank C. Park “Modern Robotics mechanics, planning, controls” Cambridge university press-2017.
8. Cameron Hughes, Tracey Hughes “Robot Programming: A Guide to Controlling Autonomous Robots”, 1/e First Edition-2016.
9. John-David Warren, Josh Adams, HaraldMolle, “Arduino Robotics” apress, 1 st edition, 2011.

Online Resources

1. https://www.arduino.cc//
2. https://www.tutorialspoint.com/arduino/index.html
3. http://microcontrollerslab.com/pic-microcontroller-compiler/
4. http://bobblick.com/techref/techref.html
5. http://www.microcontrollerboard.com/pic-microcontroller-books.html
6. http://www.nex-robotics.com/products/microcontroller-development-boards/atmega2560- microcontroller-socket.html
7. http://www.avr-asm-download.de/beginner_en

Course Code	Course Title	L	T	P	C
10212EC207	**SYSTEM ON CHIP**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

The primary focus of this integrated course "System on Chip" is the development of an embedded system using a current-day system on a chip (SoC) which consists of several different microprocessor subsystems together with memories and I/O interfaces. Students will also get an opportunity to design and implement the algorithms that are specific to real time systems/applications.

c) Prerequisite

Nil

d) Related Courses

Embedded System Design, Reconfigurable Computing with FPGA

e) Course Outcome

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Explain the functionality of ARM and PSOC architectures	S2
CO2	Implementation of interfaces on programmable SoC	S3
CO3	Demonstrate the programmable system on-chip interfacing with peripheral devices	S3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	H	L	H	L	L	-	-	-	-	M	M	-
CO2	M	M	H	L	H	L	L	-	-	-	-	M	M	M
CO3	M	L	H	L	H	L	L	L	-	-	-	M	M	M

h) Course Content:

Theory **15 Hours**

Introduction to System on Chip – Architecture – Components – Hardware and Software – Interconnections – Customization. ARM architecture – Organization and Implementation – Instructions – Assembly Language Programming – Processor Cores. PSoC Architecture – Structure – Modules – Interconnects – Memory Management – MultipleConfigurations – Project Running. APSoC Architecture – IP Creation – IP Integration – Implementation.Embedded System on SoC – Application – Automation.

i) List of experiments

S. No	CO Mapping	Practical Exercises (60 Hours)
1.	CO1	Introduction to Vivado Design Suite environment
2.	CO1	Synthesis and Implementation of Microblaze Processor.
3.	CO1	Creation of Custom IP Cores with the IP Integrator Utility.
4.	CO1	Creation of an Embedded Programmable System on Chip.
5.	CO2	Analog GPIO Driving using PSoC
6.	CO2	Digital GPIO Driving using PSoC
7.	CO2	Design and implementation of OpAmps for ADC using PSoC.
8.	CO2	Generation of PWM signal to drive servo motor using PSoC.
9.	CO2	Filter Design and Implementation using PSoC.
10.	CO2	Design and Implementation of DMA Controller using PSoC.
11.	CO2	Dynamic Reconfiguration using PSoC.
12.	CO3	Implementation of Arithmetic and Logical Unit in APSoC Architecture.
13.	CO3	Develop a System to Control the Speed of Motor in APSoC Architecture
14.	CO3	Interface a Temperature Sensor Module with APSoC architecture
15.	CO3	Design and Implementation of Embedded System on a Chip for Real Time Application

Total 75 hrs

j) Learning Resources

Text Books

1. Michael J. Flynn, Wayne Luk, "Computer System Design: System-on-Chip", Wiley Publishers,OCT 2011.
2. Steve Furber, "ARM System-on-Chip Architecture" (2nd Edition) 2nd Edition, Pearson Education Limited, 2000.
3. Robert Ashby, "Designer's Guide to the Cypress PSoC (Embedded Technology)" Elsevier, 2005.
4. Louise Crockett, Ross A Elliot, Martin A Enderwitz, "The Zynq Book Tutorials for Zybo andZedBoard Paperback", University of Strathclyde Glasgow, 2015
5. Nurmi J, "Processor Design System-On-Chip Computing for ASICs and FPGAs", Springer 2007

List of Major Equipment/ Instrument/Software with Broad Specifications

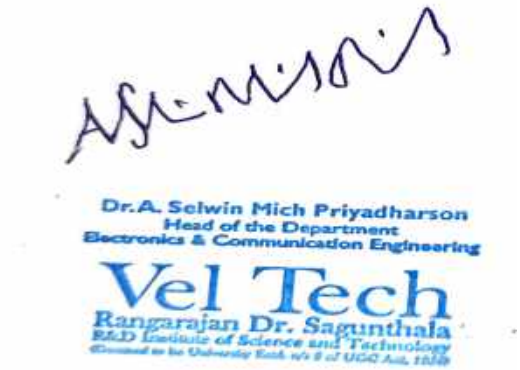
1. Vivado Compiler (Licensed version)
2. Cypress PSoC Board
3. Xilinx Zybo Board

List of Software/Learning Websites

1. https://www.xilinx.com/
2. http://www.cypress.com/
3. https://www.arm.com/

Online resources

1.http://nptel.ac.in/courses/108102045/10



Course Code	Course Title	L	T	P	C
10212EC208	VIRTUAL INSTRUMENTATION PROGRAMMING	1	0	4	3

a) Course Category

Programme Elective

b) Preamble

Virtual instrumentation provides the basics of Graphical Programming techniques through LabVIEW software, Instrument control and Real-time data acquisition and interfacing techniques of Virtual Instrumentation (VI) with practical applications.

c) Prerequisite

Nil

d) Related Courses

Digital Electronics, Control Systems and Software Defined Radio

e) Course Outcome

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Perform the basic VI programming using graphical user interface functions in LabVIEW.	S3
CO2	Apply the graphical programming functions in VI to simulate the application specific analog and digital circuits.	S3
CO3	Demonstrate the real time data acquisition using DAQ devices, control, and analysis of basic I/O devices.	S3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	H	-	-	-	M	L	-	M	-	-
CO2	M	L	L	-	H	L	-	-	M	L	-	M	L	-
CO3	L	L	M	L	H	M	L	L	M	M	L	M	M	M

g) Course Content:

THEORY **15 Hours**

Introduction to Virtual Instrumentation: Virtual Instrumentation (VI) and its evolution, advantages of VI, block diagram and architecture of a virtual instrument, graphical programming, comparison with conventional programming, development of virtual instrument using GUI.

Programming techniques in LabVIEW: LabVIEW – Introduction, data types, front panel controls and indicators, block diagram, Sub VI, creating and Saving VI , Loops – For loop & While loop, Case Structures, arrays, Charts, Graphs, Formula nodes, case and Sequence structures – flat and stacked.

Data acquisition & Instrument Control: PC based Data acquisition, Sensors & transducers, Measurement & Automation Explorer (M&A), MyRIO, software and hardware installation, configuring data acquisition hardware using the drives in application software, hardware interfacing Interface standards, Instrument Control, VISA, Case Studies.

LIST OF EXPERIMENTS **60 Hours**

List of Experiments	CO Mapping
Introduction to Graphical Programming (6 Hours) 1. Build a VI using Numeric controls and indicators to perform various arithmetic operations. 2. Build a VI using Boolean controls and indicators to perform various Boolean operations. 3. Build a VI using String controls and indicators to perform various String operations.	CO1

Operations using Data Types (6 Hours) 4. Create a Sub VI to compute area and volume of planes and solids. 5. Develop a Sub VI using to solve a quadratic equation $ax^2 + bx + c = 0$ and display whether the roots are real or imaginary. 6. Build a VI to implement and verify adder circuits using logic gates.	CO2
Loops (6 Hours) 7. Build a VI to monitor the level of tank using loop functions. 8. Simulate a VI to indicate charging of a battery level. Use appropriate functions and display notification messages.	CO2
Arrays (6 Hours) 9. Build a VI using to create a 1-D array. Perform the operations such as indexing, insertion, deletion and search of an element. 10. Build a VI to generate Fibonacci series using loop and array functions. 11. Build a VI to perform sorting of given numbers in ascending order using loop and array functions.	CO2
Case Structure (6 Hours) 12. Build a VI for temperature monitoring system using Case structures. Display the safe and emergency alarms using LEDs of varying colours. 13. Design a VI to display a 7-segment LED using caste structures.	CO2
Charts and Graphs (6 Hours) 14. Simulate a sine wave and square of variable amplitude and frequency and display the waveform using graph. Manipulate the waveforms by changing its width and colour. 15. Develop a VI program to demonstrate Frequency modulation and amplitude modulation using Formula node.	CO2
Sequence Structures (6 Hours) 16. Build a VI for traffic light control for varying time delays using sequence structures. 17. Design a Ticket vending machine system using the concept of state machine in LabVIEW. 18. Perform READ/WRITE operations on a file using sequence structures and loops.	CO2
Clusters (6 Hours) 19. Create a cluster to store information about students, such as name, age, and CGPA. Implement a user interface to input and display student data. 20. Create a VI to calculate Body Mass Index (BMI) using Clusters and display the BMI status using LED and pop-up message.	CO2
Data Acquisition (12 Hours) 21. Develop a VI to export data from DAQ assistant device and to spreadsheet.	CO3

22. Build a VI to measure temperature using thermocouple and DAQ. 23. Build a VI for image acquisition and processing using USB camera. 24. Generate Pulse-Width Modulation (PWM) signals using MyRIO to control the speed of a DC motor or the brightness of an LED. 25. Interface MyRIO with various sensors, acquire data, and log the data to a file for analysis and visualization.	

Total 75 Hours

h) Learning Resources

Text Books

1. Jovitha Jerome, "Virtual Instrumentation Using LabVIEW", PHI Learning Pvt. Ltd., 2nd edition, 2010.
2. Introduction to LabVIEW for Scientists and Engineers by John Essic, 4th Edition, Oxford University Press, 2018.

Reference Books

1. Yik Yang, "LabVIEW Graphical Programming Cookbook", Packt Publishing, 1st edition, 2014.
2. LabVIEW Graphical Programming by Johnson, 4th Edition, McGraw Hill, 2011.
3. Robert H. Bishop, "Learning with Lab VIEW", Prentice Hall, 1st edition, 2003.

Online resources

1. https://www.ni.com/getting-started/labview-basics/
2. https://www.ni.com/en-in/support/documentation/supplemental/06/getting-started-with-ni-daqmx--basic-programming-with-ni-daqmx.html
3. https://learn.ni.com/

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Course Code	Course Name	L	T	P	C
10212EC906	**Embedded Software Engineering - I**	**2**	**0**	**2**	**3**

a.) Course Category

Programme Elective

b.) Preamble

The objective of this course is to impart the concepts of design life cycles, compilation debugging process and security in an embedded system connect to the real time applications.

c.) Prerequisite Courses: -

d.) Related Courses:

e.) Course Outcomes:

Upon Successful completion of this course, students will be able to

CO Nos	Course Outcome	K-Level Based on Revised Bloom's Taxonomy
CO1	Explain the architecture, components, standard hardware interfaces, and datasheets of embedded systems.	K2
CO2	Describe the functional role of microprocessors, microcontrollers and peripherals in embedded systems, and its various debugging techniques used during development.	K2
CO3	Interpret various SDLC models for embedded system development.	K2
CO4	Outline the model-based approaches such as TDD, BDD, and MDD used in embedded system design.	K2
CO5	Summarize key security principles and testing procedures applicable to embedded and IoT systems.	K2

f.) Correlation CO's with PO's and PSO's

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	M	M	L	-	L	L	-	-	-	-	-	L	-
CO2	M	M	M	-	L	-	-	-	-	L	L	M	-
CO3	-	L	L	L	-	-	-	-	-	-	L	L	-
CO4	-	L	L	L	-	-	-	-	-	-	L	L	-
CO5	-	-	M	M	-	-	L	-	-	L	L	M	L

g.) Course Content

Unit-I Fundamentals of Embedded Systems **6**

Embedded Systems Architecture, Classification of Embedded System, Standard Interfaces-Understanding Datasheet, Software Tool Chain: Preprocessor-Compiler-Debugger-Assembler-Linker/Loader, Electrostatic Discharge Essentials.

Unit-II Components of Embedded Systems **6**

Microprocessor-Microcontroller-I/O interfaces: LCD, LED, Keypad, Switches, Touch Screen, Memory, Board based system- Processor based system, Debugging Techniques: High level simulation - Low level simulation - Onboard debuggers - Task Level debuggers - Symbolic debuggers-Emulators.

Unit-III Software Development Life Cycle (SDLC) **6**

SDLC Overview- Hardware and Software Aspects-SDLC Models-Waterfall Model-V Cycle Model-Spiral Model-Conventional Model-Co Design Model.

Unit-IV Architecting the System **6**

Test Driven Development, Behavior Driven Development, Model Driven Development, Architecting and Designing the System, Languages and Static Code Analysis, Code Repository-Build and Deployment Process, Measurement and Metrics.

Unit V System Security **6**

SDLC-Security Development Life Cycle- Embedded Testing-IoT Security

Total-30 Hours

Experiment No	Experiment
1.	Exploring the components of an Embedded System
2.	Basic C Programming: Structure and Syntax Overview
3.	Manipulating Arrays in C
4.	Pointer Fundamentals: Addressing and Data Access in C
5.	Modular Programming: Defining and Calling Functions in C
6.	Call by Value vs Call by Reference in Function Parameter Passing
7.	Exploring Open-Source C Compilers for General-Purpose Programming

8.	Implementing and Analyzing String Manipulation Functions in C
9.	Initial Setup and Installation of Keil IDE for Microcontroller Programming
10.	Developing a Traffic Light Simulation: LED Control Program
11.	Creating a Minimal C Program for Text Output Verification
12.	Developing a Functional ALU Module for Processor Simulation

h.) Resources:

Reference Books:

1. Steve Heath “Embedded Systems Design” Second Edition, Elsevier 2003
2. James K.Peckol, “Embedded Systems: A Contemporary Design Tool”, Wiley, 2019.

Online Resources:

1. Nasscom Study Material

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Course Code	Course Title	L	T	P	C
10212EC907	**LINUX SYSTEM PROGRAMMING**	**2**	**0**	**2**	**3**

a) Course Category

Program Elective

b) Preamble

This course introduces the fundamentals of Linux System Programming (LSP) for embedded systems. It covers system calls, file operations, process management, inter-process communication Inter Process Communication (IPC), signals, multithreading and memory management. Emphasis is placed on practical application of concepts through programming exercises that build strong foundations for embedded development. The course content is aligned with Wipro Center of Excellence – Next-Gen Associates (NGA) Skilling: Linux System Programming (LSP), ensuring that students acquire industry-relevant skills bridging academic learning and professional practice.

c) Prerequisite

Knowledge on
- Embedded C Programming
- Embedded System Design
- Embedded OS and Device Drivers

d) Related Courses

Embedded Linux and Device Drivers

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's and Dave's Taxonomy)
CO1	Explain the Linux architecture, user/kernel space and toolchain usage.	K2, S3
CO2	Make use of Linux system calls for file handling for I/O process.	K3, S3
CO3	Utilize the project management calls for system process creation and scheduling the signals.	K3, S3

CO4	Construct the IPC mechanisms using pipes, shared memory and message queues.	K3, S3
CO5	Develop the synchronization and multithreading using POSIX threads and basics of debugging.	K3, S3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	H	M	-	-	M	- -	-	L	L	-	L	H	M
CO2	H	H	H	M	H	- -	-	L	L	-	L	H	H
CO3	H	H	H	M	H	- -	-	L	L	-	L	H	H
CO4	H	H	H	H	H	- -	-	M	M	-	L	H	H
CO5	H	H	H	H	H	- -	-	M	M	-	M	H	H

g) Course Content

UNIT I LINUX ARCHITECTURE & TOOLCHAIN 6

Linux architecture: user space versus kernel space - GNU Compiler Collection (GCC) toolchain: preprocessor, compiler, assembler, linker - makefiles and build automation basics – command line essentials for embedded development.

UNIT II FILE I/O SYSTEM CALLS 6

Low level file I/O: open, read, write, close, lseek - file descriptors, error handling (errno) - directory operations, stat, fcntl - concept of Virtual File System (VFS).

UNIT III PROCESS MANAGEMENT SYSTEM CALLS 6

Process creation: fork, exec family, wait, exit - process hierarchy, PID, PPID - daemon processes and scheduling - signals: handling, signal (), sigaction (), kill ().

UNIT IV IPC MECHANISMS 6

Pipes: unnamed and named, FIFOs - message queues - shared memory: shmget, shmat, shmdt, shmctl - semaphores for synchronization.

UNIT V THREADS AND ADVANCED PROGRAMMING 6

POSIX threads (pthreads): creation, joining, detaching - synchronization: mutex, condition variables - multithreaded producer- consumer problem - memory management: malloc, mmap, brk - error debugging and GDB (GNU Debugger) basics.

Total: 30 hrs

h) List of Practical Experiments

S. No	CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's and Dave's Taxonomy)
1	CO1	Explore Linux file system by writing a program to list directory contents using system calls.	S2
2	CO1	Construct a Makefile to automate the build process of a simple C program.	S3
3	CO2	Develop a file copy utility using open, read, write system calls.	S3
4	CO2	Create a process management program using fork(), exec() and wait() system calls.	S3
5	CO3	Implement inter-process communication using unnamed pipes.	S3
6	CO3	Design communication between processes using named pipes (FIFOs).	S3
7	CO4	Build a multithreaded program using POSIX pthreads.	S3
8	CO4	Apply synchronization by developing a producer–consumer solution with pthreads & mutex.	S3
9	CO5	Demonstrate signal handling using sigaction() system call.	S3
10	CO5	Utilize shared memory allocation with mmap() for inter-process communication.	S3
11	CO1-CO5	Integrate concepts in a Mini Project (system calls, processes, IPC, threads, signals, memory).	S4

Total: 30 hrs

i) Learning Resources

References

1. Robert Love, “Linux System Programming”, Second Edition, O'Reilly, 2014
2. W. Richard Stevens, “Advanced Programming in the UNIX Environment”, Pearson Education, 2013.
3. Michael Kerrisk, “The Linux Programming Interface”, No Starch Press, US, 2010.

Online Resources

1. Linux manual pages: https://man7.org/linux/man-pages/
2. The Linux Documentation Project: https://tldp.org/
3. Standards documents applicable to the Linux kernel: https://kernel.org/doc/

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Course Code	Course Title	L	T	P	C
10212EC908	**LINUX DEVICE DRIVERS**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course imparts comprehensive knowledge and practical skills in Linux Device Driver (LDD) development for embedded systems. It covers kernel programming, character device drivers, interrupt handling, deferred work mechanisms, synchronization techniques and integration with Sysfs and the Linux device model. The course is designed to provide industry-oriented, application-driven training, enabling students to build real-time drivers for embedded platforms. The content is aligned with Wipro Centre of Excellence (CoE) – Next-Gen Associates (NGA) Skilling: Linux Device Drivers (LDD), ensuring that learners acquire competencies expected by industry for next-generation embedded solutions.

c) Prerequisite

Knowledge on

- Microprocessor and Microcontroller
- Embedded System Design
- Embedded OS and Device Drivers

d) Related Courses

- Embedded Linux and Device Drivers

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Revised Bloom's and Dave's Taxonomy)
CO1	Develop the kernel modules to program the basic kernel concepts.	K3, S3
CO2	Implement character device drivers supporting file operations and user–kernel communication.	K3, S3

CO3	Identify the interrupt handling mechanisms with appropriate synchronization techniques in drivers.	K3, S3
CO4	Apply deferred work mechanisms such as tasklets, work queues and timers in driver development.	K3, S3
CO5	Utilize advanced Linux device drivers with Sysfs and the Linux device model for embedded applications.	K3, S3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PSO1	PSO2
CO1	H	M	M	L	M	-	-	L	M	-	L	H	M
CO2	H	M	H	M	H	-	-	L	M	-	L	H	H
CO3	H	H	H	M	H	-	-	L	M	-	L	H	H
CO4	H	M	H	M	H	-	-	L	M	-	L	H	H
CO5	H	M	H	M	H	L	-	L	M	-	L	H	H

g) Course Content

UNIT I LINUX KERNEL & MODULE PROGRAMMING 6

Kernel architecture: user vs kernel space - kernel modules: insmod, rmmod, modprobe - module programming basics: init, exit, printk - kernel build system, makefiles for modules.

UNIT II CHARACTER DEVICE DRIVERS 6

Major and minor numbers, registering device numbers - file operations: open, read, write, release, ioctl - kernel buffer management: copy_to_user, copy_from_user – case studies: char driver.

UNIT III KERNEL INTERRUPTS AND SYNCHRONIZATION PRIMITIVES 6

Interrupt handling flow in linux - request_irq(), free_irq() - shared IRQs, interrupt context vs process context - synchronization: spinlocks, semaphores, atomic variables.

UNIT IV ASYNCHRONOUS AND DELAYED EXECUTION IN KERNEL 6

Bottom halves, tasklets and workqueues - kernel timers and time management - delayed execution in drivers - case studies: interrupt + workqueue driver.

UNIT V DEVICE MANAGEMENT AND DEBUGGING **6**

Sysfs, kobjects, udev interaction - linux device model: buses, devices, drivers - exporting attributes to user space - debugging drivers: dmesg, debugfs, ftrace basics.

Total: 30 hrs

h) List of Practical Experiments

S. No	CO Mapping	Practical Exercises	Dave's Taxonomy Level
1	CO1	Compile and load a basic kernel module (Hello Kernel).	S2
2	CO1	Demonstrate module parameters and printk logging.	S3
3	CO2	Develop a simple char driver with open, read, write operations.	S3
4	CO2	Demonstrate a program using copy_to_user/copy_from_user.	S3
5	CO3	Implement an interrupt handler for a simulated device event.	S3
6	CO3	Demonstrate shared interrupts using request_irq().	S3
7	CO4	Implement deferred work using tasklets.	S3
8	CO4	Implement deferred work using workqueues.	S3
9	CO5	Export kernel attributes to Sysfs.	S3
10	CO5	Demonstrate kobject creation and manipulation.	S3
11	CO1-CO5	Mini Project	S4

Total: 30 hrs

i) Learning Resources

References

1. Robert Love, "Linux Kernel Development", Addison-Wesley, 2010.
2. Greg Kroah-Hartman, "Linux Kernel in a Nutshell", O'Reilly Media, 2010.
3. Jonathan Corbet et al, "Linux Device Drivers", 3rd Edition, O'Reilly, 2005.

Online Resources

1. Standards documents applicable to the Linux kernel: https://kernel.org/doc/
2. The Linux Documentation Project: https://tldp.org/
3. Explore Linux v6.16.7 source code: https://elixir.bootlin.com/linux/latest/source

1) Dr. P. Rajendran TT3353V Asso. Professor
Dr. HEMAKUMAR V-S
2) Dr. H. Saheer TT3564 Assistant Professor
HOD-ECE

Course Code	Course Title	L	T	P	C
10212EC910	EMBEDDED SOFTWARE ENGINEERING-II	2	0	2	3

a) Course Category

Program elective

b) Preamble

Effective low-level programming and real-time operating system (RTOS) support are necessary for embedded systems to satisfy high performance, timing, and reliability requirements. With an emphasis on memory management, context handling, multitasking, inter-task communication and resource management, this course combines embedded operating system principles with system programming techniques using C. Students will learn how to design, create, debug and optimize embedded software for real-time applications while gaining practical experience with FreeRTOS.

c) Prerequisite

Embedded Software Engineering-I

d) Related Courses

Nil

e) Course Outcomes

On the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on Revised Blooms Taxonomy & Daves)
CO1	Explain the embedded program build process, memory layout, debugging techniques and secure coding practices used in embedded systems.	K2
CO2	Apply memory and data management techniques using C programming for efficient and reliable embedded system implementation.	K3
CO3	Infer the fundamentals of embedded operating systems, including Linux kernel basics, RTOS concepts and file system organization.	K2
CO4	Implement multitasking, scheduling, inter-task communication and synchronization mechanisms using an RTOS.	K3
CO5	Summarize the advanced RTOS features such as timer management, resource sharing and event handling in embedded applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	M	L	–	–	L	–	–	–	–	–	–	L	-
CO2	H	M	M	–	M	–	–	–	–	–	–	L	-
CO3	M	M	–	–	L	–	–	–	–	–	–	L	-
CO4	H	M	H	L	M	–	–	–	L	–	–	L	-
CO5	M	M	–	L	M	–	–	–	–	–	–	L	-

g) Course Content

UNIT I SYSTEM PROGRAMMING **6**

Embedded Program Build Process-Linker, Loader, Memory Layout-Building Libraries-Debugging and Tracing using gdb: Debugging with gdb-Tracing, Coding Practices: Coding Guidelines-Secure and Safe Coding-Developing Optimal Code.

UNIT II MEMORY AND DATA MANAGEMENT **6**

Memory Architecture-Memory allocation-Memory profiling-Variable length data structures-Structures and unions-Pointers-Dynamic binding-Bit level operations-Handling special registers, Context Management: Requirements of C startup -Execution context-Interrupt context.

UNIT III EMBEDDED OS FUNDAMENTALS **6**

LINUX Kernel Basics-Networking tools, RTOS: RTOS concepts- Free RTOS source code organization, File Systems: LINUX Filesystem-Free RTOS Filesystem,

UNIT IV RTOS MANAGEMENT **6**

Task Management-Scheduler, ITC: Queue- Interrupt management- Semaphores, RTOS Memory Management: RTOS Memory types-Memory management.

UNIT V ADVANCED RTOS **6**

Advanced OS, Timer Management: Software and Hardware Timers, Resource Management: Shared Resources-Mutex-Event Groups.

Total Hours: 30Hrs

List of Experiments:

Exp. No	List of Experiment	CO
1.	Study of Embedded build process and map file analysis.	**CO1**
2.	Creation and usage of static and shared libraries	**CO1**
3.	Debugging embedded C program using gdb	**CO1**

4.	Memory allocation and profiling techniques	**CO2**
5.	Implementation of variable-length data structures	**CO2**
6.	Pointer-based linked list implementation	**CO2**
7.	Bit manipulation for register access	**CO2**
8.	Simulation of interrupt context handling	**CO3**
9.	FreeRTOS project setup and environment familiarization	**CO3**
10.	Task creation and scheduling in FreeRTOS	**CO4**
11.	Inter-task communication using queues	**CO4**
12.	Synchronization using semaphores and mutex	**CO4**
13.	Timer creation and callback handling in FreeRTOS	**CO5**
14.	File read/write operations using FreeRTOS file system	**CO5**
15.	Mini Project	**CO1-CO5**

h) Learning Resources

References

1. Raj Kamal, "Embedded Systems-Architecture, Programming and Design", Tata McGraw Hill, 2006.
2. Michael J. Pont, "Patterns for Time-Triggered Embedded Systems", Harlow,Addison-Wesley, 2001.
3. Valvano, Jonathan W. "Embedded Systems : Real-Time Operating Systems for the Arm® Cortex(TM)-M3". Volume 3. United States, Createspace, 2014.

i) Online Resources

1. Nasscom Study Material

(Dr. Vignesh Prasanna N)

Dr. Hemakumar V.S
BOS - Incharge.

3/2/26
HOD - ECE

Dr. S. Jana
Professor & Head of the Department
Electronics and Communication Engineering
Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology

Course Code	Course Title	L	T	P	C
10212EC904	REAL-TIME OPERATING SYSTEM USING QNX	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

This course provides a comprehensive understanding of QNX RTOS, equipping students with the skills to design and implement real-time systems for embedded applications.

c) Prerequisite

Microprocessor and Microcontroller

d) Related Courses

Embedded OS and Device Drivers, Embedded C Programming

CO Nos.	Course Outcomes	Knowledge and skill Level (Based on Revised Blooms & Dave's Taxonomy)
CO1	Illustrate the QNX OS architecture with its microkernel -based design, and debug QNX-based applications using appropriate tools.	K2, S3
CO2	Apply process/thread management and synchronization techniques in QNX.	K3, S3
CO3	Utilize inter-process communication methods for real-time systems.	K3, S3
CO4	Construct and build QNX boot/OS images for specific hardware platforms.	K3, S3
CO5	Develop strong knowledge on the POSIX standards that help in System Application Development.	K3, S3

e) Correlation of COs with POs and PSOs:

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO-1	PSO-2
CO-1	H	M	M	–	–	–	–	–	–	–	–	M	–
CO-2	H	H	M	–	M	–	–	–	–	–	–	H	–
CO-3	H	H	H	M	M	–	–	–	–	–	–	H	–
CO-4	H	M	H	M	H	–	–	–	–	–	–	M	–
CO-5	M	H	M	–	H	–	–	–	–	–	–	M	–

f) Course Content

UNIT I FUNDAMENTAL OF QNX OS ARCHITECTURE 6

Overview of QNX OS architecture: microkernel - process manager - standards, protected address spaces - process/thread model - scheduling, Inter - Process Communication (IPC) and synchronization, resource managers and shared objects.

UNIT II PROCESSES, THREADS, AND SYNCHRONIZATION 6

Process management: creation – termination - memory protection, thread management: creation – termination, synchronization techniques: mutexes – semaphores - condition variables and dead lock.

UNIT III INTER-PROCESS COMMUNICATION (IPC) 6

Overview of IPC methods in QNX: message passing – pulses - shared memory, comparing IPC methods: advantages and disadvantages, practical implementation of IPC in QNX.

UNIT IV HARDWARE PROGRAMMING AND TIMING 6

Hardware access methods: IO-mapped and memory-mapped IO, interrupt handling and DMA - safe memory allocation, timing architecture: periodic timing – one shot timing - timeouts.

UNIT V BUILDING AND CONFIGURING QNX BOOT/OS IMAGES 6

Overview of QNX boot/OS image structure, components of a boot image: startup code – kernel - drivers, and scripts, building and loading boot images onto target hardware, resource managers and their implementation.

Total: 30 Hrs

LIST OF PRACTICAL EXPERIMENTS

S. No	CO Mapping	Practical Exercises (30 Hours)
1	CO1	Write an Embedded C program using QNX tool to display any alphanumeric characters using VM (virtual machine) ware.
2	CO1	Write an Embedded C program using QNX tool to display any alphanumeric characters using Raspberry Pi board.
3	CO2	Write an Embedded C program to create a child process and detect its termination using death pulses or wait(). Observe the zombie state before and after the parent handles the child's exit.
4	CO2	Implement any multi-threaded application using POSIX threads (pthread_create). Each thread should process a different part of an array and the main thread should wait for all threads to complete using pthread_join.
5	CO3	Implement a simple Send/Receive/Reply mechanism where a client sends a string to a checksum server, and the server returns the computed checksum. Compute the Embedded C code in both server and client, Build and test communication using the server's PID and CHILD.
6	CO3	Create a server process that registers to receive pulses. Write a client Embedded C program that sends pulses to the server using MsgSendPulse, and the server handle different pulse codes.

7	CO4	Implement an Embedded C program to handle hardware interrupts using an interrupt service thread. Use InterruptWait() in a loop to wait for and respond to interrupt notifications.
8	CO4	Create a repeating timer that sends pulses, initially at after 5 seconds and then every 1.5 seconds. Implement the timer setup and test it by displaying a message each time a pulse is received.
9	CO5	Create a QNX virtual machine with an increased boot disk size and build a custom boot image. Modify the image to display a message, include an executable, copy it to the target, and reboot to test.
10	CO5	Initialize the device driver and add a write() handler that prints the bytes and data written. Test the functionality using command-line operations on the target system.
11	CO5	Mini project: Design and an implement a QNX-based real time embedded system.

h) Learning Resources

References

1. Hands-on RTOS with Microcontrollers, Brian Amos, Packt Publishing, 2020.
2. Operating System Concepts, Abraham Silberschatz, Peter B. Galvin, Greg Gagne, 9th Edition, Wiley, 2018.
3. QNX Neutrino RTOS User's Guide, QNX Software Systems.
4. Programming for Embedded Systems, Michael Barr, O'Reilly Media.

Online Resources

1. QNX online training: https://www.pisquaretech.com/programdetails
2. QNX training material: https://qnx.software/en/developers/get-started/qnx-everywhere
3. QNX Documentation for SDP 8.0: https://www.qnx.com/developers/docs/8.0/com.qnx.doc.qnxsdp.nav/topic/bookset.html
4. QNXEverywhere page - https://blackberry.qnx.com/en/products/qnx-everywhere
5. QNX Gitlab page - https://gitlab.com/qnx
6. QNX on Reddit: https://www.reddit.com/r/QNX/
7. QNX on StackOverflow: https://stackoverflow.com/questions/tagged/qnx
8. QNX on YouTube: https://www.youtube.com/qnxcam
9. Collection of open-source projects (incl Links) for QNX: https://gitlab.com/qnx/projects
10. Ported libraries that work on QNX: https://github.com/qnx-ports

Course Designers

Experts from Industry	Internal Experts
Mr. Madhusudhan H M, Program Analyst, Pi Square Technologies. Mr. Mohammed Asif Nalband, Pi Square Technologies.	Dr. M. Sahaya Sheela ASP-ECE, Dr. G. Uganya, ASP- ECE, Vel Tech University, Chennai.

BOS-Incharge 3/2/26

HOD-ECE 3/2/26

2/2/26 G. Uganya

Course Code	Course Title	L	T	P	C
10212EC115	**HIGH PERFORMANCE COMMUNICATION NETWORKS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to provide the knowledge of different technologies involved in high performance communication and its Network analysis.

c) Prerequisite

Data Communication Networks

d) Related Courses

Network Security, Network Management, Internet of Things

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the architecture, protocols for ATM and high-speed LANs.	K2
CO2	Illustrate the knowledge of queuing in packet switching networks	K2
CO3	Explain congestion control in TCP and traffic management in ATM.	K2
CO4	Outline the concepts of integrated and differentiated services.	K2
CO5	Relate various protocols supporting QoS.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	-	-	-	-	-	-	-	L	L	-	-	L	-
CO2	H	M	L	L	L	-	-	-	L	L	-	L	L	-
CO3	H	M	L	L	L	-	-	-	L	L	-	L	L	-
CO4	H	-	-	-	-	-	-	-	L	L	-	L	L	-
CO5	H	-	-	-	-	-	-	-	L	L	-	L	L	-

g) Course Content

UNIT I HIGH SPEED NETWORKS 9

Introduction -frame relay networks –ATM protocol architecture -ATM logical connection –ATM cells- ATM service categories -AAL- high speed LANS: the emergence of high speed LANS -Ethernets -fiber channel-wireless LANS

UNIT II CONGESTION AND TRAFFIC MANAGEMENT 8

Queuing Analysis- Queuing Models – Single Server Queues – Effects of Congestion – Congestion Control – Traffic Management – Congestion Control in Packet Switching Networks – Frame Relay Congestion Control.

UNIT III TCP AND ATM CONGESTION CONTROL 12

TCP Flow control – TCP Congestion Control – Retransmission – Timer Management – Exponential RTO backoff – KARN's Algorithm – Window management – Performance of TCP over ATM.

Traffic and Congestion control in ATM – Requirements – Attributes – Traffic Management Frame work, Traffic Control – ABR traffic Management – ABR rate control, RM cell formats, ABR Capacity allocations –GFR traffic management.

UNIT IV INTEGRATED AND DIFFERENTIATED SERVICES 8

Integrated Services Architecture – Approach, Components, Services- Queuing Discipline, FQ, PS, BRFQ, GPS, WFQ – Random Early Detection, Differentiated Services

UNIT V PROTOCOLS FOR QOS SUPPORT 8

RSVP – Goals & Characteristics, Data Flow, RSVP operations, Protocol Mechanisms – Multiprotocol Label Switching – Operations, Label Stacking, Protocol details – RTP – Protocol Architecture, Data Transfer Protocol, RTCP.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Warland & Pravin Varaiya, "High Performance Communication Networks", Jean Harcourt Asia Pvt. Ltd., II Edition, 2001.

2. William Stallings, "High Speed Networks and Internet", Pearson Education, Second Edition, 2002.

Reference Books

1. Irvan Pepelnjk, Jim Guichard and Jeff Apcar, "MPLS and VPN architecture", Cisco Press, Volume 1 and 2, 2003

Online Resources

1. www.networks.com/categories

2. www.nptel/lectures/networking

Course Code	Course Title	L	T	P	C
10212EC116	**NETWORK SECURITY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The course deals with the underlying principles of cryptography and network security. It develops the mathematical tools required to understand the topic of cryptography. It aims to introduce students to the fundamental techniques used in implementing secure network communications, and to give them an understanding of common threats and attacks.

c) Prerequisite

Data Communication Networks

d) Related Courses

None

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Infer OSI security architecture and various cryptographic techniques.	K2
CO2	Summarize the block encryption standards like DES, double DES, Triple DES, AES.	K2
CO3	Interpret symmetric and asymmetric public key cryptosystems	K2
CO4	Explain the need of authentication and various authentication methods HASH, MD5, SHA, etc.,	K2
CO5	Outline the various threats and attacks in internet and mobile networks.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	L	-	L	-	-	-	L	L	-	-	-	-
CO2	H	M	L	-	L	-	-	-	L	L	-	-	L	L
CO3	H	M	-	-	L	-	-	-	L	L	-	L	L	L
CO4	H	-	-	-	L	-	-	-	L	L	-	L	L	L
CO5	H	-	L	L	L	-	-	-	L	L	-	L	L	L

g) Course Content

UNIT I BASIC CIPHERS 9

Services, Mechanisms and Attacks-The OSI Security Architecture – Network Security Model – Classical Encryption Techniques, Symmetric Cipher Model, Substitution Techniques, Transposition Techniques, Steganography.

UNIT II BLOCK CIPHERS 9

Block Ciphers- Simplified Data Encryption Standard -Data Encryption Standard– Block cipher principles block cipher modes of operation – Triple DES-Simplified Advanced Encryption Standard- Advanced Encryption Standard (AES), Blow Fish Algorithm.

UNIT III PUBLIC KEY SYSTEM 9

Public key cryptography: Principles of public key cryptosystems – The RSA algorithm-Key management – Diffie Hellman Key exchange - Elliptic curve arithmetic – Elliptic curve cryptography.

UNIT IV AUTHENTICATION SYSTEM 9

Authentication requirement – Authentication function – MAC – Hash function – Security of hash function and MAC –MD5 – SHA– HMAC – CMAC – Digital signature and authentication protocols - Elliptic curve digital signature algorithm – DSS – EI Gamal – Schnorr – Authentication applications – Kerberos– X.509 Authentication services and Network Access control.

UNIT V INTERNET AND MOBILE SECURITY 9

Internet Firewalls for Trusted System: Roles of Firewalls – Firewall related terminology – Types of Firewalls-Intrusion detection system – Virus and related threats – Countermeasures -Trusted systems, Email Security: Security Services for E-mail – attacks possible through E-mail – establishing keys privacy authentication of the source – Message Integrity – Non-repudiation, mobile device security, IP Security.

Total : 45 Hrs

h) Learning Resources

Text Books

1. William Stallings, Cryptography and Network Security, 7th edition, Pearson Education, 2017
2. Charlie Kaufman, Radia Perlman, Mike Speciner, Network Security, Prentice Hall of India -2002

Reference Books

1. Behrouz A Ferouzan, Cryptography & Network Security, Tata McGraw Hill-2007
2. Man Young Rhee, Internet Security: Cryptographic Principles", "Algorithms and Protocols, Wiley Publications-2003
3. Charles P fleeger, Security in Computing, Prentice Hall of India -2006
4. Ulysess Black, Internet Security Protocols, Pearson Education Asia -2000

Online Resources

1. http://www.herongyang.com/crypto/
2. http://www.cryptographyworld.com/what.htm
3. http://www.cryptography-tutorial.com
4. http://www.sans.org/reading-room/whitepapers/modeling/network-security-model 2843
5. http://searchsecurity.techtarget.com/definition/Diffie-Hellman-key-exchange
6. https://www.paloaltonetworks.com/resources/learning-center/what-is-an-intrusiondetectionsystem-ids.html
7. https://lyle.smu.edu/~nair/courses/7349/SET.ppt

Practical Aspects

1. The students shall practice the different attacks in virtual environment using kali Linux

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Head of the Department
Electronics & Communication Engineering
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Course Code	Course Title	L	T	P	C
10212EC117	**NETWORK MANAGEMENT**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the information about data communications and network management, SNMP, network management, tools, systems, engineering and applications.

c) Prerequisite

Nil

d) Related Courses

Data communication Networks, Internet of things

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the concept of communication protocols andnetworks architecture	K2
CO2	Explain network management organization models and functional models	K2
CO3	Infer network management tools and system utilities	K2
CO4	Interpret fundamental network management, architecture and applications	K2
CO5	Outline the ATM, broad band access and wireless network management.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	-	-	-	-	-	-	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	-	L	-
CO3	M	M	L	L	L	-	-	-	L	L	-	-	L	-
CO4	M	M	L	L	L	-	-	-	L	L	-	L	L	-
CO5	M	-	-	-	-	-	-	-	L	L	-	L	L	-

g) Course Content

UNIT I INTRODUCTION TO NETWORK MANAGEMENT 9

Network management overview: Analogy of telephone network management - Data and telecommunication network - Distributed computing - TCP/IP based networks - communication protocols and standards - Network management goals, organization architecture and perspectives.

UNIT II SNMP AND ITS MODELS 9

Review of information network and technology - SNMP and network management - basic foundations: Standards, models and languages - network management organization and information models - communication and functional models.

UNIT III NETWORK MANAGEMENT TOOLS, SYSTEMS AND ENGINEERING 9

System utilities management: basic tools - SNMP tools - Protocol analyzer - Network statistics measurement systems - MIB engineering - NMS design - Network management systems.

UNIT IV NETWORK MANAGEMENT AND APPLICATIONS 9

TMN - TMN conceptual model - standards - architecture - management service architecture - integrated view and implementation. Network management applications: configuration management - fault management - performance management - event correlation techniques – security management.

UNIT V ATM AND BROADBAND NETWORK MANAGEME 9

ATM Technology - ATM network management -cable modem technology - cable access network management - fixed broad band wireless access networks - mobile wireless networks.

Total: 45 Hrs

h) Learning Resources

Text Books

1. M. Subramanian, "Network management: principles and practice", Adison-Wesley, 2000

Reference Books

1. James F. Kurose and Keith W. Rose, "Computer networking", Pearson Education,LPE,2003
2. J. Burke, "Network management concepts and practice, A Hands-on approach",Pearson Education, 2000.
3. Larry L. Peterson and Bruce S. Davie, "Computer networks, a system approach", 3rd edition, Elsevier, 2003.

Online Resources

1. http://www.networkcomputing.com/
2. http://www.networkonlineresources.com/

Course Code	Course Title	L	T	P	C
10212EC118	NEXT GENERATION MOBILE NETWORKS	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course gives a comprehensive overview of the current state of the 5G landscape, covering everything from the most likely use cases, to a wide range of technology options and potential 5G system architectures, to spectrum issues.

c) Prerequisite

Nil

d) Related Courses

Internet of Things, Software Defined Networking

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the evolution of 5G systems, standardization and spectrum challenges.	K2
CO2	Explain the architecture of 5G and millimeter wave communication technologies.	K2
CO3	Outline the requirements and fundamental techniques for MTC and D2D communications.	K2
CO4	Classify the various radio access technologies for 5G networks.	K2
CO5	Illustrate the fundamentals, resource allocation and transceiver algorithms for massive MIMO.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	L	L	-	-	-	L	L	-	L	L	-
CO2	M	L	L	L	-	-	-	-	L	L	-	L	L	-
CO3	M	L	M	M	-	-	-	-	L	L	-	L	L	-
CO4	M	L	L	-	-	-	-	-	L	L	-	L	L	-
CO5	M	L	L	-	-	-	-	-	L	L	-	L	L	-

g) Course Content

UNIT I DRIVERS FOR 5G 9

Historical Trend for Wireless Communication - Mobile Communications Generations: 1G to4G – Evolution of LTE Technology to Beyond 4G – Pillars of 5G – Standardization Activities -Use cases and Requirements – System Concept – Spectrum and Regulations: Spectrum for 4G – Spectrum Challenges in 5G – Spectrum Landscape and Requirements – Spectrum Access Modes and Sharing Scenarios.

UNIT II 5G ARCHITECTURE AND MILLIMETER WAVE COMMUNICATION 9

5G Architecture: Software Defined Networking – Network Function Virtualization – Basics about RAN Architecture –High-Level Requirements for 5G Architecture – Functional Architecture and 5G Flexibility – Physical Architecture and 5G Deployment
Millimeter Wave Communication: Channel Propagation – Hardware Technologies for mmW Systems – Deployment Scenarios – Architecture and Mobility – Beamforming – Physical layer Techniques

UNIT III MACHINE TYPE AND D2D COMMUNICATION 9

MTC: Use cases and Categorization – MTC Requirements – Fundamental Techniques for MTC – Massive MTC – Ultra-reliable Low-latency MTC
D2D: from 4G to 5G – Radio Resource Management for Mobile Broadband D2D – Multi- hop D2D Communications for Proximity and Emergency Services – Multi-operator D2D Communication

UNIT IV 5G RADIO ACCESS TECHNOLOGIES 9

Access Design Principles for Multi-user Communications – Multi-carrier with Filtering – Non- orthogonal Schemes for Efficient Multiple Access – Radio Access for Dense Deployments – Radio Access for V2X Communication – Radio Access for Massive Machine-type Communication.

UNIT V MASSIVE MULTIPLE-INPUT MULTIPLE –OUTPUT SYSTEMS 9

MIMO in LTE – Single-user MIMO – Multi-user MIMO – Capacity of Massive MIMO – Pilot Design of Massive MIMO – Resource Allocation and Transceiver Algorithms for Massive MIMO – Fundamentals of Baseband and RF Implementation in Massive MIMO – Channel Models

Total: 45 Hrs

h) Learning Resources

Text Books

1. Asif Oseiran, Jose F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.

2. Jonathan Rodriquez, "Fundamentals of 5G Mobile Networks", Wiley, 2015.

Reference Books

1. Patrick Marsch, Omer Bulakci, Olav Queseth and Mauro Boldi, "5G System Design – Architectural and Functional Considerations and Long Term Research", Wiley,2018.

Online Resources

1. https://www.linkedin.com/learning/5g-technology-strategy-next-generation-mobile-networking.

2. https://onlinecourses.nptel.ac.in/noc23_ee46/preview

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Course Code	Course Title	L	T	P	C
10212EC119	**WIRELESS BODY AREA NETWORKS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to provide the knowledge of the basic concepts of wireless Body Area Networks, its implementation and applications.

c) Prerequisite

Nil

d) Related Courses

Wireless Adhoc and Sensor Networks

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the technical information and challenges in body area networks (WBAN)	K2
CO2	Illustrate the hardware requirements of WBAN	K2
CO3	Outline the network topologies, protocols and standards used for WBAN	K2
CO4	Summarize the various energy harvesting methods for wearable devices.	K2
CO5	Infer various smart applications in real time scenarios for WBAN.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	-	-	-	-	-	-	-	L	L	-	-	L	L
CO2	H	M	L	L	L	-	-	-	L	L	-	-	L	L
CO3	H	-	-	-	-	-	-	-	L	L	-	-	L	L
CO4	H	L	H	L	H	-	-		L	L	-	L	L	L
CO5	H	L	H	L	L	M	-	L	L	L	-	L	L	L

g) Course Content

UNIT I INTRODUCTION TO WBAN 9

Introduction to WBAN –Standard-Architecture-WBAN Layers-Drawbacks of WBAN Network Topologies, Protocols and Standards-Network Topologies – Stand -Alone BAN, Wireless personal Area Network Technologies. Standards – IEEE 802.15.1, IEEE 802.15.13, IEEE 802.15.14, Zigbee, Healthcare system standards.

UNIT II HARDWARE FOR WBAN 9

Wireless communication – RF communication in Body, Wearable Antennas, Matching Network, Propagation, Materials, Base Station, Power considerations, Wireless communication technologies for wearable systems, Wireless Body Area Network – In body and on body communication.

UNIT III SIGNAL PROCESSING 9

Wearability issues -physical shape and placement of sensor, Technical challenges – sensor design, signal acquisition, Constraint on sampling frequency for reduced energy consumption, light weight signal processing, Rejection of irrelevant information, Data mining.

UNIT IV ENERGY HARVESTING FOR WEARABLE DEVICES 9

Solar cell, Vibration based, Thermal based, Human body as a heat source for power generation, Hybrid thermoelectric photovoltaic energy harvests, Thermopiles.

UNIT V APPLICATIONS OF WBAN 9

Monitoring patients with chronic disease, Hospital patients, Elderly patients, Cardiac arrhythmias monitoring, Multi patient monitoring systems, Multichannel Neural recording, Gait analysis, Electronic pill, Sports Medicine and Smart Fabrics.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Guang-Zhong Yang (Ed.), Body Sensor Networks, Springer, 2006.
2. Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian, Body Area Networks, Safety, Security, and Sustainability, Cambridge University Press,2013.
3. Annalisa Bonfiglio, Danilo De Rossi," Wearable Monitoring Systems", Springer, 2011.

Reference Books

1. Annalisa Bonfiglio, Danilo De Rossi ,"Wearable Monitoring Systems", Springer,2011.
2. Zhang, Yuan-Ting, Wearable Medical Sensors and Systems, Springer, 2013.
3. Mehmet R. Yuce, Jamil Y.Khan, Wireless Body Area Networks Technology, Implementation and applications, Pan Stanford Publishing Pte. Ltd, Singapore, 2012.
4. Hang, Yuan-Ting,"Wearable Medical Sensors And Systems",Springer-2013
5. Mehmet R. Yuce, Jamil Y.Khan, "Wireless Body Area Networks Technology, Implementation and Applications", Pan Stanford Publishing Pvt., Ltd, Singapore, 2012
6. Guang-Zhong Yang(Ed.), "Body Sensor Networks, "Springer, 2006
7. Andreas Lymberis, Danilo de Rossi ,Wearable eHealth systems for Personalised Health Management – State of the art and future challenges IOS press, The Netherlands, 2004

Online Resources

1. https://www.youtube.com/watch?v=60zAe27su_E
2. https://www.youtube.com/watch?v=nO966MeDAHo
3. https://www.youtube.com/watch?v=Ijr822gxiZI
4. https://www.youtube.com/watch?v=DsVvBZQkHaM
5. https://www.youtube.com/watch?v=3M5KD4e1mdU

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Course Code	Course Title	L	T	P	C
10212EC209	**SOFTWARE DEFINED NETWORKING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

The primary aim of this course is to introduce about software defined networking, an emerging paradigm in computer networking that allows a logically centralized software program to control the behavior of an entire network.

c) Prerequisite

Data Communication Networks

d) Related Courses

Network Management, Internet of Things

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the key benefits of SDN by the separation of dataand control planes	K2
CO2	Outline the concepts of SDN data plane devices and Open flow Protocols	K2
CO3	Relate the SDN control plane with different controllers	K2
CO4	Summarize the Network services and applications in SDN	K2
CO5	Interpret the Network Functions Virtualization components and their roles in SDN	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	-	-	-	-	L	-	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	-	L	-
CO3	M	L	-	-	M	-	-	-	L	L	-	-	L	-
CO4	M	L	-	-	M	-	-	-	L	L	-	L	L	-
CO5	M	L	-	-	M	-	-	-	L	L	-	L	L	-

g) Course Content **Total : 30 Hrs**

UNIT I SDN BACKGROUND AND MOTIVATION 6

Evolving network requirements-The SDN Approach: Requirements, SDN Architecture, Characteristics of Software-Defined Networking, SDN and NFV-Related Standards: Standards-Developing Organizations, Industry Consortia, Open Development Initiatives.

UNIT II SDN DATA PLANE AND OPENFLOW 6

SDN data plane: Data plane Functions, Data plane protocols, Open flow logical network Device: Flow table Structure, Flow Table Pipeline, The Use of Multiple Tables, Group Table- Open Flow Protocol.

UNIT III SDN CONTROL PLANE 6

SDN Control Plane Architecture: Control Plane Functions, Southbound Interface, Northbound Interface, Routing, ITU-T Model- Open Daylight-REST- Cooperation and Coordination among Controllers.

UNIT IV SDN APPLICATION PLANE 6

SDN Application Plane Architecture: Northbound Interface, Network Applications, User Interface- Network Services Abstraction Layer: Abstractions in SDN, Frenetic- Traffic Engineering Measurement and Monitoring- Security- Data Center Networking- Mobility and Wireless**.**

UNIT V NETWORK FUNCTIONS VIRTUALIZATION 6

Background and Motivation for NFV- Virtual Machines- NFV Concepts: Simple Example of the Use of NFV, NFV Principles, High-Level NFV Framework, NFV Benefits and Requirements.

h) Laboratory **Total : 30 Hrs**

List of experiments

S. No	Practical Exercises	Course Outcome
1	Network Topology creation and REST API introduction.	CO2
2	Create a network and run a simple performance test.	CO2
3	Dynamically change the forwarding rules.	CO2
4	Mininet Random Topology Generator.	CO2
5	Influencing flows via c URL commands.	CO3
6	Use –ovs-vsctl command to directly control open v switch.	CO3
7	Dynamically change the network parameters-link delay analysis.	CO4

Total: 60 Hrs

h) Learning Resources

Text Books

1. William Stallings, Foundations of Modern Networking, Pearson Ltd., 2016.

2. Software Defined Networks: A Comprehensive Approach by Paul Goransson and Chuck Black, Morgan Kaufmann Publications, 2014

Reference Books

1. Feamster, Nick, Jennifer Rexford, and Ellen Zegura. "The road to SDN: an intellectual history of programmable networks." ACM SIGCOMM Computer Communication Review 44.2 : 87-98., 2014

2. Kreutz, Diego, et al. "Software-defined networking: A comprehensive survey." Proceedings of the IEEE 103.1 : 14-76, 2015

3. Thomas D. Nadeau & Ken Gray, O'Reilly, "SDN- Software Defined Networks" ,2013

Online Resources

1. https://www.digimat.in/nptel/courses/video/108107107/L01.html

2. https://www.classcentral.com/subject/sdn

3. https://onlinecourses.nptel.ac.in/noc23_ee121/preview

Course Code	Course Title	L	T	P	C
10212EC210	**COGNITIVE RADIO NETWORKS**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

The primary aim of this course is to introduce an intelligent wireless communication system that is aware of its surrounding environment, learns from the environment and adapts its internal states to statistical variations in order to achieve predefined objectives.

c) Prerequisite

Data Communication Networks

d) Related Courses

Software Defined Networking, Network Security, Network management

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the fundamentals of SDR and its transformation to cognitive radio networks	K2
CO2	Outline the various spectrum sensing techniques for single and multi-band applications	K2
CO3	Illustrate the concepts of cooperative spectrum sensing and handoff process	K2
CO4	Infer the challenges of MAC & network layer and its protocols	K2
CO5	Classify the various security attacks and its counter measures	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	-	-	-	-	-	-	-	M	M	-	-	-	-
CO2	H	L	L	L	M	-	-	L	M	M	L	L	L	L
CO3	H	-	-	L	M	-	-	L	M	M	L	L	L	L
CO4	H	L	L	L	M	-	-	L	M	M	L	L	L	L
CO5	H	-	-	L	M	-	-	L	M	M	L	L	L	L

g) Course Content **Total : 30 Hrs**

UNIT I INTRODUCTION TO COGNITIVE RADIO **6**

Introduction –Software Defined Radio: Architecture–Digital Signal Processor and SDR Baseband architecture – Reconfigurable Wireless Communication Systems – Digital Radio Processing –Cognitive Radio: Cognitive radio Framework – Functions – Paradigms of Cognitive Radio

UNIT II SPECTRUM SENSING **6**

Introduction –Spectrum Sensing – Multiband Spectrum Sensing – Sensing Techniques – Other algorithms -Comparison – Performance Measure & Design Trade-Offs: Receiver operating characteristics – Throughput Performance measure –Fundamental limits andtrade-offs

UNIT III COOPERATIVE SPECTRUM ACQUISITION **6**

Basics of cooperative spectrum sensing–Examples of spectrum acquisition techniques – cooperative transmission techniques – sensing strategies– Acquisition in the Presence of Interference: Chase combining HARQ – Regenerative cooperative Diversity– spectrumoverlay– spectrum handoff

UNIT IV MAC PROTOCOLS AND NETWORK LAYER DESIGN **6**

Functionality of MAC protocol in spectrum access –classification –Inter frame spacing and MAC challenges – QOS –Spectrum sharing in CRAHN –CRAHN models – CSMA/CA based MAC protocols for CRAHN – Routing in CRN– Centralized and Distributed protocols – Geographical Protocol

UNIT V TRUSTED COGNITIVE RADIO NETWORKS **6**

Trust for CRN: Fundamentals – Models – Effects of Trust Management – Security properties in CRN – Route Disruption attacks –Jamming attacks –PU Emulation attacks.

h) Laboratory **Total : 30 Hrs**

List of experiments

S. No	Practical Exercises (30 Hrs)	Course Outcome
1	Analyze the impact of pulse shaping and matched filtering using Software Defined Radio.	CO1
2	Simulate small scale fading and large scale fading in wireless network.	CO2
3	Plot SNR Vs Probability of Detection for energy detection in Cognitive Radio systems.	CO2
4	Plot SNR Vs Probability of Detection for matched filter detection in Cognitive Radio Systems.	CO2
5	Plot SNR Vs Probability of False Alarm for Spectrum Sensing in Cognitive Radio Networks.	CO2
6	Plot Detection Probability Vs False Alarm Probability for matched filter Detection in Cognitive Radio Systems.	CO2
7	Optimization in Cooperative Spectrum Sensing in Cognitive Radio Systems.	CO3
8	Study of CRCN Simulator (Cognitive Radio Cognitive Network) using NS3.	CO4
9	Mini Project.	CO4

Total : 60 Hrs

i) Learning Resources

Text Books

1. Mohamed Ibnkahla, "Cooperative Cognitive Radio Networks: The complete SpectrumCycle" I edition, 2014
2. Ahamed Khattab, Dmitri Perkins, Bagdy Byoumi, "Cognitive Radio Networks fromTheory to practice", 2013.

Reference Books

1. Kwang– Cheng Chen and Ramjee Prasad, "Cognitive Radio Networks, Wiley Publication, 2009.
2. Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou," Cognitive Radio Communications and Networks". I edition, 2010.

Online Resources

1. www. nptel/Cognitive Radio and Wireless Communications
2. https://www.iitk.ac.in/eeold/archive/courses/2013/wireless/topics.html

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Course Code	Course Title	L	T	P	C
10212EC211	**WIRELESS SENSOR NETWORKS AND ITS APPLICATION**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course will provide students with an understanding of wireless sensor networks enable them to recognize the wide range of applicability of these networks and provide them with an understanding of the major design issues including topics such as protocol mechanisms and resource constraints

c) Prerequisite

Nil

d) Related Courses

Data Communication Networks, Internet of Things

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the fundamental concepts of wireless sensor networks architecture and protocol standards.	K2
CO2	Summarize the MAC protocol design issues and Formation of MAC protocol for wireless sensor networks.	K2
CO3	Infer the routing protocols for wireless sensor networks with respect to power efficient.	K2
CO4	Outline the concepts of transport layer and stating main ideas of congestion avoidance.	K2
CO5	Illustrate the node localization approaches and the applications in real time.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	-	-	-	-	-	-	-	L	L	-	-	L	L
CO2	H	L	L	L	L	-	-	-	L	L	-	L	L	L
CO3	H	L	L	L	L	-	-	-	L	L	-	L	L	L
CO4	H	L	L	L	L	-	-	-	L	L	-	L	L	L
CO5	H	L	L	L	L	-	-	-	L	L	-	L	L	L

g) Course Content **Total : 30 Hrs**

UNIT I INTRODUCTION 6

Introduction to Wireless Sensor Networks, Motivation, Performance Requirement, Wireless Sensor Network Architecture: Protocols and Standards - Sensing and Communication Range. Hardware components, Energy consumption of sensor nodes

UNIT II MAC PROTOCOLS FOR WSN 6

Medium Access Control Protocols for Wireless Sensor Networks Fundamentals of MAC Protocols, Performance Requirements, Types of MAC protocols-Schedule-Based and Random Access-Based Protocols.

UNIT III ROUTING PROTOCOLS FOR WSN 6

Routing Protocols for Wireless Sensor Networks Fundamentals of Routing Protocols, Performance Requirements, outing Strategies in Wireless Sensor Networks - Flooding and its variants, LEACH & LEACH-C Power-Efficient Gathering in Sensor Information Systems.

UNIT IV TRANSPORT LAYER IN WSN 6

Traditional Transport Control Protocols-TCP, UDP; Feasibility of Using TCP or UDP for WSNs, Transport Protocol Design Issues, Existing Transport Control Protocols-CODA (Congestion Detection and Avoidance), ESRT (Event-to-Sink Reliable Transport) Performance of Transport Control Protocols.

UNIT V LOCALIZATION AND APPLICATIONS 6

Localization approaches-proximity, trilateration and triangulation. Sensor node hardware-Berkeley Motes, Node levels of software platforms-NS2/NS3& Cup carbon Simulator-Case study: Clustering, Energy, Routing - Localization- QoS Models.

LIST OF EXPERIMENTS **Total : 30 Hrs**

S.No.	Practical Exercises	CO Level	Skill Level
1.	Create a sample wireless topology by Node creation and Deployment	CO1	S2
2.	Configuring a Network Using Routing Protocols	CO1	S2
3.	To execute a Power Efficient and Delay Aware MAC protocol	CO2	S2
4.	Executing a Proactive and Reactive based MAC protocol	CO2	S2
5.	Cluster Formation & Cluster Head Election	CO3	S2
6.	Routing in wireless sensor network using AODV	CO3	S2
7.	Executing User Datagram Protocol (UDP)	CO4	S2
8.	To Execute Congestion Detection and avoidance protocol	CO4	S2
9.	Localization using TOA	CO5	S2
10.	Demonstrate any QoS model	CO5	S2

Total : 60 Hrs

h) Learning Resources

Text Books

1. C.Siva Ram Murthy and B.S.Manoj, "AdHoc Wireless Networks: Architectures and Protocols ", Pearson Education, 2008.
2. Labiod. H, “Wireless Adhoc and Sensor Networks”, Wiley, 2008.

Reference Books

1. Carlos DeMorais Cordeiro, Dharma Prakash Agrawal “AdHoc & Sensor Networks: Theory and Applications”, World Scientific Publishing Company, 2nd edition, 2011.
2. Li, X, “Wireless ad-hoc and sensor Networks: theory and applications”, Cambridge University Press, 2008.
3. Kazem Sohraby, Daniel Minoli, & Taieb Znati,“Wireless Sensor Networks Technology, Protocols, and Applications”, JohnWiley, 2007.
4. Anna Hac, “Wireless Sensor Network Designs”, John Wiley, 2003.
5. Feng Zhao and Leonides Guibas, "Wireless Sensor Networks", Elsevier Publication Holger Karl and Andreas Willig “Protocols and Architectures for Wireless Sensor Networks”, Wiley, 2005.

Online Resources:

1. https://www.netacad.com/courses/packet-tracer
2. https://www.nsnam.org/

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Course Code	Course Title	L	T	P	C
10212EC212	**FLYING IOT**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to provide the hands on experience on design, fabrication and flying of Unmanned Arial Vehicle category aircraft. Students will get in-depth skill set on design and fabrication techniques of Unmanned Arial Vehicle.

c) Prerequisite

Nil

d) Related Courses

Network Security, Internet of Things

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the fundamental concepts of aerodynamics, propulsion & structures of model aircrafts.	K2
CO2	Classify the payloads, sensors and measuring devices using in UAV.	K2
CO3	Explain the concept of navigation and guidance system of aerial robot.	K2
CO4	Illustrate the design process of drones and software tools.	K2
CO5	Infer the drone application for plant health monitoring and soil field analysis	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	L	-	-	-	L	L	L	-	-	-	-
CO2	M	L	L	L	-	-	-	-	L	L	-	-	L	L
CO3	M	L	L	L	L	-	-	L	L	L	-	L	L	L
CO4	M	L	L	L	L	-	-	L	L	L	-	L	L	L
CO5	M	L	L	L	L	L	L	L	L	L	L	L	L	L

g) Course Content **Total : 30 Hrs**

UNIT I UNMANNED AERIAL VEHICLE 6

Difference between aircraft and UAV - Parts and functions of Fixed, Rotorcraft and flapping wing UAV – various History of UAV's, Types of Drones, Applications and Uses. Characteristics of Multi rotor vehicle, Fixed Wing vehicle, Flapping wing Vehicles and their applications – Defence, Civil, Environmental monitoring (physical, chemical and biological).

UNIT II PAYLOADS FOR UAV 6

Payloads – Classification of Payloads – camera – sensors – radars – various measuring devices – classification of payload based on applications – Hyper spectral sensors – laser detection and range – synthetic aperture radar – thermal cameras – ultra sonic detectors - case study on payloads.

UNIT III NAVIGATION AND GUIDANCE SYSTEM OF AERIAL ROBOT 6

Flight Control System –Path planning- Way point Navigation system-GPS – GCS-Telemetry – Transmitter & Receiver.

UNIT IV DRONE SOFTWARE TOOL AND TELEMETRY 6

Introduction to ArduPilot, System components, peripheral hardware, Mission planner, Mav Proxy. Wireless communication modules and topology, Zig-bee, Bluetooth, LORA, Zero power devices, Energy Harvesting technology.

UNIT V PLANT HEALTH MONITORING AND TECHNOLOGIES FOR FARMING 6

Measurement of leaf health, chlorophyll detection, ripeness level, crop mapping, fertilizing, Drone technology for soil field analysis and assistive operations. Water quality monitoring, micro-irrigation system, solar pump and lighting system, Fencing, Android based automation, Agricultural Robots, Standards for agriculture

Laboratory **Total : 30 Hrs**

List of Experiments

S. No	Practical Exercises (30 Hrs)
1	Making of Drone
2	Auto Pilot Simulation
3	Path Planning for UAV
4	Swarm of UAV's
5	Communication among UAV's
6	Communication with drones
7	Smart Irrigation systems
8	Smart Farming systems

Total: 60 Hrs

h) Learning Resources

Text Book

1. Andey Lennon "Basics of R/C model Aircraft design" Model airplane news publication, October 1996.

References Book

1. Smart Agriculture: An Approach towards Better Agriculture Management: Editor: Prof. Dr. Aqeel-ur-Rehman, OMICS, 2015.
2. Daniel Tal, Jon Altschuld "Group. Drone Technology in Architecture, Engineering and Construction: A Strategic Guide to Unmanned Aerial Vehicle Operation andImplementation" February 2021.

Online resources

1. https://ardupilot.org/
2. https://dojofordrones.com/drone-programming/
3. https://pythonprogramming.net/building-quadcopter-tutorial-intro/

Course Code	Course Title	L	T	P	C
10212EC120	ADVANCED DIGITAL SIGNAL PROCESSING	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

Advanced Digital Signal Processing provides knowledge about estimation and prediction of signals. It covers parametric and nonparametric models of spectrum estimation, linear prediction, adaptive filtering techniques and methods of signal analysis.

c) Prerequisite

Discrete Time Signal Processing

d) Related Courses

DSP Algorithms and Architecture, Estimation theory

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level(Based on Revised Bloom's Taxonomy)
CO1	Explain various power spectrum estimation techniques in system modelling.	K2
CO2	Describe various lattice filter structures for adaptive signal processing	K2
CO3	Apply the concepts of linear prediction and filtering on discrete time signals.	K3
CO4	Illustrate various adaptive filter algorithms and their applications.	K2
CO5	Make use of different transformation techniques for signal analysis	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	M	-	-	-	-	L	L	-	L	L	M
CO2	H	M	M	M	L	-	-	-	L	L	-	L	L	M
CO3	H	M	M	M	L	-	-	-	L	L	-	L	L	M
CO4	H	M	M	M	L	-	-	-	L	L	-	L	L	M
CO5	H	M	M	M	-	-	-	-	L	L	-	L	L	M

g) Course Content

UNIT I SPECTRUM ESTIMATION 9

Nonparametric Methods: Periodogram, Modified Periodogram, Bartlett method, Welch method, Blackman Tukey method, Performance comparisons-Parametric Methods: AR, MA, ARMA Signal modeling- The Yule Walker method for the AR model parameters- The Burg's method for the AR model parameters.

UNIT II LATTICE FILTERS 9

FIR Lattice Filter- Split Lattice Filter- IIR Lattice Filters: All-pole Filter, Other All-pole Lattice Structures, Lattice Filters Having Poles and Zeros- Lattice Methods for All-Pole Signal Modeling: The Forward Covariance Method, The Backward Covariance Method-Stochastic Modeling

UNIT III LINEAR PREDICTION AND FILTERING 9

Linear prediction: Forward Linear Prediction, Backward Linear Prediction- The Levinson-Durbin Algorithm- Wiener filter: FIR Wiener Filter, IIR Wiener Filter- Discrete Kalman Filter.

UNIT IV ADAPTIVE FILTERS AND APPLICATIONS 9

FIR Adaptive filters-Adaptive filters based on steepest descent method-LMS Adaptive algorithm -Adaptive channel equalization-Adaptive echo cancellation -Adaptive noise cancellation-Adaptive recursive filters –Recursive least squares: Exponentially Weighted RLS, Sliding Window RLS.

UNIT V TIME-FREQUENCY ANALYSIS 9

Short-Time Fourier Analysis: Time-Frequency Resolution, The Uncertainty Principle, The Spectrogram, Reconstruction- Spectral Subtraction based on the STFT-Wavelet Transform: Wavelets for Time-Scale Analysis, Wavelet Series, Discrete Wavelet Transform.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Monson H.Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons, 2002. (Unit I to IV)
2. Alfred Mertins, "Signal Analysis: Wavelets, Filter Banks, Time-Frequency Transforms and Applications", John Wiley & sons, 1999. (Unit V)

Reference Books

1. John G.Proakis and Dimitris G.Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", 3rd edition, Prentice Hall of India, 2001.
2. Simon Haykin, "Adaptive Filter Theory", 2nd Edition, Prentice Hall India, 2001.
3. Roberto Crist, "Modern Digital Signal Processing", Thomson Brooks/Cole, 2004.
4. Saeed V. Vaseghi, "Advanced Digital Signal Processing and Noise Reduction", 2nd Edition, John Wiley and Sons, 2008.

Online resources

1. https://nptel.ac.in/courses/117101001 - Advanced Digital Signal Processing - Multirate and wavelets.
2. https://www.youtube.com/watch?v=DaSijOex6rM - Adaptive Filter applications.

Course Code	Course Title	L	T	P	C
10212EC121	**ESTIMATION THEORY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides an introduction to random variables, parameter estimation in presence of noise and the different types of optimum filtering algorithms based on the probabilistic and stochastic processes. It also covers signal modeling, adaptive filtering & its applications.

c) Prerequisite

Nil

d) Related Courses

Signal Processing Techniques for Speech Recognition

e) Course Outcomes

On successful completion of the course, the students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain basic constituents of a random variable	K2
CO2	Discuss concepts related to parameter estimation techniques	K2
CO3	Summarize the various practical estimators	K2
CO4	Describe the different bayesian estimators	K2
CO5	Apply the wiener filtering techniques in signal processing applications	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	-	H	-	-	-	-	L	-	-	L	-	-
CO2	H	H	-	M	-	-	-	-	L	L	-	L	L	L
CO3	H	H	M	L	-	-	-	-	L	L	-	L	L	L
CO4	H	M	L	L	M	-	-	-	L	L	-	L	L	L
CO5	H	H	H	L	-	-	-	-	L	L	-	L	L	L

g) Course Content

UNIT I REVIEW OF RANDOM VARIABLES 9

Introduction of Random Variables, Spectral Representation of Random Signals, Wiener Khinchine Theorem, Properties of Power Spectral Density, Gaussian Process and White Noise Process, Linear System with Random input, Spectral Factorization Theorem and its importance.

UNIT II PARAMETER ESTIMATION THEORY 9

Principle of Estimation and Applications, Properties of Estimates, Unbiased and Consistent Estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer-Rao bound.

UNIT III PRACTICAL ESTIMATORS 9

BLUE, Maximum likelihood Estimators, Asymptotic Properties of MLE, Least Squares, Linear and Nonlinear Techniques, Method of Moments

UNIT IV BAYESIAN ESTIMATORS 9

Risk Functions, MMSE Estimators, MAP Estimators, Linear Bayesian Estimators, Vector Parameter Estimation, Sequential Estimators

UNIT V GAUSSIAN NOISE SIGNAL ESTIMATORS 9

Wiener Filters, Noise Cancellation, Lattice Representation for the FIR Wiener Filter, IIR Weiner Filter Kalman filters, MATLAB implementation of Wiener Filters

Total 45 Hrs

h) Learning Resources

Text Books

1. Fundamentals of Statistical Signal Processing: Estimation Theory, Volume I, Steven M Kay, Pearson, 2010
2. Monson H. Hayes, **"**Statistical Digital Signal Processing and Modeling," John Wiley & Sons, 2008.
3. H. Stark and J. Woods, "Probability and Random Processes with Applications to Signal Processing", 3rd edition, Pearson Education, 2001

Reference Books

1. John G. Proakis "Algorithms for Statistical Signal Processing", Pearson Education,2002.
2. Dimitris G. Manolakis "Statistical and Adaptive Signal Processing", Tata McGraw Hill, 2000.
3. Papoulis and S. Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes",Fourth Edition, McGraw Hill, 2002.

Online Resources

1. https://www.coursera.org
2. https://www.upgrad.com
3. https://www.udemy.com

Course Code	Course Title	L	T	P	C
10212EC122	**DSP ALGORITHMS AND ARCHITECTURE**	**3**	**0**	**0**	**3**

a) Course Category:

Programme Elective

b) Preamble

DSP algorithms and Architecture course provides an introduction on the industry-based DSP processor's architecture and their algorithms. This course will give a platform to learn about the addressing modes, instruction set and memory allocation of the TMS320C67XX processor.

c) Prerequisite

Discrete Time Signal Processing

d) Related Courses

Signal Processing Techniques for Speech Recognition

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the digital signal processing algorithm and the various processor architectures.	K2
CO2	Summarize the basic signal processing concepts and architectures of DSP processor.	K2
CO3	Describe the interfacing concepts of external memory, serial and parallel I/O devices.	K2
CO4	Illustrate the basic DSP algorithms in TMS320C67XX processor.	K3
CO5	Identify the development tools and blocks involved in DSP applications.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	-	-	-	L	L	-	M	-	-
CO2	M	-	L	-	-	-	-	-	L	L	-	L	-	-
CO3	M	L	L	L	-	-	-	-	L	L	-	L	M	-
CO4	L	M	L	L	M	L	-	-	L	L	-	L	L	-
CO5	L	L	H	L	H	M	-	-	L	L	-	L	M	-

g) Course Content

UNIT I ARCHITECTURES FOR PROGRAMMABLE DIGITAL SIGNAL PROCESSORS 9

Basic Digital Signal Processor's Architectural Features – DSP Computational Building Blocks– Bus Architecture and Memory – Data Addressing Capabilities – Address Generation Unit – Programmability and Program Execution – Features for External Interfacing, Difference between DSP and other microprocessor architectures

UNIT II PROGRAMMABLE DIGITAL SIGNAL PROCESSORS 9

Introduction, Commercial digital Signal processing Devices, TMS320C67XX Processor: Data Addressing Modes- Memory Space-Program Control-Techniques for enhancing computational throughput, Detail Study of Instructions and Programming-On-Chip peripherals -Interrupts – Pipeline Operation.

UNIT III PERIPHERAL INTERFACING WITH DSP PROCESSOR 9

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), Synchronous Serial Interface.

UNIT IV IMPLEMENTATION OF BASIC DSP ALGORITHMS 9

Introduction, the Q-notation, FIR Filters, IIR Filters, Interpolation and Decimation Filters (one example in each case), Poly-phase decomposition, Implementation of FFT Algorithms: Overflow and Scaling–Bit Reversed Index Generation–Implementation on the TMS320C67XX

UNIT V DEVELOPMENT TOOLS AND APPLICATIONS OF DSP PROCESSOR 9

DSP Development Tools – The DSP System Design Kit (DSK) – The Assembler and the Assembly Source File – The Linker and Memory Allocation – The Code Composer Studio. Building blocks involved in a DSP Based Bio-telemetry Receiver and Image Processing Algorithms.

Total: 45 Hrs

h) Learning Resources

Text Books

1. AvtarSingh and S.Srinivasan, "Digital Signal Processing", 4th edition, Thomson Publications, 2004
2. SenM.Kuo, Woon-SengS.Gan, "Digital Signal Processor-Architectures, Implementation and Applications", Pearson Prentice Hall, 2005.

Reference Books

1. PeterPirsch,"Architectures for Digital Signal Processing", 2ndedition, JohnWeily, 2007
2. B.Venkataramani and M.Bhaskar, "Digital Signal Processors, Architecture, Programming and Applications", 2 Editions, TMH, 2004.
3. Jervis, "Digital Signal Processing-A practical approach", 4thedition, Pearson Education, 2004.
4. J.G.Proakis, "Algorithms for Statistical Signal Processing", 4thedition, Pearson, 2002.
5. TMS320C50,TMS320C54XX,TMS320C6713databooks

Online Resources

1. http://www.ti.com/product/TMS320C6713/technicaldocuments
2. http://www.ti.com/tool/tmdsdsk6713

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Course Code	Course Title	L	T	P	C
10212EC123	**SIGNAL PROCESSING TECHNIQUES FOR SPEECH RECOGNITION**	**3**	**0**	**0**	**3**

a) Course Category

Programme elective

b) Preamble

This course provides concepts, methodology and analysis of speech signals. It covers mathematical foundations required for speech signal processing. This course includes deterministic and statistical approach of speech recognition techniques and performance measures to analyze the speech recognition systems.

c) Prerequisite

Nil

d) Related Courses

Digital Image and Video Processing

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on RevisedBloom's Taxonomy)
CO1	Describe the fundamentals of speech production and speech perception.	K2
CO2	Apply time and frequency domain characteristics of speech signals for speech analysis.	K3
CO3	Explain the various signal processing methods in performing speech recognition.	K2
CO4	Illustrate hidden markov model and language models for training statistical speech recognition system.	K3
CO5	Summarize the various isolated word recognition approaches and relate them for command and control applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	L	L	-	-	-	-	-	-	-	L	L	-
CO2	H	M	L	L	L	-	-	-	L	L	-	L	M	L
CO3	H	M	L	L	L	-	-	-	L	L	-	L	M	L
CO4	H	H	M	M	L	-	-	-	L	L	-	L	M	L
CO5	H	M	M	M	L	-	-	-	L	L	-	L	M	L

g) Course Content

UNIT I SPEECH PRODUCTION AND PERCEPTION 8

Speech Production mechanism – Articulatory phonetics - Acoustic phonetics – Discrete time modelling of Speech production – coarticulation - prosody - Auditory perception – Human auditory system - perception of sound - psychoacoustics.

UNIT II SHORT TIME SPEECH ANALYSIS 10

Speech signal analysis – segmental, sub-segmental and supra-segmental levels - Methods for extracting the short time Energy, Average Magnitude – Zero crossing Rate – Short Time Auto Correlation Function – Pitch period estimation using Auto Correlation Function. Short time Fourier analysis – Formant Estimation, Mel Frequency Feature Extraction.

UNIT III SIGNAL PROCESSING METHODS FOR SPEECH RECOGNITION 8

Filter Bank Model for Speech Recognition – LPC model for speech recognition – Vector Quantization Model – Elements of VQ, Training, Similarity Measure and Clustering of Training vectors.

UNIT IV SPEECH RECOGNITION USING STATISTICAL MODEL 10

Introduction to Markov Chain – Hidden Markov Models – HMMs for speech Recognition Three basic problems in HMM – Types of HMMs – Implementation Issues - Language Models - Performance Measures for ASR systems.

UNIT V SPEECH RECOGNITION BASED ON CONNECTED WORD MODELS AND ITS APPLICATIONS 9

Isolated Word Recognition – Linear Time Warping, Dynamic Time Warping, End-point detection - Connected Word Recognition – two level dynamic programming algorithm, Level Building Algorithm - Command and Control Applications using isolated word recognition.

Total: 45 Hrs

h) Learning Resources

Text Books

1 Lawrence Rabiner and Biing-Hwang Juang, "Fundamentals of Speech Recognition", 1st edition, Pearson Education, 2003. (Unit – 1, 3, 4)
2 Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc., Singapore, 2004. (Unit -1, 5, 4)

Reference Books

1 L.R. Rabiner and S. W. Schafer, "Digital Processing of Speech Signals", Pearson Education, 2007. (Unit – 2)
2 Thomas F Quatieri, "Discrete-Time Speech Signal Processing – Principles and Practice", Pearson Education, 2006.
3 Douglas O'Shaughnessy, "Speech Communications Human and Machine" – Second Edition Universities Press, Electrical Engineering, 2004.

Online resources

1 https://www.youtube.com/watch?v=GxkzxTFvhDU (Overview of ASR systems)
2 https://www.youtube.com/watch?v=EMmckCO9QhA&list=PLvv3PyiCcNrFuT7CEIvIr4a4g4orascx3 (Speech Production, Time Domain Analysis, Feature Extraction)
3 https://www.youtube.com/watch?v=E3qrns5f3Fw (Hidden Markov Model)

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Course Code	Course Title	L	T	P	C
10212EC124	**ANN AND DEEP LEARNING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course covers the fundamentals from Artificial Neural Network to the current trending topic of Convolution Neural Network. Deep Learning is one of the most exciting and promising segments of Artificial Intelligence and machine learning technologies.

c) Prerequisite

Nil

d) Related Courses

Fuzzy Neural systems

e) Course Outcomes

On successful completion of the course, the students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts in neural networks and applications	K2
CO2	Describe feed forward networks and their training issues	K2
CO3	Summarize different types of ANN architectures	K2
CO4	Apply the deep learning concepts for real time applications	K3
CO5	Demonstrate various CNN architectures for object detection	K3

f) Correlation of COs with Pos and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	H	H	-	-	L	-	-	-	-	-	-	M	-	M
CO2	H	H	M	M	L	-	-	-	-	-	-	M	L	M
CO3	H	H	M	M	L	-	-	-	-	-	-	M	L	M
CO4	H	H	M	M	L	-	-	-	M	M	-	M	L	M
CO5	H	H	H	H	L	-	-	-	M	M	-	M	L	M

g) Course Content

UNIT I INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS 9

Fundamentals of Neural Networks – Biological neuron – Artificial Neuron – Learning Methods – Activation functions -- Taxonomy of Neural Network Architectures – McCulloch Pitts model, linear separability, Hebb model – Applications

UNIT II FEED FORWARD NEURAL NETWORKS 9

Perceptron Models: Discrete, Continuous and Multi-Category – MLP – Training Algorithms of Perceptron Networks – Limitations of the Perceptron model – Adaline network, Medaline network, Generalized Delta Rule, Derivation of Back propagation (BP) Training algorithm

UNIT III OTHER ANN ARCHITECTURES 9

Associative Memory – Exponential BAM – Associative Memory for Real Coded Pattern Pairs – Applications Adaptive Resonance Theory – Introduction – ART 1 – ART2 – Applications – Neural Networks Based On Competition – Kohenen Self Organizing Maps – Learning VectorQuantization – Counter Propagation Networks – Industrial Applications.

UNIT IV DEEP LEARNING 9

Deep Feed Forward network, training deep neural networks, problem and solution of under fitting and over fitting, Cross validation, Regularization, Hyper parameters, Back propagation, Setup and initialization issues, vanishing and exploding Gradient problems, Gradient Descent strategies, Batch normalization, Case study on feed forward neural network : Loan approval.

UNIT V CONVOLUTIONAL NEURAL NETWORK 9

Introduction to Convolutional Neural Network, Architectural Overview, Layers, Filters, Convolution and Pooling Operation, Parameter sharing, Case Studies: AlexNet, GoogLeNet, Mobilenetv1, ResNet – Application: Object Detection.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Laurene Fausett, Fundamentals of Neural networks: architectures, algorithms and applications, Pearson India, 2008. .(UNIT I, UNIT II, UNIT III)
2. CharuC.Aggarwal "Neural Networks and Deep learning" Springer International Publishing, 2018. (UNIT IV, UNIT V)

Reference Books

1. Sivanandam, Deepa, Principles of Soft Computing, Second Edition, Wiley India, 2011.
2. Pattanayak, Santanu, Pattanayak, and Suresh John, "Pro deep learning with tensorflow", New York, NY, USA, Apress, 2017.
3. Satish Kumar, "Neural Networks, A Classroom Approach", Tata McGraw -Hill, 2007.
4. Simon Haykin, "Neural Networks, A Comprehensive Foundation", 2nd Edition, Addison Wesley Longman, 2001.

Online Resources

1. http://neuralnetworksanddeeplearning.com/
2. https://machinelearningknowledge.ai/category/deep-learning/
3. https://www.deeplearningbook.org/contents/optiization.html
4. https://nptel.ac.in/courses/106/106/106106224/ Deep Learning for Computer Vision, IIT Hyderabad
5. http://neuralnetworksanddeeplearning.com/ Michael Nielsen, "Neural Networks and Deep Learning", Determination Press, 2015.

Course Code	Course Title	L	T	P	C
10212EC125	**FUZZY-NEURAL SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course covers the fundamentals of Fuzzy systems and Neural Networks. Fuzzy logic is a form of multi-valued logic to deal with reasoning. Also, it can be used in handling ambiguity and uncertainty in complex problem. Neural networks can be trained to learn complex patterns and provide suitable solutions.

c) Prerequisite

Nil

d) Related Courses

ANN and Deep Learning.

e) Course Outcomes

On the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the fundamentals of fuzzy set theory.	K2
CO2	Compare the various fuzzy inference systems.	K2
CO3	Summarize the basics of neural network, supervised and unsupervised learning Networks.	K2
CO4	Illustrate the adaptive neuro-fuzzy inference system and its applications.	K2
CO5	Apply neural network and fuzzy logic in real time applications.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	L	-	-	-	-	L	L	-	-	-	-
CO2	M	M	M	L	L	-	-	-	L	L	-	-	-	-
CO3	M	M	M	L	L	-	-	-	L	L	-	-	L	M
CO4	M	M	M	M	L	-	-	-	L	L	-	L	L	M
CO5	M	M	M	M	L	-	-	-	L	L	-	L	L	M

g) Course Content

UNIT I FUZZY SET **9**

Introduction–Basic definitions and terminology, Set-theoretic Operations, MF Formulation and Parameterization, MFs of one Dimension, MFs of two Dimension, Derivatives of Parameterized MFs, Fuzzy Complement, Fuzzy Intersection and Union, Parameterized T-norm and T-conorm.

UNIT II FUZZY INFERENCE SYSTEM **9**

Extension Principle, Fuzzy Relations, Linguistic variables, Fuzzy If-Then Rules, Composite rule of inference, Fuzzy Reasoning, Mamdani Fuzzy Models – Other variants, Sugeno Fuzzy Models– Tsukamoto Fuzzy Models.

UNIT III NEURAL NETWORKS **9**

Mcculloch-Pitts Neuron, Linear Separability, Hebb Net, Supervised Learning Network: Perceptron, Adaline, Backpropagation Multilayer Perceptron, Radial Basis Function Networks, Unsupervised Learning Network: Competitive Learning Networks, Kohonen Self-Organizing Maps, Hebbian Learning, Principal Component Networks, The Hopfield Network

UNIT IV ADAPTIVE NEURO-FUZZY INFERENCE SYSTEMS AND APPLICATIONS **9**

Adaptive Neuro-Fuzzy Inference Systems – ANFIS Architecture, Hybrid Learning Algorithm, Applications: Printed Character Recognition,–Channel Equalization – Adaptive Noise cancellation

UNIT V NEURAL NETWORK AND FUZZY LOGIC APPLICATIONS **9**

Neural network applications: Character Recognition, Signal Processing, Neural networks for visual recognition - Fuzzy logic applications: Fuzzy logic control and Fuzzy classification, Fuzzy logic as a tool for rain prediction.

Total: 45 Hrs

h) Learning Resources

Text Books

1. J.S.R.Jang, C.T.Sun and E.Mizutani, “Neuro-Fuzzy and Soft Computing”, PHI /Pearson Education 2004 (Unit I- III, V).
2. S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd, 2006 (Unit IV).

Reference Books

1. Laurene Fausett, "Fundamentals of Neural Networks”, Pearson Education, 2004.
2. TimothyJ. Ross, "Fuzzy Logic With Engineering Applications", Tata Mc Graw -Hill Inc .2000
3. George J.Klirand BoYuan, “Fuzzy Sets and Fuzzy Logic-Theory and Applications”, Prentice Hall, 1995.
4. JamesA. Freeman and David M.Skapura, “Neural Networks Algorithms, Applications and Programming Techniques”, Pearson Edn., 2003.
5. S.N.Sivanandam and S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt Ltd, 2011.

Online Resources

1. https://nptel.ac.in/courses/106105173/2- Introduction to soft computing.
2. https://nptel.ac.in/courses/117105084/- Introduction to Artificial Neural Networks.
3. https://cs231n.github.io/neural-networks-case-study/ Visual recognition
4. chrome-extension://efaidnbmnnnibpcajpcglclefindmkaj/http://wwjmrd.com/upload/fuzzy-logic-as-a-tool-for-rainfall-prediction-a-case-study_1511780408.pdf

Course Code	Course Title	L	T	P	C
10212EC126	**BIOMEDICAL INSTRUMENTATION AND IMAGING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course is designed to make the student acquire an adequate knowledge of the physiological systems of the human body and relate them to the parameters that have clinical importance. The fundamental principles of equipment that are actually in use at the present day are introduced

c) Prerequisite

Nil

d) Related Courses

Digital Image and Video Processing

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the nervous system and physiology of the human body for biomedical applications	K2
CO2	Describe the various non-electrical physiological measurements for cardiovascular studies	K2
CO3	Summarize the functions of various medical imaging systems and their advancements	K2
CO4	Illustrate various special imaging devices for physiological measurements.	K2
CO5	Discuss on safety measures and various therapeutic & assisting equipment.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	-	-	-	L	-	L	L	-	L	L	L
CO2	M	M	L	-	-	-	L	-	L	L	-	L	M	L
CO3	M	M	L	-	-	-	L	-	L	L	-	L	M	L
CO4	M	M	L	-	-	-	L	-	L	L	-	L	M	L
CO5	M	M	L	-	-	-	L	-	L	L	-	L	L	L

g) Course Content

UNIT I PHYSIOLOGY AND COMPONENTS 9

Cell and its structure - sources of bioelectric potentials – resting and action potentials-propagation of action potentials nervous system – CNS – PNS – nerve cell – synapse – cardio pulmonary system –physiology of heart and lungs – circulation and respiration- block diagram of biomedical instrumentation system- transducers for biomedical applications-electrodes- selection criteria.

UNIT II NON ELECTRICAL PHYSIOLOGICAL MEASUREMENTS 9

ECG – EEG – EMG – ERG – lead systems and recording methods – typical waveforms. Measurement of blood pressure – cardiac output – cardiac rate – heart sound –respiratory rate - Plethysmography – pH of blood, ESR - GSR measurements

UNIT III MEDICAL IMAGING SYSTEMS 9

Picture archiving and communication system (PACS)-Principles of sectional imaging, scanner configuration, detectors - 2D image reconstruction technique, X-Ray imaging- Computer Tomography-Ultrasound scanner–PET scan–MRI Imaging.

UNIT IV SPECIAL IMAGING TECHNIQUES 9

Cine radiography, cine fluorography, stereoscopic radiography, magnification radiography, microradiography, tomography, neutron radiography. Cine angiogram– LASER imaging endoscopy.

UNIT V THERAPEUTIC EQUIPMENT & SAFETY MEASURES 9

Physiotherapy and electrotherapy - short ware, microwave diathermy –defibrillators – cardio vector-hearing aid – dialysis machine, pace makers. patient safety & monitoring – electrical safety, patient electrical safety, types of hazards, natural protective mechanism, leakage current, patient isolation, hazards in operation rooms, grounding conditions in hospital environment.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Leshie Cromwell, Fred. J.Weibell and Erich. A.Pfeiffer, "Biomedical Instrumentation and Measurements", 2nd Edition, PHI, 2003. (Unit I, II)
2. R.S.Khandpar,"Hand Book of Biomedical Instrumentation and measurement", McGraw Hill publishingCo.,1990 (Unit III, IV, V)

Reference Books

1. Arumugam,"Biomedical Instrumentation" ,Anuradha Agencies Publishers, Vidayal Karuppar,612606, Kumbakonam,R.M.S:1992
2. Joseph J. Carr and John M. Brown, "Introduction to Biomedical Equipment Technology", Pearson Education, 2004.
3. R.Anandanatarajan, "Biomedical Instrumentation", PHI Learning, 2009.

Online Resources

1. www.globalspec.com
2. https://www.youtube.com/playlist?list=PLm_MSClsnwm-kjSqlfwaEhKwfnnfLUUBM (Biomedical Instrumentation)

Course Code	Course Title	L	T	P	C
10212EC175	**FUNDAMENTALS OF QUANTUM COMPUTING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

Quantum computing is an emerging technology that provides several advantages over classical computing. This course will provide knowledge on the basic concepts of quantum computing, superposition, entanglement and error correction. The course also covers Quantum algorithms and its applications.

c) Prerequisite

Nil

d) Related Courses

-

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the basic principles of quantum computing.	K2
CO2	Summarize quantum state transformations.	K2
CO3	Apply various quantum computing algorithms in real time applications	K3
CO4	Illustrate the concepts of quantum entanglement and error correction for robust computation.	K3
CO5	Discuss the applications of quantum computation.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	-	-	-	-	-	L	L	-	-	-	M
CO2	H	M	M	L	-	-	-	-	L	L	-	-	-	M
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO4	H	M	M	M	L	-	-	-	L	L	-	-	M	M
CO5	H	M	M	M	-	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I QUANTUM BUILDING BLOCKS 9

The Quantum Mechanics of Photon Polarization, Qubit: The qubit state - matrix and Bloch sphere representation - computational basis – unitary evolution. Multi-qubit states - No-cloning theorem - Superdense coding - Pure states to Bell states – Bell inequalities.

UNIT II QUANTUM STATE TRANSFORMATIONS 9

Unitary Transformations, Quantum Gates, Unitary Transformations as Quantum Circuits, Reversible Classical Computations to Quantum Computations, Language for Quantum Implementations.

UNIT III QUANTUM ALGORITHMS 9

The Complexity Classes P and NP, Deutsch's algorithm, Complexity Notions, Quantum Fourier Transformations, Shor’s Algorithm and Generalizations, Grover’s Algorithm and Generalizations, Application of Deutsch-Jozsa algorithm for Formal Language Analysis

UNIT IV QUANTUM ENTANGLEMENT AND ERROR CORRECTION 9

Quantum Subsystems, Unentangled Qubits Calculation, Entangled Qubits Calculation, Entangled Quantum Clocks, Quantum Error Correction, Graph states and codes, Fault Tolerance and Robust Quantum Computing

UNIT V QUANTUM INFORMATION PROCESSING 9

Quantum Computing Limitations, Alternatives to the Quantum Computation Circuit Model, Quantum Protocols, Building Quantum Computers, Simulating Quantum Systems, Quantum Teleportation, Quantum Cryptography, Internet traffic interception via encryption using Shor's Algorithm

Total: 45 Hrs

h) Learning Resources

Text Books

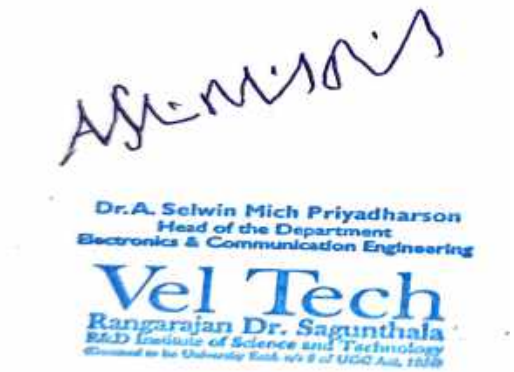
1. Chris Bernhardt, "Quantum Computing for Everyone", The MIT Press, 2019
2. Eleanor Rieffel and Wolfgang Polak, "Quantum Computing: A Gentle Introduction (Scientific and Engineering Computation)", The MIT Press 2014
3. Nielsen M. A., "Quantum Computation and Quantum Information", Cambridge University Press.2002

Reference Books

1. John Gribbin, Computing with Quantum Cats: From Colossus to Qubits, 2021
2. Benenti G., Casati G. and Strini G., Principles of Quantum Computation and Information, Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific. 2004
3. Pittenger A. O., An Introduction to Quantum Computing Algorithms 2000 Reference Books

Online Resources

1. John Preskill's lecture notes http://www.theory.caltech.edu/people/preskill/ ph229/ David
2. Mermin's lecture notes http://people.ccmr.cornell.edu/~mermin/qcomp/ CS483.html
3. YouTube Quantum learning series: https://www.youtube.com/playlist?list=PLOFEBzvs-Vvp2xg9-POLJhQwtVktlYGbY
4. Introduction to Quantum Computing: Quantum Algorithms and Qiskit - Course (nptel.ac.in)



Course Code	Course Title	L	T	P	C
10212EC213	**DIGITAL IMAGE AND VIDEO PROCESSING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course is designed to make the student to acquire an adequate knowledge of image processing, image transform, image enhancement, image restoration, image segmentation and image compression. Also, it inculcates the basic knowledge of video processing and motion estimation.

c) Prerequisite

Nil

d) Related Courses

Fundamentals of Machine Learning, ANN and Deep Learning

e) Course Outcomes

On successful completion of the course students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the basic operations and suitable image transform operations on images	K2
CO2	Demonstrate various image enhancement and restoration techniques on images	K3
CO3	Experiment with the various image segmentation techniques on images	K3
CO4	Apply the various image compression techniques on images	K3
CO5	Compute the sampling of video signal and perform motion estimation	K3

f) Correlation of COs with Pos and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	M	H	-	-	L	H	-	-	L	L	L
CO2	H	H	L	M	H	-	-	L	L	-	-	L	L	L
CO3	M	M	L	M	H	-	-	L	L	-	-	L	L	L
CO4	M	M	L	M	H	-	-	L	L	-	-	L	L	L
CO5	M	L	L	M	H	-	-	L	L	-	-	L	L	L

g) Course Content

UNIT I INTRODUCTION TO IMAGE PROCESSING AND IMAGE TRANSFORMS 6

Introduction- Image sampling- Quantization- Resolution- Image file formats- Elements of image processing system- Need for transform- Image transform: Discrete Fourier transform- Discrete cosine transform- Discrete Wavelet transform- Haar transform.

UNIT II IMAGE ENHANCEMENT AND RESTORATION 6

Image Enhancement: Spatial domain methods - Histogram processing- Fundamentals of Spatial filtering- smoothing spatial filters- Sharpening spatial filters. Frequency domain methods: image smoothing- image sharpening- Image Restoration: Image degradation- Image restoration model.

UNIT III IMAGE SEGMENTATION 6

Introduction - Point, Line and Edge Detection- Thresholding- Region-based segmentation: region growing-Region splitting and merging-Segmentation using morphological watersheds-The use of motion in segmentation

UNIT IV IMAGE COMPRESSION 6

Image Compression: need for image compression-Redundancy in images-Classification of redundancy in mages- compression models- lossless and lossy compression- Huffman coding- arithmetic coding -LZW coding- Run length coding - JPEG Standards.

UNIT V VIDEO PROCESSING AND MOTION ESTIMATION 6

Analog video- digital video- time-varying image formation models: Three-dimensional motion models- sampling of video signals- Motion estimation:Optical flow- general methodologies- pixel-based motion estimation- block- matching algorithm- mesh-based motion estimation- global motion estimation

LIST OF EXPERIMENTS **30 Hrs**

S. No.	Name of the Experiment	CO
1	Perform basic operations on images like arithmetic, logical, transformation etc	CO1
2	Perform DFT and DCT operations on an image	CO1
3	Perform Discrete Wavelet Transform operation on an image	CO1
4	Perform enhancement operation on image in spatial domain	CO2
5	Perform enhancement operation on image in frequency domain	CO2
6	Apply restoration techniques on an image	CO2
7	Apply edge based and thresholding based segmentation techniques on an image	CO3
8	Perform region growing image segmentation on an image	CO3
9	Perform Lossy image compression	CO4
10	Perform Lossless image compression	CO4
11	Conversion of video into various frames	CO5
12	Apply Motion estimation technique on video	CO5

Total : 60 Hrs

h) Learning Resources

Text Books

1. Rafael C.Gonzalez, Richard E.Woods, "Digital Image Processing", Pearson Prentice Hall, Fourth Edition, 2018.(Unit I-Unit IV)
2. A.Murat Tekalp, "Digital Video Processing", Prentice Hall, Second Edition,2015. (Unit V)

Reference Books

1. Scotte E Umbaugh, "Digital Image Processing and Analysis-Human and Computer Vision Application with CVIP Tools", 2nd Edition, CRC Press, 2011.
2. S Jayaraman, S. Esakkirajan and T.Veera Kumar, "Digital Image processing," Tata Mc Graw Hill publishers, 2009 (Unit I)
3. A Murat Tekalp, "Digital Video Processing", Prentice Hall International, 2nd Edition, 2015.
4. John Woods, "Multidimensional Signal, Image and Video Processing and Coding", Elsevier, 2nd Edition, 2011.
5. Keith Jack, "Video Demystified – A Hand Book for the Digital Engineer", Elsevier, 5th Edition., 2007.

Online Resources

1. https://archive.nptel.ac.in/courses/117/104/117104020/
2. https://nptel.ac.in/courses/117105079

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Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology

Course Code	Course Title	L	T	P	C
10212EC214	**FUNDAMENTALS OF MACHINE LEARNING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course is proposed to meet a growing professional need of individuals skilled in artificial intelligence, machine learning, statistical programming and other software skills. The course integrates theory and practice to enable the student to gain the necessary knowledge to compete in the ever changing work environment.

c) Prerequisite

Python Programming

d) Related Courses

ANN and Deep Learning

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the basic machine learning concepts for simple regression and classification problems.	K2
CO2	Utilize the principle and concepts of bayes decision theory for the implementation of prediction and classification problems.	K3
CO3	Make use of the linear and logistic regression models for the prediction and binary classification applications.	K3
CO4	Experiment with supervised learning algorithms for real time data classification.	K3
CO5	Apply unsupervised learning algorithms for real time clustering application.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO1 2	PSO 1	PSO 2
CO1	L	L	L	L	H	-	-	L	L	L	-	L	L	L
CO2	M	M	M	M	H	L	-	L	L	L	-	M	M	M
CO3	M	M	M	M	H	L	-	L	L	L	-	M	M	M
CO4	M	M	M	M	H	L	-	L	L	L	-	M	M	M
CO5	M	M	M	M	H	L	-	L	L	L	-	M	M	M

g) Course Content

UNIT I MACHINE LEARNING BASICS 6

Definition of learning systems- Designing a learning system- Learning paradigms: Supervised, Unsupervised and Reinforcement learning - Learning theory and Performance Metrics - Concepts of overfitting and underfitting, Regularization

UNIT II BAYESIAN DECISION THEORY 6

Bayes rule – Independence and conditional independence – Common discrete and continuous distributions – Bayesian concept learning - MAP estimation – Bayes classifier - Bayes estimators for common loss functions -The false positive Vs false negative trade off – Naïve Bayes model.

UNIT III LINEAR AND LOGISTIC REGRESSION 6

Simple linear regression –Multiple linear regression– F-tests – Least squares estimation- Logistic Regression Model–Multiple logistic regression - stepwise Logistic Regression- Best subset Logistic Regression

UNIT IV CLASSIFICATION ALGORITHMS 6

Introduction to Classification - k-Nearest Neighbor Algorithm - Decision Trees: Univariate, Multivariate trees, ID3 algorithm - Random Forests-Support Vector Machines.

UNIT V CLUSTERING AND DIMENSIONALITY REDUCTION 6

Introduction to clustering - Mixture densities - k-Means Clustering - Hierarchical Agglomerative Clustering - choosing number of clusters, Dimensionality Reduction - Need for Dimensionality Reduction – Subset Selection – Principal Component Analysis.

LIST OF EXPERIMENTS

Hardware requirement:

- i5 Processor, 8GB RAM, & Internet Connection

Software Environment:

- IDE recommended PYCHARM, JUPYTER

S. No.	Name of the Experiment	CO
	Program to perform/demonstrate	
1	Online retail case study using Python libraries.	CO1
2	Simple classification using Naïve Bayes algorithm.	CO2
3	Simple prediction using Naïve Bayes algorithm.	CO2
4	Regression model for house price prediction.	CO3
5	Multiple linear regression model.	CO3
6	Binary and multiple logistic regression models.	CO3
7	Logistic regression model for iris data.	CO3
8	The working of the decision tree based ID3 algorithm.	CO4
9	The random forest classifier for a sample training data set stored as a .CSV file format.	CO4
10	Support Vector Machine based classification model.	CO4
11	Clustering model for the medical data using hierarchical method.	CO5
12	Principle Component Analysis on face recognition.	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Kevin P. Murphy, "Machine Learning: A Probabilistic Perspective", MIT Press 2012. (Unit 1-4)
2. Ethem Alpaydin, "Introduction to Machine Learning", 3nd Edition, MIT Press 2014.(Unit 5)

Reference Books

1. Richert & Coelho, "Building Machine Learning Systems with Python", 3rd Edition, Packt Publishers, 2018.
2. Trevor Hastie, Robert Tibshirani, Jerome Friedman, "The Elements of Statistical Learning", Second edition Springer 2017.
3. Weisberg, Sanford, "Applied Linear Regression", 4th Edition, John Wiley & Sons, 2014.
4. Bishop, Christopher M. "Pattern Recognition and Machine Learning". Springer, 2006
5. David W. Hosmer Jr., Stanley Lemeshow, Rodney X. Sturdivant, "Applied Logistic Regression", 3rd Edition John Wiley & Sons, 2013.

Online Resources

1. https://www.coursera.org/learn/machine-learning/home/info/AndrewNg/"Machine learning" Stanford University.
2. https://nptel.ac.in/courses/106105152/1/ Sudeshna Sarkar/ "Introduction to Machine Learning" IIT Kharagpur.
3. https://nptel.ac.in/courses/106106139/1/ Balaraman Ravindran/ "Introduction to Machine Learning" IIT Madras.
4. Machine Learning Tutorials, Machine Learning Tutorial (tutorialspoint.com)
5. Machine Learning Mastery, Best Machine Learning Resources for Getting Started (machinelearningmastery.com)

Course Code	Course Title	L	T	P	C
10212EC215	**PROFESSIONAL PYTHON PROGRAMMING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

The purpose of the course is to provide students with the basic knowledge of python programming. This course also emphasizes algorithms and programming techniques utilized in many applications to effectively handle real-world challenges.

c) Prerequisite

Python Programming

d) Related Courses

Fundamentals of Machine Learning

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Utilize object-oriented programming concepts in python tosolve problems	K2
CO2	Demonstrate basic file processing operations on different kinds of files like XML, CSV, and SQL database	K2
CO3	Apply common python functionality and features for data science	K3
CO4	Compare and plot the data using different kinds of plots	K3
CO5	Experiment with the python programming for networking applications	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	L	-	H	-	-	L	L	L	-	M	L	M
CO2	H	M	L	-	H	-	-	L	L	L	-	M	L	M
CO3	H	M	L	-	H	-	-	L	L	L	-	M	L	M
CO4	H	M	L	-	H	-	-	L	L	L	-	M	L	M
CO5	H	M	L	-	H	-	-	L	L	L	-	M	L	M

g) Course Content

UNIT I OBJECT ORIENTED PROGRAMMING WITH PYTHON 12

Class and objects, _init_ method, constructor, class with multiple objects, class attributes vs data attributes, types of variables, types of methods, inner class, encapsulation, inheritance, polymorphism.

UNIT II FILE PROCESSING 12

Processing different kinds of files: interacting with SQLite databases, creating and processing, XML files, CSV file reading and writing, basics logging facility for Python, configuration file parser. Communicating with a program's environment: interacting with the operating system, manipulating with dates and time, time access and conversions.

UNIT III PYTHON FOR DATA SCIENCE 12

Introduction to data science, Data science Packages: NumPy with Python – NumPy array creation using array () function and initial placeholder content, Basic arithmetic operations, Mathematical functions, Changing the shape of an array, stacking and splitting of arrays, Pandas series, data frame.

UNIT IV DATA VISUALIZATION IN PYTHON 12

Introduction to data visualization, Matplotlib, Line Plots, Area Plots, Histograms, Bar Charts, Pie Charts, Box Plots, Scatter Plots, Waffle Charts.

UNIT V PYTHON FOR NETWORKING 12

Introduction-Basics of sockets and methods-working with TCP socket-UDP socket, network analysis-port scanner-banner grabbing, sending Email-GUI programming-Tkinter.

LIST OF EXPERIMENTS

S.No.	Name of the Experiment	CO
1	Simulation of elliptical orbits in Pygame	CO1
2	Simulation of bouncing ball using Pygame	CO1
3	Demonstrate class variable, instance variable, and self variable for implementing (a) Robot (b) ATM Machine	CO1
4	Develop a Python program to interact with SQLite databases	CO2
5	Demonstrate the processing of XML files in Python	CO2
6	Demonstrate the processing of CSV files in Python	CO2
7	Develop a python program to explore python packages – NumPy and Pandas	CO3
8	Creation of dataframe from ndarrays/lists/list of dictionaries	CO3
9	Demonstration of filtering data in a Pandas dataframe	CO3
10	Demonstrate the use of Matplotlib package and bringing other Python libraries with Matplotlib	CO4
11	Demonstrate the use of line plots and area plots	CO4
12	Demonstrate the use of Bar Charts, Pie Charts	CO4
13	Creation of client server programming using TCP/UDP socket	CO5
14	Develop a python program to send e-mail.	CO5
15	Creation of GUI application using Tkinter module.	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Matt Weisfeld, “The Object-Oriented Thought Process”, Bronkella Publishing LLC, 4th Edition, 2013, ISBN: 978-0-321-86127-6. (Unit I,II)
2. Lillian Pierson, “Data Science Dummies”, John Wiley Publishers, 2nd Edition, 2017, ISBN:978-1-119-32763-9. (Unit III, IV, V)

Reference Books

1. Guido van Rossum and Fred L. Drake Jr, “An Introduction to Python”, Revised and updated for Python 3.2, Network Theory Ltd., 2011.
2. John V Guttag, “Introduction to Computation and Programming Using Python”, Revised and expanded Edition, MIT Press , 2013
3. Jeeva Jose &P.SojanLal, “Introduction to Computing and Problem Solving with PYTHON”, Khanna Publishers, New Delhi, 2016.
4. Wesley J. Chun, “Core Python Applications Programming”, 3rd Edition, Pearson Education, 2016.

Online Resources

1. https://docs.python.org/
2. https://online.umich.edu/courses/introduction-to-data-science-in-python/

Course Code	Course Title	L	T	P	C
10212EC243	APPLIED PROGRAMMING SKILLS USING PYTHON	3	0	2	4

a. Course Category
Programme Elective

b. Preamble
This course develops problem-solving and programming skills using Java. It focuses on Data Structures and Algorithms concepts, encouraging students to implement, test, and optimize solutions for real-world computational problems. Students will learn to design efficient programs using arrays, linked lists, stacks, queues, trees, graphs, and advanced algorithmic techniques.

c. Prerequisite Course –

d. Course Objectives
Learners are exposed to:
- Understand and use linear data structures for efficient data processing.
- Apply stacks, queues, trees, heaps, and graphs to solve programming problems.
- Use greedy, divide-and-conquer, and dynamic programming techniques.
- Choose suitable data structures and algorithms to solve problems effectively.
- Handle large inputs and time-critical programming scenarios.

e. Course Outcomes
On successful completion of the course, students will be able to:

COs	Course Outcomes	K Level
CO1	Use linear data structure techniques to process competitive programming inputs efficiently.	K3
CO2	Implement stack- and queue-based patterns to solve constrained sequence problems.	K3
CO3	Apply tree and heap structures to handle hierarchical data and priority-based computations.	K3
CO4	Utilize graph and set-based structures to analyze connectivity, traversal, and relationship-driven problems.	K3
CO5	Develop algorithmic solutions using programming strategies for optimization problems.	K3

f. Correlation of COs with POs and PSOs

Cos	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2	PSO3
CO1	3	2	2	1	1	1	-	-	-	-		2	3	2
CO2	3	3	2	2	1	1	-	-	-	-		2	3	2
CO3	3	3	3	2	2	1	-	-	-	-		3	3	2
CO4	3	3	3	3	2	1	-	-	-	-		3	3	3

CO5	2	3	3	3	3	2	-	-	1	2	1	2	3	3

g. Course Contents

UNIT I LINEAR DATA STRUCTURES FOR COMPETITIVE INPUT PROCESSING 9

Two Pointers – Sliding Window – Prefix Sum – Difference Array – Binary Search – Quick Sort and Merge Sort, Greedy pairing – Hashing for frequency/count – In-place array manipulation – Linked list fast/slow pointer – Merge two lists – Reverse nodes in k-group – Detect/remove cycle – Intersection of linked lists.

UNIT II STACK AND QUEUE BASED COMPETITIVE PROBLEM MODELING 9

Monotonic Stack – Next Greater Element pattern – Valid parentheses variants – Min Stack design – Stack simulation problems – Queue using stacks – Sliding window maximum using deque – FIFO processing with queue – Circular queue simulation – Task scheduling with queue.

UNIT III HIERARCHICAL AND PRIORITY-ORIENTED DATA STRUCTURES 9

Tree – Tree Traversal – Print Birdseye View of a Tree - Path sum - Root-to-leaf problems – Diameter/height problems – Lowest Common Ancestor – Kth smallest/largest in Binary Search Tree – Heap - Top-K pattern – K-way merge using heap.

UNIT IV NETWORK AND RELATIONSHIP-DRIVEN DATA STRUCTURES 9

Graph – Breadth First Search –Depth First Search – Connected components – Cycle detection (directed/undirected) – Topological sorting– Shortest path in unweighted graphs – Grid traversal (islands, flood fill) – Union Find (Disjoint Set Union) – HashSet patterns – Frequency map and sorting by keys/values.

UNIT V ALGORITHM DESIGN TECHNIQUES 9

Divide and Conquer pattern – Merge sort for counting inversions – Quick select (Kth element) – Dynamic Programming – One Dimensional (house robber, climbing stairs) –Two Dimensional (grid paths) – Subset Dynamic Programming (0/1 knapsack style) – Greedy interval scheduling – Backtracking (subsets, permutations, combinations).

Total:45 Hrs

G. Laboratory Experiments

Part A

Task 1: (Level: Easy)
Given an array of intervals, merge all overlapping intervals.
Approach / Explanation: Sort by start. Iterate, merging when current.start <= last.end.
Sample Test Case:
Sample Input:
4
1 3
2 6
8 10
15 18
Sample Output:
1 6
8 10

15 18

Task 2: (Level: Easy)
Insert a new interval into a list of non-overlapping, sorted intervals, merging if necessary.
Approach / Explanation: Add all intervals ending before new.start, merge overlaps, then append the rest.
Sample Test Case:
Sample Input:
3
1 3
6 9
12 16
4 10
Sample Output:
1 3
4 10
12 16

Task 3: (Level: Easy)

You are given an array arr[] of size n - 1 that contains distinct integers in the range from 1 to n (inclusive). This array represents a permutation of the integers from 1 to n with one element missing. Your task is to identify and return the missing element.
Examples:
Input: arr[] = [1, 2, 3, 5]
Output: 4
Explanation: All the numbers from 1 to 5 are present except 4.
Input: arr[] = [8, 2, 4, 5, 3, 7, 1]
Output: 6
Explanation: All the numbers from 1 to 8 are present except 6.
Input: arr[] = [1]
Output: 2
Explanation: Only 1 is present so the missing element is 2.
Constraints:
$1 \leq$ arr.size() ≤ 106
$1 \leq$ arr[i] $\leq$ arr.size() + 1

Task 4: (Level: Easy)
Write a function that finds and returns the Nth prime number. The number N will be passed as input to the function
constraint: 1<=N<=1000,where N is the position of the prime number
Sample Test Case:
Sample Input:
10
Sample Output:
29

Task 5: (Level: Medium)
Given the head of a singly linked list, the task is to remove a cycle if present. A cycle exists when a node's next pointer points back to a previous node, forming a loop. Internally, a variable "**pos"** denotes the index of the node where the cycle starts, but it is not passed as

a parameter. The terminal will print true if a cycle is removed otherwise, it will print false.
Examples:
Sample Input 1: head = 1 -> 3 -> 4->1, pos = 0
Sample Output 1: true
Explanation: The linked list has a loop is present in the list, and it is removed.

Sample Input 2: head = 1 -> 8 -> 3 -> 4, pos = 0
Sample Output 2: false
Explanation:
The Linked list does not contains any loop.

Sample Input 3: head = 1 -> 2 -> 3 -> 4->1, pos = 0
Sample Output 3: true
Explanation: The linked list has a loop is present in the list, and it is removed.
Constraints:
$1 \leq$ size of linked list $\leq 10^5$

Task 6: (Level: Hard)
Library Management System
Scenario: A city-library chain wants to digitise its inventory and borrower system.
Internal tasks:
1. Design and implement data structures for book inventory (arrays or linked lists) and borrower records.
2. Implement borrow/return operations using a queue of pending returns and stack for recent returns.
3. Implement search (linear & binary) for books by title/ISBN, and sort books by popularity (using quick sort or merge sort).

Task 7: (Level: Easy)
Given a string s containing '()[]{}', determine if it is valid.
Approach / Explanation: Use a stack; push openings and check matching closings.
Sample Test Case:

Sample Input1:
()[]{}
Sample Output2:
True
Sample Input2:
( ]
Sample Output2:
False

Task 8 : (Level: Easy)

You are developing a music streaming app that manages user playlists. Each playlist is a collection of songs stored in an array of integers, where each integer represents a unique song ID. To enhance the listening experience, the app allows users to rotate the playlist to the right by a given number of positions. Write a program to rotate the playlist and print the updated order of songs.

Input Format

- The first line contains an integer n, the number of songs in the playlist.
- The second line contains n space-separated integers representing the song IDs.
- The third line contains an integer k, the number of positions to rotate the playlist to the right.

Output Format

- Print the updated playlist after rotation as n space-separated integers.

Sample Test Case:

Sample Input:
5
1 2 3 4 5
2
Sample Output:

4 5 1 2 3

Task 9: (Level: Easy)
You are given a string S that contains lowercase and uppercase English letters along with brackets '(' and ')'. Your task is to:

1. Remove all brackets '(' and ')' from the string.
2. Reverse the resulting string.
3. Print the final reversed string.

Input Format:

- The first line contains a string S ($1 \leq |S| \leq 10^5$) consisting of lowercase and uppercase letters and brackets '(' and ')'.

Output Format:

- Print the final string after removing brackets and reversing.

Sample Test Case:

Sample Input:
a(bc)d

Sample Output:
dcba

Task 10: (Level: Hard)
E-commerce Inventory & Sales System

Scenario: An online store's backend needs to manage product catalogue, sort & search products, and track top sellers.
Internal tasks:
1. Use arrays/linked lists to model product items (CRUD: create, read, update, delete).
2. Sort product lists by price, sales count, rating using various sort algorithms (bubble, selection, insertion, quick, merge).
3. Use Java Collections: HashSet for unique product IDs; TreeMap for product → price mapping; PriorityQueue for top-selling products.

Task 11: (Level: Easy)
Given an integer array nums and integer k, return the k most frequent elements.
Approach / Explanation: Count with hashmap; use bucket sort (frequency -> list of values) or a min-heap of size k.

Sample test Case:

Sample Input 1:
1 1 1 2 2 3
2

Sample Output 1: 1 2

Task 12: (Level: Easy)
Given two strings s and t, determine if t is an anagram of s.
Approach / Explanation: Count characters with fixed-size array.

Sample Test Cases:
Sample Input 1:
listen
silent

Sample Output 1:
true

Sample Input 2:
Rat
tar

Sample Output 2:
False

Task 13: (Level: Medium)

You are given a binary tree with N leaf nodes, each leaf node containing a positive integer representing its data size.
You need to combine all leaf nodes into a single file using the minimum total cost.

The cost of merging two leaf nodes is equal to the sum of their sizes.
Each time you merge two files, the resulting file is pushed back to the set of available files.

Your task is to find the minimum total cost to merge all the files into one. This problem is analogous to constructing an Optimal Binary Merge Tree (OBMT) — or equivalently, the Huffman coding tree — where merging with minimal total cost is achieved using a min-heap (priority queue).

Explanation
Let's say you have leaf sizes:
[5, 3, 8, 2]

Pick the two smallest → 2 and 3 → merge cost = 2 + 3 = 5.
New list → [5, 5, 8]

Pick the two smallest → 5 and 5 → merge cost = 5 + 5 = 10.
New list → [8, 10]

Pick the two smallest → 8 and 10 → merge cost = 8 + 10 = 18.
Total cost = 5 + 10 + 18 = 33

Minimum total merge cost = 33

Input Format

N
a1 a2 a3 ... aN

N → number of leaf nodes (1 ≤ N ≤ 10^5)

ai → integer size of each leaf (1 ≤ ai ≤ 10^6)

Output Format

Minimum total cost

Sample Input1
4
5 3 8 2

Sample Output1
33

Sample Input2
3
10 20 30

Sample Output2
90

Explanation

Merge 10 & 20 → cost = 30 → new list [30, 30]

Merge 30 & 30 → cost = 60

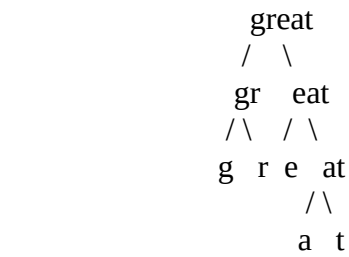
Total = 30 + 60 = 90

Task 14: (Level: Hard)
Real-Time Stock Price Tracker & Analyzer
Scenario: A fintech startup needs to monitor live stock price streams, track top movers and send alerts.
Internal tasks:
1. Use an array or list to store incoming price updates and apply sorting (e.g., merge

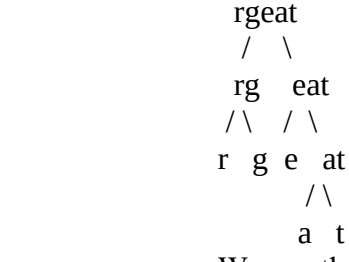
sort or quick sort) for top gainers/losers.
2. Use a min-heap or max-heap priority queue to keep track of top N stocks efficiently as data updates.
3. Maintain a BST for quick look-up of any given stock's history, and provide find-min/find-max operations.

Task 15: (Level: Hard)
Chatbot with Real-Time Response Analysis
Scenario: A customer-service chatbot that processes incoming messages and provides responses, tracking priority issues.
Internal tasks:
1. Use queue (FIFO) to process incoming user messages; use stack for rollback or to manage recent conversations.
2. Use hash map to map keywords → responses; implement search and update operations.
3. Use priority queue to elevate urgent queries (e.g., containing "urgent", "error") and ensure they are handled first.

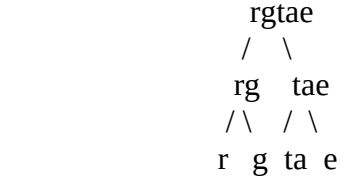
Task 16: (Level: Hard)
Given a string A, we may represent it as a binary tree by partitioning it to two non-empty substrings recursively.
Below is one possible representation of A = "great":



To scramble the string, we may choose any non-leaf node and swap its two children.
For example, if we choose the node "gr" and swap its two children, it produces a scrambled string "rgeat".



We say that "rgeat" is a scrambled string of "great".
Similarly, if we continue to swap the children of nodes "eat" and "at", it produces a scrambled string "rgtae".



/ \
t a
We say that “rgtae” is a scrambled string of “great”.
Given two strings A and B of the same length, determine if B is a scrambled string of S.

Input Format:
The first argument of input contains a string A.
The second argument of input contains a string B.

Output Format:
Return an integer, 0 or 1:
=> 0 : False
=> 1 : True
Constraints:
1 <= len(A), len(B) <= 50

Sample Input 1:
A = " rgtae "
B = "great"
Sample Output 1:
1

Sample Input 2:
A = "hello"
B = "hel"
Sample Output 2:
0

Task 17: (Level: Hard)

Online Voting / Polling System
Scenario: A website runs polls or elections and wants to manage votes, handle unique voters, show results.
Internal tasks:
1. Use HashSet to track unique voters (prevent duplicates); use HashMap to map candidates → vote count.
2. Use quick/merge sort to sort candidates by vote count to display top winners.
3. Use a priority queue to track upcoming or most-popular polls; manage insertion/deletion of polls dynamically.

Task 18: (Level: Hard)
Minimum Cost to Connect All Cities
You are given N cities (numbered 1 to N) and M bidirectional roads.
Each road connects two cities u and v and has a construction cost w.
Your task is to find the minimum total cost required to connect all cities — that is, every city should be reachable from every other city. If it’s not possible to connect all cities, print -1. This problem represents finding the Minimum Spanning Tree (MST) of a graph.
Explanation:

- We can use Kruskal’s Algorithm with Disjoint Set Union (DSU) to efficiently find the MST.

- Sort all edges by their cost.
- Use DSU to add edges one by one (avoid cycles).
- Keep adding edges until all cities are connected.

Input Format

N M
u1 v1 w1
u2 v2 w2
...
uM vM wM
N → number of cities (1 ≤ N ≤ 10^5)
M → number of roads (1 ≤ M ≤ 2×10^5)
ui, vi → cities connected by the i-th road
wi → cost of that road

Output Format

Minimum total cost to connect all cities. If it's not possible to connect all, print -1.

Sample Input

4 5
1 2 5
1 3 10
2 3 4
2 4 11
3 4 2

Sample Output

11

Explanation

The edges in the MST are:
(3–4) → 2
(2–3) → 4
(1–2) → 5
Total cost = 2 + 4 + 5 = 11

Task 19: (Level: Easy)

Write a method to print the characters which occur a minimum number of times in the array. In case of a dilemma, print the char which is alphabetically earlier.
Consider the input as "ABCC".
The output is 'A' as it occurs a minimum number of times.
Please note that 'A' and 'B' occur the same number of times but 'A' is earlier than 'B'.

Sample Test Cases:
Sample Input:
ABCC

Sample Output:
A

Task 20: (Level: Hard)
Social Media Friend Recommendation Engine

Scenario: A social network needs to suggest new friend connections to users.
Internal tasks:
1. Model users and friendships as a graph (adjacency matrix or adjacency list).

2. Use BFS/DFS to compute "friends-of-friends" and mutual connections.
3. Use a priority queue (heap) to rank suggestions by strength of connection (mutual friend count) and display top K.

Task 21: (Level: Hard)
Campus Navigation & Way-finding System

Scenario: A university wants an app that helps students navigate between buildings, labs, facilities.
Internal tasks:
1. Model the campus as a graph (nodes = buildings/rooms, edges = paths) using adjacency matrix/list.
2. Implement BFS/DFS to explore reachable locations from a given start point; compute shortest unweighted path.
3. Use Java Collections (List, Set, and Map) to maintain visited nodes, path history, and map node IDs to building names; compare performance.

Task 22: (Level: Hard)
Travel Planner / Route Finder
Scenario: A travel-app that finds routes between cities, suggests trip plans.
Internal tasks:
1. Represent cities and routes as a graph; store routes (edges) and cities (nodes).
2. Use BFS/DFS to find reachable cities; maybe implement shortest path in unweighted graphs.
3. Sort possible routes by number of stops or cost using sorting algorithms and present top options.

Task 23: (Level: Hard)
Contact Management & Search System
Scenario: A company wants a digital phonebook/contact system with fast search and sorting.
Internal tasks:
- Use array or linked list to store contacts; implement CRUD operations (add, delete, update, and retrieve).
- Sort contacts by name or last update using insertion/selection/quick sort; implement search via binary and linear search.
- Enhance with a hash map (HashMap) for lookup by phone number; analyze the time complexity differences between list vs. hash-map lookup.

Task 24: (Level: Hard)
Maze / Labyrinth Solver
Scenario: A game or robotics simulation navigates a maze from start to exit.
Internal tasks:
- Model the maze as a 2D-array (matrix) where walls = blocked cells, open cells = nodes.
- Use BFS/DFS to find a path from start to finish (or all possible paths).
- Use backtracking to explore and mark dead-ends, count the number of unique paths; compare stack vs. recursion implementations.

Task 25: (Level: Hard)
Expense Tracker / Budget Management
Scenario: A personal finance app where users log expenses, sort and filter them, get

analytics.
Internal tasks:
1. Use array/list to store expense entries (date, category, and amount).
2. Sort expenses by date or amount using quick sort/merge sort; implement search for entries by category/date.
3. Use HashMap category → total amount; use tree structure (TreeMap) to maintain sorted categories; present top expense categories via priority queue.

Task 26:(Level: Hard)

File / Data De-duplication Tool
Scenario: A cloud storage provider wants to detect duplicate files and save space by de-duplication.
Internal tasks:
1. Use hash map (file-hash → list of files) to detect duplicates; support insert and delete.
2. Use sorting algorithms to sort files by size or last-modified date for efficient checking.
3. Use tree or priority queue to list largest duplicates removed, track space saved; implement find-max and delete operations.

Task 27:(Level: Hard)
Multiplayer Online Game Leader board & Event System
Scenario: An online game maintains player scores, sorts leader boards, and handles events and matchmaking.
Internal tasks:
- Use array/list for players and their scores; implement quick sort/merge sort for leader board.
- Use priority queue to manage event scheduling or matchmaking, where top players get priority in events.
- Use graph structure for matchmaking (players = nodes, edges = connections or past matches); use BFS/DFS to find potential match clusters or teams.

Task 28 : (Level: Easy)

An automobile company manufactures both a two wheeler (TW) and a four wheeler (FW). A company manager wants to make the production of both types of vehicle according to the given data below:

- 1st data , Total number of vehicle (two – wheeler + four - wheeler)=v
- 2nd data, Total number of wheels=w

The task is to find how many two-wheelers as well as four-wheelers need to manufacture as per the given data. Print “INVALID INPUT”, if inputs did not meet the constraints.

Constraints:

- 2<=W
- W%2=0
- V<W

Sample Test Cases:
Sample Input:
200 540

Sample Output: 130 70

Task 29: (Level: Easy)

Given weights and values of n items, put these items in a knapsack of capacity W to get the maximum total value in the knapsack.

Input: An integer n, the number of items. Two lists: weights and values. An integer W, the maximum capacity of the knapsack.

Output: Print the maximum total value. **Constraints:** 1 <= n <= 1000 1 <= W <= 10^5

Approach/Explanation: Use dynamic programming to solve the 0/1 knapsack problem.

Sample Test Case:
Sample Input:
n = 3
values = [60, 100, 120]
weights = [10, 20, 30]
W = 50

Sample Output:
220

Task 30: (Level: Hard)

Data Compression Tool using Huffman Coding
Scenario: A software firm needs to compress text files using efficient encoding.
Internal tasks:
1. Given character frequency count, build Huffman tree via greedy algorithm using priority queue (heap).
2. Traverse the Huffman tree (preorder/inorder/postorder) to assign codes to characters.
3. Implement encoding and decoding of text; compare size of encoded vs. original; analyze time/space complexity.

TOTAL:30 Hours

H. Learning Resources

Text Books:

1. Data Structures and Algorithms in Java: A Project-Based Approach — Dan S. Myers, 1st Edition, Cengage Learning, 2024
2. Data Structures & Algorithms in Java (6th Ed) — Michael T. Goodrich, Roberto Tamassia, Michael H. Goldwasser, Wiley India, 2023 (Indian Edition).
3. Data Structures & Algorithms in Java (2nd Ed) — Oswald Campesato, Packt Publishing, 2022.
4. Data Structures & Algorithms Made Easy in Java — Narasimha Karumanchi, CareerMonk

Publications, 2023.
5. M. A. Weiss, Data Structures and Algorithm Analysis in Java, 3rd ed., Pearson Education, New Delhi, India, ISBN 978-8131760635.
6. M. T. Goodrich, R. Tamassia, M. H. Goldwasser, and S. Banerjee, Data Structures and Algorithms in Java, 6th ed., Indian Adaptation, Wiley India Pvt. Ltd., 2022, ISBN 978-9354247934.

Reference Books:

1. Introduction to Java Programming and Data Structures, Comprehensive Version — Y. Daniel Liang, 12th Edition, Pearson Education, 2023.
2. Data Structures and Algorithms in Java (Comprehensive) — S. K. Srivastava & Deepali Srivastava, BPB Publications, 2026.

Online Resources:

1. "Competitive Programming - A Complete Guide", [Online] Last Updated: 22.08.2025. Available: https://www.geeksforgeeks.org/dsa/competitive-programming-a-complete-guide/
2. w3schools.com, Explore Java programming language, [Online] Last Updated: 22.08.2025. Available: w3schools.com

(Placement Coordinator ECE)

Verified
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Dean - Campus to Corporate
Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology

24/12/25
Dr. S. Jana
Professor & Head of the Department
Electronics and Communication Engineering
Vel Tech Rangarajan Dr. Sagunthala R&D Institute of Science and Technology

Course Code	Course Title	L	T	P	C
10212EC127	LOW POWER VLSI DESIGN	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course provides the basic and design knowledge about low power VLSI which involves sources of power dissipation, power optimization techniques and power estimation.

c) Prerequisite

VLSI Design

d) Related Courses

VLSI Design Techniques, Analog VLSI Design, Digital IC Design

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the sources and limits of power dissipation in CMOS	K2
CO2	Summarize the power optimization and trade-off techniques in digital circuits.	K2
CO3	Interpret the special techniques to mitigate the power consumption in VLSI circuits	K2
CO4	Illustrate the power estimation at logic and circuit level	K2
CO5	Demonstrate the software design for low power in various level	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	H	H	M	L	-	-	-	-	-	-	-	H	M	-
CO2	M	L	L	-	-	M	-	-	-	-	-	L	L	-
CO3	H	M	M	M	M	-	-	-	-	-	-	L	H	-
CO4	H	M	M	M	M	-	-	-	-	-	-	M	M	-
CO5	H	M	H	M	-	H	-	-	-	-	-	H	L	M

g) Course Content

UNIT I POWER DISSIPATION IN CMOS 9

Sources of power dissipation – Needs for Low Power VLSI Chips - Physics of power dissipation in MOSFET devices: The MIS structure, Long channel MOSFET, Submicron MOSFET, Gate induced drain leakage – Power dissipation in CMOS: Short circuit dissipation, Dynamic dissipation, Load capacitance – Low power VLSI design limits: Principles of low power design, Hierarchy of limits, Fundamental limit, Material limit, Device limit, Circuit limit, System limit and Practical limits.

UNIT II DESIGN OF LOW POWER CIRCUITS 9

Transistor and Gate Sizing: Sizing an Inverter Chain, Transistor and Gate Sizing for Dynamic Power Reduction, Transistor Sizing for Leakage Power Reduction – Equivalent Pin Ordering - Network Restructuring and Reorganization: Transistor Network Restructuring, Transistor Network Partitioning and Reorganization - Special Latches and Flip-flops: Self-gating Flip-flop, Combinational Flip-flop, Double Edge Triggered Flip-flop - Low Power Digital Cell Library: Cell Sizes and Spacing, Varieties of Boolean Functions - Adjustable Device Threshold Voltage

UNIT III POWER OPTIMIZATION USING SPECIAL TECHNIQUES 9

Power reduction in clock networks: Clock gating, Reduced swing clock, Oscillator circuit for clock generation, Frequency division and Multiplication, Other clock power reduction techniques - CMOS floating node: Tristate keeper circuit, Blocking gate - Low power bus: Low swing bus, Charge recycling bus - Delay balancing - Low power techniques for SRAM: SRAM cell, Memory bank partitioning, Pulsed word line and reduced bit line swing.

UNIT IV ADVANCED LOW POWER TECHNIQUES 9

Adiabatic Computation - pass transistor logic synthesis - asynchronous circuits - energy recovery circuit design - designs with partially reversible logic: design with reversible logic, adiabatic dynamic logic, energy recovery SRAM core, and optimal voltage selection - supply clock generation.

UNIT V SOFTWARE DESIGN FOR LOW POWER 9

Sources of software power dissipation - Software power estimation: Gate level, Architecture level, Bus switching activity, Instruction level power analysis - Software power optimization: Minimizing memory access costs, Instruction selection and ordering, Power management - Automated low power code generation – Co-design for low power.

Total: 45 Hrs

h) Learning Resources

Text Books

1 Kaushik Roy and S.C.Prasad, "Low power CMOS VLSI circuit design", Wiley, 2000
2 Gary Yeap, "Practical low power digital VLSI design", Kluwer, 1998
3 A.P.Chandrasekaran and R.W.Broadersen, "Low power digital CMOS design", Kluwer, 1995

Reference Books

1 DimitriosSoudris, Christians Pignet, Costas Goutis, "Designing CMOS Circuits for LowPower", Kluwer, 2002
2 J.B.Kulo and J.H Lou, "Low voltage CMOS VLSI Circuits", Wiley 1999
3 AbdelatifBelaouar, Mohamed.I.Elmasry, "Low power digital VLSI design", Kluwer, 1995
4 James B.Kulo, Shih-Chia Lin, "Low voltage SOI CMOS VLSI devices and Circuits", JohnWiley and sons, inc. 2001
5 Steven M.Rubin, "Computer Aids for VLSI Design", Addison Wesley Publishing, 1987.

Online Resources

1 http://freevideolectures.com/Course/3059/Low-Power-VLSI-Circuits-and-Systems
2 http://www.springer.com/us/book/9788132219361

Course Code	Course Title	L	T	P	C
10212EC128	**VLSI DESIGN TECHNIQUES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces basic techniques and algorithms for physical design and optimization of VLSI circuits. The necessary background in graph theory and mathematical optimization, application of different analytical and algorithmic techniques to physical design of VLSI circuits will be studied. The students shall emphasize VLSI design issues encountered in deep sub-micron technology. Throughout the course, students will be exposed to research methodology and to a set of academic and commercial CAD tools for physical design.

c) Related Courses

Low Power VLSI Design, Analog VLSI Design

d) Course Outcome

Upon the successful completion of the course, students will be able to:

e) Pre requisite

VLSI Design

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the design automation algorithms and various constraints posed by VLSI fabrication and design technology	K2
CO2	Illustrate the layout optimization techniques and map them to the algorithms.	K2
CO3	Classify the design algorithms to meet the physical design parameters.	K2
CO4	Summarize VLSI interconnects and routing strategies in deep sub-micron.	K2
CO5	Relate sub-micron challenges and relate them to issues in physical synthesis of ICs.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	M	L	M	L	-	-	-	-	-	M	M	-
CO2	H	M	M	M	M	L	L	-	-	-	-	L	M	-
CO3	M	L	M	M	M	L	L	-	-	-	-	L	L	-
CO4	H	H	M	H	M	L	L	L	L	L	L	M	M	-
CO5	M	M	H	H	-	-	-	L	-	L	H	M	L	-

g) Course Content

UNIT I DESIGN METHODS AND AUTOMATION TOOLS 9

Design domain sand Actions –Design methods and Technologies – Levels of abstractions in Design Automation tools – Graph terminology – data structures for the representation of graphs –Complexity Issues and NP-Hardness: algorithms for NP-hard problems– Graph Algorithms: Depth-First Search Algorithm, Breadth-First Search Algorithms and Dijikstra's Shortest path Algorithms.

UNIT II LAYOUT DESIGN 8

Design Rules – Symbolic Layout – Problem Formulation: Classification of Compaction algorithms- 3/2 dimensional compaction-2D compaction- Hierarchical compaction- Recent trends in Compaction, Informal Problem formulation, Graph theoretical formulation, Maximum design constraints, Algorithms for Constraint graph compaction.

UNIT III PLACEMENT, PARTITIONING AND PLANNING 10

Circuit Representation – Wire length estimation – Placement Problems – Placement Algorithms: Constructive placement, Iterative improvements – Partitioning: K-Lin Partitioning Algorithms – Floor planning concepts: Terminology and Floor plan representation, Optimization problems in Floor planning – Shape functions and Floor plan sizing.

UNIT IV ROUTING **9**

Local routing problems – Area routing – Channel routing: Models, The vertical constraint graphs, horizontal constraints and left-edge algorithms, Channel Routing Algorithms – Global Routing: Standard cell layout, Building-block layout and Channel ordering, Algorithms for Global Routing: Problem definition and discussion, efficient rectilinear Steiner-Tree construction, Local transformations for Global Routing.

UNIT V SIMULATION, SYNTHESIS AND VERIFICATION **9**

Gate level modelling: Signal Modelling, Gate modelling, Delay modelling, Connectivity modelling, Compiler driven simulation, Event driven simulation – Switch level modelling: Connectivity and Signal Modelling, Simulation Mechanisms – Combinational logic synthesis, Binary Decision Diagrams, Two level logic synthesis.

Total: 45 Hrs

h) Learning Resources

Text Books

1. SabihH.Gerez,"AlgorithmsforVLSIDesignAutomation,"WileyIndiaPvtLtd, 2006.
2. Naveed, A. Sherwani, "Algorithms for VLSI Physical Design Automation," Springer, 2005.

Reference Books

1. Charles J Alpert, Dinesh P Mehta, Sachin S Sapatnekar, "Handbook of Algorithms for Physical Design Automation," CRC Press, 2008.
2. M. Sarrafzadeh and C.K. Wong, "An Introduction to VLSI Physical Design," Mc GrawHill, 1996.

Online Resources

1. http://people.ece.umn.edu/~kia/Courses/EE5323/tutorial/Cadence_tuto rial.html
2. https://www.eit.lth.se/cadsys/chapter1.pdf
3. https://www.mics.ece.vt.edu/ICDesign/Tutorials/Cadence/index_old.html

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Course Code	Course Title	L	T	P	C
10212EC129	**VLSI FOR WIRELESS COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to understand the knowledge of VLSI for Wireless Communication and also emphasis on the fundamentals design of wireless systems as well as Transmitter, Receiver, mixers, frequency synthesizers and Power Amplifier.

c) Prerequisite

VLSI Design

d) Related Courses

Communication Systems

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the transmitter and receiver architectures for wireless communication systems	K2
CO2	Interpret the low noise amplifier for wide band, narrow band for impedance matching and power amplifier	K2
CO3	Classify the types of mixer and its parameters	K2
CO4	Explain the application of frequency synthesizers	K2
CO5	Discuss the VLSI architecture for wireless communication	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	M	M	L	-	-	L	L	-	L	-	-
CO2	M	M	L	L	M	L	L	-	L	L	-	L	-	-
CO3	M	L	L	L	M	-	-	-	-	-	-	-	-	-
CO4	M	L	L	L	M	-	-	-	-	-	-	L	-	-
CO5	M	L	L	L	M	L	L	-	L	L	-	L	L	-

g) Course Content

UNIT I OVERVIEW OF WIRELESS COMMUNICATION SYSTEMS 9

Introduction of wireless system-Transmitter Back End-Quadrature LO generator- Receiver Front end- Filter Design-Rest of receiver front end: non idealities and design parameters-Derivation of Noise Figure (NF) and input third order Intercept points (IIP3) of receiver front end-Partitioning of required NF and IIP3 of receiver front end into individual NF and IIP3

UNIT II LOW NOISE AMPLIFIER AND POWER AMPLIFIER 9

Low Noise Amplifier – Matching Network-Wideband LNA –DC Bias-Gain and frequency Response- Noise Figure-Narrowband LNA-Impedance Matching- Matching of Imaginary and real Part- Interpretation of Power Matching-Power Amplifier Design-Specifications-Power output control- Class A Amplifiers-Class AB/B/C Amplifiers-Class E Amplifier.

UNIT III MIXERS 9

Active Mixer: Balancing Mixer-Qualitative Description of the Gilbert Mixer- Conversion Gain-Distortion-Analysis of Gilbert Mixer of Low Frequency Case and High-Frequency Case-Noise.

Passive Mixer: Switching Mixer – Distortion-Conversion Gain and Noise in Unbalanced Switching- Conversion Gain-Sampling Mixture-Gain-Distortion and noise in Single Ended Sampling Mixer.

UNIT IV FREQUENCY SYNTHESIZER 9

Phase Locked Loops-Phase Detector-VCO-Dividers-LC Oscillators-Ring Oscillators-Phase Noise- Loop Filter-First order filter-Second order filter-High Order filter-Design Approach: A complete synthesizer design example (DECT Application)-Implementation of a Frequency Synthesizer with a Fractional Divider Architecture

UNIT V VLSI ARCHITECTURE FOR WIRELESS COMMUNICATION 9

Design and Implementation of Ultralow-Power ZigBee/WPAN Receiver-Split- LNTA + 50% LO Receiver-Comparison of Split-LNTA + 50% LO and Single- LNTA + 25% LO" Architectures-Gain- NF-IIP3-Current and Voltage-Mode Operations-Circuit Techniques-Impedance Up-conversion

Matching- Mixer–TIA Interface Biased for Impedance Transfer Filtering- RC-CR Network and VCO co-design

Total: 45 Hrs

h) Learning Resources

Text Books

1. Bosco H Leung "VLSI for Wireless Communication", Springer, 2nd edition, 2011.
2. Rhee, Woogeun, ed. "Wireless Transceiver Circuits: System Perspectives and Design Aspects", CRC Press, 2015.
3. Crols, Jan, and Michiel Steyaert "CMOS wireless transceiver design", Vol. 411. Springer Science & Business Media, 2013.
4. Razavi, Behzad, and Razavi Behzad "RF microelectronics", Vol. 2. New York: Prentice hall, 2012.

Reference Books

1. ThomasH. Lee "The Design of CMOS Radio–Frequency Integrated Circuits", Cambridge University Press, 2003.
2. Marzuki, Arjuna "CMOS Analog and Mixed-signal Circuit Design: Practices and Innovations", CRC Press, 2020.
3. Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI Wireless Design – Circuitsand Systems", Springer, 2002.

Online Resource

1. www.nptelvideos.in/2012/12/wireless-communication.html
2. www.springer.com/us/book/9781461409854/.

Course Code	Course Title	L	T	P	C
10212EC130	**SOLID STATE DEVICES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

To impart knowledge on physics of semiconductors, transport of carriers in semiconductors and semiconductor based devices.

c) Prerequisite

Nil

d) Related Courses

VLSI Design, Nano Scale Transistors

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the fundamental physics of semiconductors	K2
CO2	Classify the carrier transport mechanisms in semiconductors	K2
CO3	Summarize an operation of PN junctions with the help of semiconductor physics	K2
CO4	Illustrate the physics of operation of bipolar junction transistor	K2
CO5	Interpret the physics of operation of MOS capacitor and MOSFET	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	*H*	*M*	-	*L*	-	-	-	-	-	-	-	*M*	-	-
CO2	*H*	*M*	-	*M*	-	-	-	-	-	-	-	*M*	*L*	-
CO3	*M*	*H*	-	*L*	-	-	-	-	-	-	-	*M*	-	-
CO4	*M*	*H*	*L*	*L*	*L*	*L*	-	-	*L*	*M*	*L*	*M*	*M*	-
CO5	*M*	*H*	*L*	*L*	*L*	-	-	-	*L*	*M*	*L*	*M*	*M*	-

g) Course Content

UNIT I BASICS OF SEMICONDUCTORS 9

Energy bands: metals, semiconductors and insulators, direct and indirect semiconductors, Charge carriers in semiconductors: electrons and holes, intrinsic and extrinsic material: n-material and p-material, carrier concentration: fermi level, electron and hole concentrations at equilibrium, temperature dependence.

UNIT II CARRIER TRANSPORT IN SEMICONDUCTORS 9

Conductivity and mobility: drift and resistance, effect of temperature and doping on mobility, high field effects, Generation and Recombination mechanisms of excess carriers: direct and indirect recombination, steady state carrier generation, quasi Fermi levels, Diffusion of carriers: diffusion processes, Einstein relations.

UNIT III PN JUNCTIONS 9

PN junctions: formation of junction, contact potential, electrical field, potential and charge density at the junction, space charge at a junction, energy band diagram, Ideal diode equation, electron and hole component of current in forward biased p-n junction, Reverse bias breakdown in p-n junctions: zener and avalanche break down.

UNIT IV BIPOLAR JUNCTION TRANSISTORS 9

Bipolar transistor action: Basic principle of operation, modes of operation, amplification with bipolar transistors, minority carrier distributions: forward active mode, other modes of operation.

UNIT V METAL INSULATOR SEMICONDUCTOR DEVICES AND MOSFET 9

Metal Insulator semiconductor devices: The ideal MOS capacitor, band diagrams at equilibrium, accumulation, depletion and inversion, surface potential, CV characteristics, effects of real surfaces, work function difference, interface charge, threshold voltage
MOSFET scaling, short channel effects, Advanced MOSFETs – Fin FETs and Junction less FETs.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Ben G. Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, Pearson, 7/e, 2014.
2. Achuthan, K N Bhat, Fundamentals of Semiconductor Devices, 1e, Tata McGraw Hill,2015

Reference Books

1. Robert F. Pierret, Semiconductor Devices Fundamentals, Pearson, 2006
2. Sze S.M., Physics of Semiconductor Devices, John Wiley, 3/e, 2005
3. Donald A. Neamen, Semiconductor Physics and Devices, McGraw Hill, 4/e, 2012

Online Resources

1. https://nptel.ac.in/courses/117106091
2. https://nanohub.org/groups/semiconductors

Course Code	Course Title	L	T	P	C
10212EC131	**ARCHITECTURAL DESIGN OF DIGITAL INTEGRATED CIRCUITS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course explains the fundamental principles of algorithms available for performing arithmetic operations and evaluation of more complex operations on digital computers.

c) Prerequisite

Digital Electronics

d) Related Courses

Low power VLSI Design

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Infer the various algorithms for efficient architectural mapping	K2
CO2	Explain the various adder and multiplier architecture	K2
CO3	Summarize the VLSI architecture for various DSP blocks	K2
CO4	Interpret CORDIC architecture with any applications	K2
CO5	Illustrate the timing issues in VLSI	K2

f)	Correlation of COs with POs and PSOs													
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	H	M	M	L	L	–	–	–	–	–	–	H	M	–
CO2	H	H	M	H	L	–	–	–	–	–	–	L	H	–
CO3	M	L	H	M	L	M	L	–	M	L	–	L	L	–
CO4	H	H	M	H	L	M	L	–	M	L	–	M	M	–
CO5	M	M	H	H	L	–	–	–	–	–	–	H	L	–

g) Course Content

UNIT I ALGORITHM TO EFFICIENT ARCHITECTURE MAPPING 9

One bit incrementer, n-bit incrementer and decrementer, ones' complement, two's complement, Single bit addition, sum of N –natural numbers, Resource sharing , prioritization, greatest common divisor (GCD).

UNIT II ADDER AND MULTIPLIERARCHITECTURE 9

Carry – Skip adder, Carry-Look ahead adder, Carry –Select adder, Array multiplication, squaring, shift and add multiplier, Tree Multiplier, Booth algorithm, Dadda multipliers

UNIT III EFFICIENT VLSI ARCHITECTURE FOR VARIOUS DSP BLOCKS 9

Reconfigurable constant Multiplier Design- common sub expression algorithm- 3 Tap FIR Filter architecture – Radix -2 FFT architecture design .Fixed point representation –optimum word length.

UNIT IV CORDIC ARCHITECTURE 9

CORDIC method, rotation and vectoring mode, convergence, precision and range, scaling factor and compensation, implementations: word-serial and pipelined– Micro rotation to Angel Recoding (MAR), Binary to Bipolar Recoding (BBR).

UNIT V ISSUES IN TIMING CLOSURE 9

Static and Dynamic timing analysis, System Considerations - edge triggered, clock skew, handling asynchronous inputs, sequential machine, clock cycle time, Violation – maximum propagation delay, race through, Re-timings.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Behrooz Parhami, “Computer Arithmetic Algorithms and Hardware Designs”, second edition, Oxford University Press, 2010

2. M. D. Ercegovac and T. Lang. “Digital Arithmetic”, Elsevier Science (USA).2003

Reference Books

1. Ulrich W. Kulisch . “Advanced Arithmetic for the Digital Computer”, Springer- Verlag Wien, 2002.

Online resources

1. https://www.youtube.com/watch?v=iQHmtEtEggY
2. https://onlinecourses.nptel.ac.in/noc22_ee58.

Course Code	Course Title	L	T	P	C
10212EC132	**NANO SCALE TRANSISTORS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides insight to the fundamentals of novel transistors and impinges the basics of multigate MOS system and its working. Various Nanowire FETs along with their performance evaluation is analyzed so as to study the radiation effects of MOSFETs. Further discussion is to design the circuits using the concepts of multigate devices and the ways to reduce short-channel effects.

c) Prerequisite

Nil

d) Related Courses

Solid state devices

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain about the various novel MOSFETs to tackle short channel effects	K2
CO2	Interpret the physics of multigate MOS system	K2
CO3	Summarize the performance of Nanowire FETs	K2
CO4	Relate the working of transistors at the molecular scale along with their radiation effects	K2
CO5	Apply the concept of multigate devices to design a circuit	K3

f)	Correlation of COs with POs and PSOs													
	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	H	M	-	L	-	-	-	-	-	-	-	M	M	-
CO2	H	M	-	M	-	-	-	-	-	-	-	M	M	-
CO3	H	H	-	L	-	-	-	-	-	-	-	M	M	-
CO4	H	H	-	L	-	L	-	-	L	M	-	M	M	-
CO5	H	H	M	L	H	H	L	M	L	M	M	M	M	-

g) Course Content

UNIT I INTRODUCTION TO NOVEL MOSFETS 9

Fundamentals of Novel Transistors- Comparison Normal and Novel Transistor with advantages- Construction of MOSFET- MOSFET scaling, short channel effects-channel engineering - source/drain engineering – high k dielectric - copper interconnects - strain engineering, SOI MOSFET– Types of Gates in SOI MOSFETs.

UNIT II PHYSICS OF MULTIGATE MOS SYSTEM 9

MOS Electrostatics – 1D – 2D MOS Electrostatics, MOSFET Current-Voltage Characteristics – CMOS Technology – Ultimate limits, double gate MOS system – gate voltage effect – semiconductor thickness effect – asymmetry effect – oxide thickness effect – electron tunnel current.

UNIT III NANOWIRE FETs 9

Nanowires and their classification-Silicon nanowire MOSFETs – Evaluation of I-V characteristics – The I-V characteristics for non-degenerate carrier statistics – The I-V characteristics for degenerate carrier statistics – Properties of Carbon nanotubes – Carbon nanotube FETs.

UNIT IV TRANSISTORS AT THE MOLCULAR SCALE AND RADIATION EFFECTS 9

Electronic conduction in molecules – General model for ballistic nano-transistors – MOSFETs with 0D, 1D, and 2D channels – Molecular transistors -Radiation effects in SOI MOSFETs, total ionizing dose effects – single gate SOI – multigate devices.

UNIT V CIRCUIT DESIGN USING MULTIGATE DEVICES 9

Digital circuits – impact of device performance on digital circuits – leakage performance - trade off – SRAM design, Analog circuit design – transconductance – intrinsic gain – flicker noise – self heating – band gap voltage reference -comparator designs.

Total: 45 Hrs

h) Learning Resources

Text Books

1. J P Colinge, FINFETs and other multi-gate transistors, Springer – Series onintegrated circuitsand systems, 2008
2. Mark Lundstrom Jing Guo, Nanoscale Transistors: Device Physics, Modeling andSimulation,Springer,2006

Reference Books

1. M S Lundstorm, Fundamentals of Carrier Transport, 2nd Ed., Cambridge University Press, Cambridge UK, 2000
2. Yuan Taur and Tak H. Ning, Fundamentals of Modern VLSI Devices, 2nd Edition , Cambridge Univ. Press, Cambridge UK, 2021
3. R.F. Pierret, Advanced Semiconductor Fundamentals, 2nd Edition Prentice Hall, 2003

Online Resources

1. https://onlinecourses.nptel.ac.in/noc22_ee47/preview
2. https://onlinecourses.nptel.ac.in/noc22_ee47/preview

Course Code	Course Title	L	T	P	C
10212EC133	**OPTO ELECTRONIC DEVICES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

Optoelectronic devices aim to learn different types of optical emission, detection and optoelectronic integrated circuits and their applications.

c) Prerequisite

Nil

d) Related Courses

Optical and Microwave Communication Systems

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the fundamentals of optoelectronics	K2
CO2	Compare the different types of display devices and operating principle of laser	K2
CO3	Classify the different types of photo detectors	K2
CO4	Explain about the modulators and switching devices	K2
CO5	Illustrate the integration methods, materials, OEIC transmitters receivers, guided wave devices and photonic integrated circuits	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	L	L	-	-	-	-	-	-	-	L	-	-
CO2	L	M	M	L	M	L	-	-	L	L	-	M	L	-
CO3	M	M	L	M	L	L	-	-	M	L	L	M	-	L
CO4	L	L	M	M	L	L	-	L	L	L	L	M	L	-
CO5	M	M	L	L	M	M	L	-	M	M	M	M	-	L

g) Course Content

UNIT I FUNDAMENTALS OF OPTOELECTRONICS 9

Nature of Light, Wave Nature of Light: Polarization – Interference - Diffraction, Light Sources: Blackbody Radiation, Units of Light, Generation of Photo electronics, Elements of Solid State Physics - Quantum Mechanical Concept, Energy Bands in Solids, Semiconductors and Semiconductor Junction Devices.

UNIT II DISPLAY DEVICES AND LASER 9

Luminescence, Photoluminescence Cathode luminescence, Cathode Ray Tube, Electro Luminescence, Injection Luminescence, LED: Materials - Commercial LED Materials – Construction - Drive circuitry, Plasma Display, Liquid Crystal Displays, Thermal Sensing andFAX printing-Emission and Absorption of Radiation, Population Inversion, Laser losses, LaserModes: Mode Locking- Active Mode Locking - Passive Mode Locking, Laser Applications

UNIT III PHOTO DETECTORS 9

Thermal Detectors - Thermoelectric Detectors - Bolometer – Pyro electric Detectors- Organic detectors, Photon Devices - Photo Emissive Devices - Vacuum Photodiodes - Photo Multipliers- Nanomaterial detector- Photon Counting Techniques - Photo Conductive Detectors, Detector Performance Parameters.

UNIT IV MODULATION AND SWITCHING DEVICES 9

Analog and Digital Modulation, Franz- Keldysh and Stark Effect Modulators, Quantum well Electro- Absorption Modulators, Electro-Optic Modulators- Birefringence and Electro- Optic Effect - Kerr Modulators - Magneto Optic Modulators, Optical switching, and logic devices.

UNIT V PHOTONICS & OPTOELECTRONIC INTEGRATED CIRCUITS 9

Hybrid and Monolithic Integration, Applications of Optoelectronic Integrated Circuits, Materials and Processing for OEICs, Integrated Transmitters and Receivers- Front End Photo Receiver - PIN HBT Photo Receiver - OEIC Transmitter, Guided Wave Devices. Photonics, Photonic Integrated Circuits, Recent Developments in Photonic Integrated Circuits.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Pallab Bhattacharya "Semiconductor Opto Electronic Devices", Prentice Hall ofIndia Pvt., Ltd., New Delhi, 2006.
2. J. Wilson and J.Haukes, "Opto Electronics – An Introduction", Prentice Hall, 1995
3. G. Ghione, Semiconductor Devices for High-Speed Optoelectronics, Cambridge University Press (2009)

Reference Books

1. S C Gupta, Opto Electronic Devices and Systems, Prentice Hal of India, 2005.
2. Jasprit Singh, "Opto Electronics – As Introduction to Materials and Devices", McGraw-Hill International Edition, 1998
3. B. E. A. Saleh and M. C. Teich, Fundamentals of Photonics, John Wiley & Sons, Inc., 2nd Ed. (2007).
4. A. Yariv and P. Yeh, Photonics: Optical Electronics in Modern Communication, Oxford University Press (2007), 6 th Ed.
5. G. Keiser, Optical Fiber Communications, McGraw-Hill Inc., 3 rd Ed. (2000).
6. J. Singh, Semiconductor Optoelectronics: Physics and Technology, McGraw-Hill Inc. (1995).

Online Resources

1. https://nptel.ac.in/courses/115/102/115102103/
2. https://nptel.ac.in/courses/117/101/117101054/

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Course Code	Course Title	L	T	P	C
10212EC134	**ELECTRONIC INSTRUMENTATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course Electronic Instrumentation provides adequate knowledge in Electronic Instruments.

c) Pre requisite

Analog Electronics

d) Related Courses

Virtual Instrumentation

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the working and measurement of electronic parameters with various types of electronic measurement devices.	K2
CO2	Demonstrate the working principle and measurement techniques of various types of oscillators and signal analyzers.	K2
CO3	Classify the working and measurement techniques of different types of waveform generators.	K2
CO4	Illustrate the various measurements and errors in instrumentations.	K2
CO5	Summarize the standard forms of interfaces used in electronic instrumentation for various applications.	K2

f) Correlation of COs with POsand PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	M	M	M	-	-	-	-	-	-	L	L	-
CO2	M	M	M	M	L	-	-	-	-	-	-	M	L	-
CO3	M	M	M	M	L	-	-	-	L	L	L	L	L	-
CO4	M	L	M	L	-	-	-	-	-	-	-	L	L	-
CO5	H	M	M	M	L	L	L	-	L	L	L	L	-	-

g) Course Content

UNITI ELECTRONIC INSTRUMENTS 9

Classification of instruments, Electronic voltmeter and their advantages – types, digital IC tester, source follower, rectifier – True RMS reading voltmeter – electronic multimeter and ohmmeter, Digital frequency meter, Digital LCR meter, Q-Meter, Digital wattmeter and energy meters, microprocessor based DMM with auto ranging and self-diagnostic features.

UNIT II OSCILLOSCOPE & SIGNAL ANALYZERS 9

General purpose cathode ray oscilloscope – Dual trace, dual beam and sampling oscilloscopes– analog and digital storage oscilloscope-frequency selective and heterodyne wave analyser – harmonic distortion analyser – spectrum analyser.

UNIT III WAVEFORM GENERATORS 9

Wien's bridge and phase shift oscillators – Hartley and crystal oscillators – square wave and pulse generators – triangular wave-shape generator - signal and function generators, square, triangular sinusoidal waveform generator– Q meter, electronic counters.

UNIT IV MEASUREMENTS AND CALIBRATION 9

Introduction, significance of measurement, measurement characteristics, measurement of quality factor (Q), Calibration of instruments, Static & dynamic characteristics. Current, Power and Energy Measurement, Time measurement, Frequency measurement, phase angle measurement, Humidity and moisture measurement.

UNIT V COMMON INSTRUMENTATION INTERFACES 9

Modern instrumentation and control systems – OSI model – EIA 232 interface standard -EIA 485 interface standard - EIA 422 interface standard –20 mA current loop – serial interface converters.

Total: 45 Hrs

h) Learning Resources

Text Books

1. A.K.Sawhney, ACoursein "Electrical & Electronic Measurements and Instrumentation", Nineteenth revised edition, Dhanpat Rai and Co, New Delhi, 2011.
2 DavidABell, "Electronic Instrumentation and Measurements", Third edition, Oxford University Press, 2013.
3 Cooper W.D and Helfrick A.D, "Modern Electronic Instrumentation and Measurement Techniques", 4th Edition, Pearson India Education, 2015.

Reference Books

1. A.D. Helfrick and W.D. Cooper, Modern Electronic Instrumentation and Measurement Techniques, Prentice Hall India Private Ltd., New Delhi, 2010
2. J.J.Carr, Elements of Electronic Instrumentation and Measurement, Pearson Education India, New Delhi, 2011
3. M.M.S. Anand, Electronics Instruments and Instrumentation Technology, Prentice HallIndia, New Delhi, 2009.

Online Resources

1. http://www.getbookee.org/electrical-measurement-sawhney/
2. http://ebookbrowse.com/measurements-and-instrumentation-pdf-d971599983.
3. http://www.bookpump.com/bwp/pdf-b/2335004b.pdf

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Course Code	Course Title	L	T	P	C
10212EC135	**NANO PHOTONICS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course shall introduce the basic principles, applications and latest advances in the area of Nano photonics. Student shall have a clear view about this excited new area and ready to contribute to the advances of photonic technology in the broad area of applications such as light-matter interactions, lithography, nano photonic devices in medicine and various other emerging fields.

c) Prerequisite

Electromagnetics field.

d) Related Courses

Opto Electronic Devices, Fiber Lasers and Application

e) Course Outcomes

Upon the successful completion of the course, students will be able to,

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Relate the devices and general concepts used in nano optics, nano photonics and nano opto-electronics.	K2
CO2	Summarize the basics of photonics, building blocks of photonic circuits and its effects.	K2
CO3	Explain the basic functions, properties and different methods of nanolithography process.	K2
CO4	Illustrate the impact of biomedical research in biotechnology	K2
CO5	Interpret the scientific discoveries lead to technological inventions with nano photonics.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	M	L	-	-	L	M	-	-	L	-	-
CO2	H	M	M	L	M	-	-	L	-	-	-	M	L	-
CO3	M	M	L	H	-	L	-	-	M	L	L	-	-	-
CO4	L	L	M	M	M	-	-	L	-	-	-	M	-	-
CO5	M	M	L	L	M	M	L	-	M	M	M	M	M	-

g) Course Content

UNIT I INTRODUCTION **9**

Introduction, Photonics, Nano photonics, Frontier in Nanotechnology, Impact of Nano photonics, Trends in Nano photonics, Opportunities for Basic Research and Development of New Technologies, scope of nano photonics, electron tunneling, photon tunneling.

UNIT II NANO PHOTONICS FOUNDATION **9**

Photons and Electrons, Similarities and Differences - Free-Space Propagation - Confinement of Photons and Electrons. Nanoscale Optical Interactions - Axial Nanoscopic Localization - Lateral Nanoscopic Localization. Nanoscale Confinement of Electronic Interactions - Quantum Confinement Effects, Nanoscopic Interaction Dynamics, New Cooperative Transitions, Nanoscale Electronic Energy Transfer, Cooperative Emission.

UNIT III NANO LITHOGRAPHY **9**

Introduction, Lithography, Two Photon Lithography, Near Field Lithography, Near Field Phase Mask, Soft Lithography, Plasmon Printing, Nanosphere Lithography, Dip-Pen Nanolithography, Nano imprint Lithography, Photonically Aligned Nano arrays.

UNIT IV NANO PHOTONICS FOR BIOTECHNOLOGY **9**

Near-Field Bioimaging, Nanoparticles for Optical Diagnostics and Targeted Therapy, Semiconductor Quantum Dots for Bioimaging, Biosensing - Photonic Crystal Biosensors, Optical Nanofiber Sensors. Nanoclinics for Optical Diagnostics and Targeted Therapy.

UNIT V NANO PHOTONICS AND ITS APPLICATIONS 9

Nanotechnology, Lasers and Photonics: Nanotechnology – Photonics – Nano photonics, Optical Nanomaterials: Nanoparticle Coatings - Sunscreen Nanoparticles - Self-Cleaning Glass - Fluorescent Quantum Dots – Nanobarcodes - Photonic Crystals - Photonic Crystal Fibers, Quantum-Confined Lasers, Near-Field Microscopy, Nanolithography, Photonics in Future: Power Generation and Conversion - Information Technology - Sensor Technology – Nanomedicine

Total 45 Hrs

h) Learning Resources

Text Book

1. Paras N. Prasad, "Nanophotonics", John Wiley & Sons, Inc. 2004, ISBN:9780471649885

Reference Books

1. Sergey V. Gaponenko, Introduction to Nanophotonics", Cambridge University Press, 2010.
2. F. Graham Smith, Terry A. King and Dan Wilkins, "Optics and Photonics: An Introduction", second edition, John Willey Sons limited, 2007.
3. Connelly, Michael J. "Semiconductor Optical Amplifiers" Springer 2002. ISBN: 978-0-306-48156-7.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc23_ee141/preview
2. https://archive.nptel.ac.in/courses/108/106/108106186/
3. https://onlinecourses.nptel.ac.in/noc23_ee139/preview

Course Code	Course Title	L	T	P	C
10212EC136	**FIBER LASERS AND APPLICATIONS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

To impart knowledge on laser operation, different types of fiber lasers- Continues Wave (CW) and Pulsed lasers- Q-switching - Mode-locking techniques and applications of fiber lasers.

c) Prerequisite

Nil

d) Related Courses

Opto Electronic Devices, Nano Photonics

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the theoretical background of laser operation and types	K2
CO2	Classify the various fabrication processes of different lasers using the electromagnetic field equations.	K2
CO3	Interpret the types of laser with different design parameters	K2
CO4	Illustrate the laser characteristics by the modelling of laser cavity.	K2
CO5	Explain the various applications of fiber lasers in different fields.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	M	L	-	-	L	M	-	-	L	-	-
CO2	H	M	M	L	M	-	-	L	-	-	-	M	L	-
CO3	M	M	L	H	-	L	-	-	M	L	L	-	-	-
CO4	L	L	M	M	M	-	-	L	-	-	-	M	-	-
CO5	M	M	L	L	M	M	L	-	M	M	M	M	M	-

g) Course Content

UNIT I Introduction to lasers **9**

Introduction to general lasers and their types, Schrodinger wave equation, Atomic systems, emission and absorption processes, Population inversion, gain, optical cavities, three- and four-level lasers, CW and pulsed lasers, Q-switching and mode-locking techniques.

UNIT II Laser systems **9**

Atomic, ionic, molecular, excimer and liquid laser systems- Review of Electromagnetic properties - Basic principle of laser action, Fabrication of lasers - Modulation of lasers - Quantum Well and Quantum Dot Lasers - Passive mode locking Lasers.

UNIT III Fiber lasers **9**

Basic concepts - cavity design – continuous wave (CW) lasers – ytterbium doped fiber lasers – erbium doped fiber lasers - passive mode-locking - saturable absorber - nonlinear fiber loop mirror- graphene based saturable absorber - nonlinear polarization rotation - role of fiber nonlinearity and dispersion - saturable absorber mode-locking

UNIT IV Numerical modeling of fiber lasers **9**

Modeling of passively mode-locked fiber lasers – lumped and distributed modeling - scalar and vector modeling - nonlinear dynamics inside the laser cavity – multi wavelength fiber laser modeling – numerical methods – split step Fourier method – variational analysis – finite difference and finite element beam propagation methods – Runge kutta method.

UNIT V Applications **9**

Laser cooling; Laser barcode scanner, Laser trimming, Cutting, Welding, Drilling and Tracking, Pattern formation by laser etching; LIDAR; Laser-tissue interaction, Laser surgery; Holography, Interferometry, Microscopy.

Total 45 Hrs

h) Learning Resources

Text Books

1. Govind P. Agarwal," Applications of Nonlinear Fiber Optics" Second Edition, 2007.

Reference Books

1. Andrew. M. Weiner, "Ultrafast Optics" Wiley Series in Pure and Applied Optics, 2008.
2. Le Nguyen Binh , Nam Quoc Ngo, "Ultra-Fast Fiber Lasers" Principles and Applications with MATLAB Models", CRC Press, 2011.
3. Jean-Claude Diels, Wolfgang Rudolph," Ultra short Laser Pulse Phenomena, Fundamentals, Techniques, and Applications on a Femtosecond Time Scale" Academic Press ,Second Edition, 2006.
4. Laser Application in Surface Science and Technology, by H. G. Rubahn; John Wiley and Sons, 1999.
5. Laser Spectroscopy: Basic Concepts and Instrumentation, by Demtroder; Springer, 2004.

Online Resources

1. https://archive.nptel.ac.in/courses/115/102/115102124/
2. https://archive.nptel.ac.in/courses/104/104/104104085/

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Course Code	Course Title	L	T	P	C
10212EC137	SENSORS AND TRANSDUCERS	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to provide the analysis of various sensors and transducers by giving them in-depth knowledge about static, dynamic characteristics and error analysis methods.

c) Prerequisite

Basic Electrical and Instrumentation Engineering

d) Related Courses

Electronic Instrumentation

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize various calibration techniques and signal types for sensors	K2
CO2	Explain the construction, working principle, characteristicsand applications of various resistance transducers	K2
CO3	Interpret the working principle of various inductance and capacitance transducers	K2
CO4	Illustrate the basic principles of various smart sensors.	K2
CO5	Discuss the operation and applications of modern industrial transducers	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	H	-	-	-	-	-	-	-	L	L	-
CO2	L	L	M	M	-	H	-	L	-	-	-	L	M	-
CO3	L	M	L	M	-	-	L	-	L	L	-	L	L	-
CO4	L	M	H	M	M	L	-	L	L	L	L	M	M	L
CO5	M	L	H	M	M	L	-	L	M	M	M	M	M	L

g) Course Content

UNIT I INTRODUCTION TO MEASUREMENTS SYSTEMS 9

Generalized measurement system - Static calibration – Limiting error and probable error- Classification of errors – Error analysis – Statistical methods – Odds and uncertainty – Static characteristics – Accuracy, precision, resolution, threshold, sensitivity, linearity, repeatability, reproducibility, loading effect, drift, static error, span and range, hysteresis, dead time and dead zone, Dynamic characteristics

UNIT II RESISTANCE TRANSDUCERS 9

Classification of transducers – Selection of transducers, potentiometer: Principle of operation, construction details, Strain gauge – types , Load and torque measurement, Resistance temperature detector (RTD)- Thermistor –Hot-wire anemometer– constant current and constant temperature operation - Resistive humidity sensor

UNIT III INDUCTANCE AND CAPACITANCE TRANSDUCERS 9

Induction potentiometer – Variable reluctance transducer – Eddy current transducer –Principle of operation, construction details, characteristics and applications of Linear Variable Differential Transducers, proximity sensors, tacho-generators –Capacitive transducer and types - Differential arrangement – Variation of dielectric constant for measurement of liquid level - Dynamic microphone.

UNIT IV OPTICAL & ELECTRICAL SENSORS 9

Photo conductive cell, photo voltaic, Photo resistive, LDR – Pressure – Diaphragm, Bellows, Tactile sensors, Acoustic Sensors, Radiation Sensors - Smart Sensors - Film sensor, Motion Sensors –Accelerometer, Range Sensors – Ultrasonic Ranging, Laser Range Sensor (LIDAR). Nano sensors, semiconductor sensor.

UNIT V MISCELLANEOUS TRANSDUCERS 9

Piezoelectric transducer – Hall Effect transducer – Magneto resistor - Digital displacement Transducer– Fiber optic sensor - Introduction to SQUID sensor, Touch screen sensor, Smart Transducer, MEMS and Introduction to linearization of transducer.

Total 45 Hrs

h) Learning ResourcesText

Text Books

1. Ernest O.Doebelin,- Measurement systems‖, 6th Edition, Tata McGraw Hill EducationPrivate Ltd, New Delhi, 2012.
2. A.K. Sawhney,- A course in Electrical & Electronic Measurement and Instrumentation, Dhanpat Rai and Company Private Limited, Reprint: 2014.

Reference Books

1. D. Patranabis, ―Sensors and Transducers‖, 2nd Edition, Prentice Hall ofIndia, 2010.
2. John P.Bentley, ―Principles of Measurement Systems‖, 4th Edition,Pearson Education, 2004.
3. Neubert H.K.P., ―Instrument Transducers – An Introduction to their Performanceand Design‖, Oxford University Press, Cambridge, 2003 .
4. Murthy D.V.S., ―Transducers and Instrumentation‖, 2nd Edition, PrenticeHallof India Private Limited, New Delhi, 2010.
5. S.Renganathan, ―Transducer Engineering‖, Allied Publishers, 2005.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc21_ee32/preview

Course Code	Course Title	L	T	P	C
10212EC216	**FPGA ARCHITECTURE TECHNOLOGIES AND TOOLS**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course discusses the features, programming and applications of Programmable Logic Devices. The students shall emphasize the VLSI architectures such as Altera series Max 5000/7000 series, cypress flash, Virtex- II, Flex architectures, case study. It provides VLSI system design experience using FSM. This course introduce the VHDL models, process, concurrent and sequential statements, loops, delay models, library packages, functions, procedures, test bench and Digital Front End Digital Design Tools

c) Prerequisite

Nil

d) Related Courses

Reconfigurable Computing With FPGA

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the features of programmable logic devices, CPLD, performance and its applications.	K2
CO2	Summarize the various FPGA architectures, programmable interconnects and one hot encoding.	K2
CO3	Illustrate the syntax and behavior of the VHDL language	K2
CO4	Construct the combinational circuit using VLSI system design	K3
CO5	Model the sequential circuits using VLSI system design	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	-	L	-	-	-	-	-	-	-	M	M	-
CO2	H	L	-	H	-	-	-	-	-	-	-	M	M	-
CO3	M	L	-	M	-	-	-	-	-	-	-	M	M	-
CO4	H	H	H	H	H	M	M	-	H	L	M	H	H	-
CO5	H	H	H	H	H	M	M	-	H	L	M	H	H	-

g) Course Content

UNIT I PROGRAMMABLE LOGIC DEVICE 6

Introduction to features of ROM, PLD, PLA, PAL, GAL, CPLD-Altera series – Max 5000/7000 series - Cypres FLASH 370 Device Technology, Lattice LSI's Architectures – 3000 Series– Applications of CPLDs.

UNIT II FIELD PROGRAMMABLE GATE ARRAYS 6

FPGAs- Logic blocks, Routing architecture, programmable interconnect, Mapping for FPGAs, Xilinx FPGA Architecture: Xilinx XC3000, XC4000 – Altera Architecture: FLEX 8000, Case studies: Xilinx Virtex II Pro.

UNIT III VHDL FOR SYNTHESIS 6

Introduction, data flow, behavioral, structural models, operators, process, concurrent statements, Sequential Statements, Loops, Modeling Delays, Sequential Circuits, Library, Packages, Functions, Procedures, Test bench.

UNIT IV COMBINATIONAL CIRCUIT USING DESIGN TOOLS 6

Digital Front End Design Tools for FPGAs & ASICs: Guidelines and Case Studies of inverters, parallel adder, multiplexers, comparator, CMOS design using Cadence Tool.

UNIT V FINITE STATE MACHINES 6

Top down Approach to Design, State diagram, State Transition Table, State assignments for FPGAs, Case study Mealy & Moore Machines, FSM issues-Starring state, Power on Reset, State diagram optimization, Fault Tolerance.

h) List of experiments

S.No.	Experiment Title	CO
1.	Implementation of PLD Design using VHDL	CO1
2.	Implementation of CMOS Inverter using VHDL	CO2
3.	Implementation of Comparator using VHDL	CO3
4.	Implementation of Parallel Adder using Cadence	CO4
5.	Implementation of Array Multiplier using Cadence	CO4
6.	FSM Design using VHDL	CO5
7.	Design of Vending Machine Controller using VHDL	CO5

Total: 60 Hours

i) Learning Resources

Text Books

1. P.K.Chan& S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall (Pte), 1994.
2. M. J. S. Smith, "Application Specific Integrated Circuits," Addition – Wesley Longman Inc., 1997.
3. VHDL Primer, J. Bhasker, American Telephone and Telegraph Company, Bell Laboratories Division, P T R Prentice Hall, Englewood Cliffs, New Jersey 07632
4. Ian Grout, Digital System Design using FPGA and CPLD, Elsevier, 2008.

Reference Books

1. Jon F Wakerly, Digital Design: Principles and Practices, Prentice Hall.
2. Douglas L. Perry, VHDL: Programming by Example, McGraw-Hill Education,Fouth Edition.
3. S.Trimberger, Edr., Field Programmable Gate Array Technology, Kluwer, Academic Publications, 1994.
4. Kevin Skahil, VHDL for programmable logic, Addison Wesley.
5. J. Old Field, R.Dorf, Field Programmable Gate Arrays, John Wiley & Sons, Newyork, 1995.

Online Resources

1. https://www.nptelvideos.com/lecture.php?id=9548
2. https://www.udemy.com/course/fpga-design-and-implementation/

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COURSE CODE	COURSE TITLE	L	T	P	C
10212EC217	ELECTRONICS CIRCUIT SIMULATION AND PCB DESIGN	1	0	4	3

a) Course Category

Programme Elective

b) Preamble

The course is aimed at making the students to understand electronic circuit simulation process for better understanding and designing of cost-effective Printed Circuit Boards. Emphasizing the students to understand how to design a PCB layout of given circuit using available circuit simulation and PCB layout design CAD tools (free or licensed). This course helps the student to simulate the circuit, develop the complete hardware circuit on PCB and assemble the components using SMD soldering technique

c) Prerequisite Courses

Nil

d) Related Courses

Analog Electronics, Linear Integrated Circuits

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Demonstrate and simulate and perform various analysis for the given electronic circuit.	S3
CO2	Perform a PCB layout for the given circuit	S3
CO3	Fabricate the PCB and assemble the components.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	M	H	H	H	H	-	-	M	-	-	M	H	H
CO2	L	M	H	M	H	-	-	-	M	-	-	M	M	H
CO3	L	M	H	M	H	-	-	-	M	-	-	M	L	L

g) Course Content

Theory **15 Hours**

Electronics Circuit Simulation

State the features of different circuit simulation tools (Open source or licensed) used for electronic circuit simulation. Different PCB layout design tools (Open source or License) used for PCB layout design. General terms and elements used in circuit simulation software. Assemble electronics circuit using circuit simulation software. Types of Circuit Analysis- Transient Analysis, Bias Point Analysis, Frequency Response.

PCB Layout Design

Terms used: net list file, back annotation, bill of material, foot print, PTH, track width, mil, etc. used in PCB layout design software. Place, route and generate the layout of given circuit using manual or auto routing using PCB layout design software. Raw Materials - Types of PCBs: Single layer - Double layer - Multi layer – Rigid – Flexible - Flex Rigid - High frequency - Aluminium_Backed - Track Width Calculation - Layout Design - Back Annotation -Gerber File - NC Drill File - Fab and Assembly Drawings – Legend - Bill of Material. Packaging Trends - Package Classifications - Package Type and Characteristics: Through-Hole Mounting - Surface Mounting - Special Packages- Package Symbols and Codes. Symbols-Reference Designators- Values and Attributes-Schematic Design Guidelines-Routing - Nodes – Joints - Design Error Check.

PCB Manufacturing and Assembly

Design to Manufacturing - CAM Editor - Reverse Engineering of PCBs - From File to Film - Printing the Inner layers - Removing the Unwanted Copper - Layer Alignment and Optical Inspection - Layer-up and Bond – Drill Plating- Copper Deposition - Outer Layer Imaging Plating- Final Etching - Solder Mask Application - Surface Finish – Silkscreen- Electrical Test - Profiling and V-Scoring - Soldering: Soldering Tools- Assembly and Support Equipment.

h) List of Experiments

S.No.	**COs**	**Practical Exercises** **60**
1.	CO1	Getting acquainted with simulation tool
2.	CO1	Design a Variable Power Supply Circuit using LM338/LM317
3.	CO1	Design a Hartley Oscillators Circuit and simulate its response.
4.	CO1	Design an AstableMultivibrator Circuit and simulate its response.
5.	CO1	Design and simulate response of Active and Passive Filter Circuits.
6.	CO2	Getting acquainted with PCB layout tool

7.	CO2	Design a PCB layout for the given circuit (Basic Level)
8.	CO2	Design a PCB layout for the given circuit (Advanced Level)
9.	CO2	Board to Layout Design (Reverse Engineering)-FM Board.
10.	CO3	Hands on Experience-Soldering and types of Soldering
11.	CO3	THT components- Drilling and Soldering.
12.	CO3	Complete Board Assembly-FM Board

Total 75 hrs

i) Learning Resources

Textbooks

1. Make Your Own PCBs with EAGLE: From Schematic Designs to Finished Boards, Simon Monk; McGraw Hill Education, 2014
2. Complete PCB Design Using OrCAD Capture and PCB Editor, Kraig Mitzner Newnes; Pap/Cdr edition (28 May 2009), 2011, ISBN: 978-1-4493- 9357-1

Major Equipment/ Instrument/Software with Broad Specifications

3. Altium Designer (Licensed version)
4. Express PCB (Free version)
5. Eagle (Free version)
6. MultiSim (Student Version)
7. UtilBoard (Student Version)

Online resources

8. www.techdocs.altium.com/
9. www.ni.com (Multisim and Ultiboard - Academic version)
10. www.cadence.com (Orcade - Student version)
11. www.youtube.com (PCB Manufacturing Videos

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Course Code	Course Title	L	T	P	C
10212EC232	**Reconfigurable System Design**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

Reconfigurable Computing as a reference on the wide range of concepts that designers must understand to make the best use of FPGAs and related reconfigurable chips, including FPGA architectures, FPGA logic applications, and FPGA CAD tools. In this course, students will understand the state-of the-art in reconfigurable computing both from a hardware and software perspective.

c) Prerequisite

VLSI Design

d) Related Courses

System on Chip

e) Course Outcomes

Upon the successful completion of the course, student will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Execute reconfigurable system using HDL and FPGAs.	S2
CO2	Demonstrate the partial reconfiguration for various applications using peripheral devices.	S2
CO3	Perform skilfully an embedded system on FPGA using IP blocks.	S3

f) Correlation of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	M	H	M	H	-	-	-	-	L	-	M	M	-
CO2	M	L	H	M	H	L	L	-	-	L	-	M	M	L
CO3	M	L	H	M	H	L	L	-	L	L	-	M	M	M

g) Course Content

Theory **15 Hours**

Reconfigurable Computing: Logic, the Computational Fabric, the Array and Interconnect Configuration

Reconfigurable Processing Fabric Architectures: Fine Grained, Course grained, RPF Integration into Traditional Computing Systems - Independent Reconfigurable Coprocessor Architectures - Processor + RPF Architectures

Intellectual Property Based Design: Soft core, Firm core and Hard Core, Software tools. Multi-FPGA Systems: Logic Emulation - Uses of Logic Emulation Systems, Issues Related to Contemporary Logic Emulation, Parallel FPGA Compilation for the VLE System.

h) List of experiments

S. No	Practical Exercises (60 Hours)	CO Mapping
1.	Introduction to Software and Hardware Tools	CO1
2.	Design and implement Full adder using Multiplexer on FPGA	CO1
3.	Design and implement Flip Flops on FPGA	CO1
4.	Design and implement encoder and decoder on FPGA	CO1
5.	Implementation of an Arithmetic and Logical Unit on FPGA	CO1
6.	Design and implement a Mealy machine for a binary input sequence (Consider different combination) on FPGA	CO2
7.	Design and implement a Moore machine for a binary input sequence (Consider different combination) on FPGA	CO2
8.	Design and Implementation of Filters on FPGA	CO2
9.	Implementation of IP Cores in FPGA.	CO2
10.	Synthesis and Implementation of Microblaze Processor	CO2
11.	Synthesis and Implementation of Zynq Processing system.	CO2
12.	Interfacing of Temperature sensor with FPGA using Basys3	CO3
13.	Interfacing of Max Sonar sensor with FPGA using ZYBO	CO3

Total : 75 hrs

i) Learning Resources

Text books

1. Scott Hauck, "Reconfigurable Computing: The Theory and practice of FPGA based Computation", Morgan Kaufmann, 1st Edition, 2008.
2. Simon, "Programming FPGA's: Getting started with Verilog", McGraw-Hill Education, 2016.
3. Wayne Wolf, "FPGA-Based System Design", Pearson Education, 1e, 2005.
4. S. Palnitkar, "Verilog HDL", Pearson Education, 2nd Edition, 2003.
5. John Michael Williams, "Digital VLSI Design with Verilog", 2nd Edition, Springer 2016.
6. Neil K.E.Weste , "CMOS VLSI Design A Circuits And Systems Perspective", Pearson Education, 2020.

List of Major Equipment/ Instrument/Software with Broad Specifications

1. Xilinx VIVADO 2019.2 (Licensed version)
2. Basys 3
3. ZYBO
4. PMODs

List of Software/Learning Websites

1. https://www.microsoft.com/en-us/research/video/candidate-talk-reconfigurable-computing-architectural-and-design-tool-challenges/

Online resources

1. Kuruvilla Varghese , Digital System design with PLDs and FPGAs [MOOC] NPTEL. https://nptel.ac.in/courses/117108040

Course Code	Course Title	L	T	P	C
10212EC233	**VLSI CHIP DESIGN**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

The course focused on enhancements of CMOS integrated circuit technology and application for analogue, digital integrated circuits using schematic, layout, and verification using Cadence Tool software suite such as the Virtuoso Schematic Editor, Spectre, Virtuoso Layout Editor and Assura. It is an effective track for design capture through verification. Virtuoso Layout Editor is a complete physical layout and verification that accelerates design cycles.

c) Prerequisite

VLSI Design

d) Related Courses

VLSI Design Techniques, Low power VLSI

e) Course Outcomes

Upon the successful completion of the course, student will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Replicate the VLSI physical design flow and physical design requirements in VLSI technology	S1
CO2	Perform the design and implementation of a basic logic gates and explore the constraints related to digital circuit design	S2
CO3	Demonstrate skilfully the integrated circuit and explore the constraints related to digital circuit design	S3
CO4	Build the integrated circuit and explore the constraints related to analog circuit design	S3
CO5	Perform skilfully DRC, LVS, power calculation and export GDSII for integrated circuits using cadence tool	S3

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	M	M	H	M	H	-	-	-	-	L	-	M	M	-
CO2	M	L	H	M	H	L	L	-	-	L	-	M	M	L
CO3	M	L	H	M	H	L	L	-	L	L	-	M	M	M
CO4	M	L	H	M	H	L	L	-	L	L	-	M	M	M
CO5	H	L	L	L	H	M	-	-	M	L	-	-	M	L

g) Course Content

Theory **15 Hours**

Overview of Physical Design flow, physical design requirements for VLSI: technology; chip performance and cost; technology updateability; reliability.

Static timing analyses procedures and constraints. Critical path considerations, Scan chain insertion, Floor planning, Routing and Placement procedures. Power planning, Layout generation, LVS and back annotation, Total power estimate.

Goals of CTS, Types of Clock-tree, CTS Specification, Building clock tree, Analyse the results, Fine-tuning the Clock-tree and Guidelines for best CTS results.

ECO Flow, Types of ECO, Timing & Functional ECO prep, rolling in the ECO, Performing the ECO placement and routing.

h) List of experiments

S. No	Practical Exercises (60 Hours)	CO Mapping
1.	Introduction to Cadence Tools viz. Schematic and Layout Design	CO1
2.	Work Space Creation & Writing RTL Code for CMOS Inverter	CO1
3.	Synthesis of CMOS Inverter using the GENUS Tool	CO2
4.	Design and simulate a CMOS Inverter Digital Flow using INCISIVE Simulator	CO2
5.	Design and simulate a CMOS Basic Gates using INCISIVE Simulator and GENUS Tool	CO2

6.	Design and Implementation of FLIP FLOPS using INCISIVE Simulator and GENUS Tool	CO3
7.	Design and simulate a 4-bit synchronous counter using a Flip-Flops using INCISIVE Simulator and GENUS Tool	CO3
8.	Design and Simulate a CMOS Inverting Amplifier using Spectre	CO4
9.	Design and Simulate Basic Common Source Amplifiers using Spectre	CO4
10.	Design and Simulate Basic Common Gate & Common Drain Amplifiers using Spectre	CO4
11.	Design and simulate 5 transistor differential amplifier using Spectre	CO4
12.	DRC, LVS, Parasitic Extraction, Back Annotate, and Export GDS II for CMOS Logic	CO5
13.	Power Calculation of Custom Design using Cadence	CO5

Total: 75hrs

i)Learning Resources

Textbooks

1. M.Sarrafzadeh, "Introduction to VLSI Physical Design", McGraw Hill (IE), 1996.
2. Andrew B. Kahng, Jens Lienig, Igor L. Markov, Jin Hu, "VLSI Physical Design: From Graph Partitioning to Timing Closure", Springer, June 2023

References

1. N.A.Sherwani, "Algorithms for VLSI Physical Design Automation", Kluwer,2012.
2. S.M. Sait , H. Youssef, "VLSI Physical Design Automation", World scientific, 2010.
3. M. Bushnell and V. D. Agarwal, "Essentials of Electronic Testing for Digital, Memory and Mixed-Signal VLSI Circuits", Kluwer Academic Publishers,2000

List of Major Equipment/ Instrument/Software with Broad Specifications

Cadence – Virtuoso Schematic Editor, Spectre, Virtuoso Layout Editor and Assura - Generic various nm (Licensed version)

List of Learning Websites

1. https://www.cadence.com/en_US/home/resources.html

Online resources

1. Indranil Sengupta, VLSI Physical Design [MOOC]
   NPTEL. https://onlinecourses.nptel.ac.in/noc21_cs12/preview

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Course Code	Course Title	L	T	P	C
10212EC901	VLSI DESIGN AND VERIFICATION USING SYSTEM VERILOG	2	0	4	4

a) Course Category

Programme Elective

b) Preamble

This course introduces the fundamentals of System Verilog Language and its usage for RTL coding and Test bench Development. Students will go through the complete Design and Verification flow along with hands-on experience using standard EDA tools and protocols

c) Prerequisite

VLSI Design

d) Related Courses

SOC Design and Verification

e) Course Outcomes:

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on Revised Blooms & Dave's Taxonomy)
CO1	Demonstrate RTL Verilog coding for a given design block	K2, S3
CO2	Develop a Test bench using a System Verilog for the required components	K3, S3
CO3	Implementation and verification of Classes and Objects setup	K3, S3
CO4	Design and verification of IPS ,subsystems, chips and SOC architecture	K3, S3
CO5	Demonstrate the on chip protocols and develop test bench for UART, I2C,SPI and AMBA APB	K2, S3

f) Course Outcomes:

Correlation of COs with POs and PSOs:

CO/PO	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PSO1	PSO2
CO1	H	M	L	L	L	-	-	M	L	L	L	M	-
CO2	H	M	M	L	H	-	-	M	L	L	L	M	-
CO3	H	H	M	L	H	-	-	M	L	L	L	M	-
CO4	H	H	M	L	H	-	-	M	L	L	L	M	-
CO5	H	H	L	L	H	-	-	M	L	L	L	M	-

g) Course content:

UNIT I VLSI Verification and Introduction to System Verilog 6

VLSI Technology Overview - SOC Architecture - VLSI Design Flow - Design Verification –Types : RTL - Gate level - Emulation - Formal - SIP verification - Components - test bench hierarchy - Evolution of system Verilog - data types - arrays - packed - unpacked - dynamic - associative array methods-queues - structures - control flow - functions and tasks - blocking and non - blocking statements

UNIT II Basic constructs in System Verilog Processes and connecting Interfaces 6

Processes - fork join - Inter process communication- functions – tasks - void function-arguments-semaphores methods - SV mailboxes - events- interface - interface constructs - connecting test bench and design with interface constructs - bundles- modports- clocking blocks

UNIT III Advanced constructs Classes and Objects in System Verilog 6

Class - class properties and methods –inheritance - polymorphism-static - shallow/deep copy-parameterized classes- extern keyword- access control -qualifier- local and protected -abstract Class-typedef class-virtual methods – pre-post randomization

.

UNIT IV Constraints and Coverage in System Verilog 6

Constraints-Introduction- inside constraint- implication constraint- foreach constraint – randomization methods- program block- scope resolution operator – coverage code- functional coverage-cross coverage- cover point bins

UNIT V System Verilog Assertions and Methods and On-chip Protocols 6

Assertions- introduction – immediate assertion - concurrent assertion – SVA methods – On-chip protocols architectures - UART-I2C-SPI-AMBA-APB- APX

Total: 30 Hrs

LIST OF PRACTICAL EXPERIMENTS

S. No	CO Mapping	Practical Exercises (60 Hours)
1	CO1	RTL code test bench using System Verilog for Digital design
2	CO2	Development of Test bench for Interface
3	CO2	Development of Test bench driver class
4	CO2	Development of Test bench adding driver task
5	CO2	Development of Test bench adding mailbox
6	CO3	Development of Test bench for transaction class
7	CO3	Development of Test bench randomize the transaction class
8	CO3	Development of Test bench generator class, driver
9	CO3	Development of Test bench complete environment class code
10	CO4	Development of Test bench for monitor class
11	CO4	Development of Test bench complete monitor code
12	CO4	Development of Test bench complete scoreboard code with coverage
13	CO5	Design verification using System Verilog for complete Top module test bench for combinational circuits
14	CO5	Design verification using System Verilog for complete Top module test bench for sequential circuits
15	CO4,CO5	MINI PROJECT

h) Learning Resources

Text Books

1. IEEE Standard for System Verilog—Unified Hardware Design, Specification, and Verification Language, IEEE Computer Society and the IEEE Standards Association Corporate Advisory Group IEEE Std 1800™-2017

Online Resources

1. https://edaplayground.com/
2. https://www.chipverify.com/tutorials/systemverilog

Course Designers

Experts from Industry	Experts from Higher Technical Institutions	Internal Experts
Mr. Ravishankar, Wipro Mr. Srinivasa Shikaripura, Wipro Mr. Resty Roy, Wipro Mr. Anandhakrishnan Devaraj, Wipro, Chennai.	Dr. Bhagyaveni, Professor of ECE, HOD, Anna University, CEG, Tamilnadu, Chennai. Dr. C. K. Jayadas, Associate Professor, Govt. Model Engineering college, kerala	Dr. Ezilarasan M.R AP-ECE, Dr. R. Sathesh Raaj, ASP- ECE, Vel Tech University, Chennai

1. Dr. Ezilarasan M.R
2. Dr. R. Sathesh Raaj

INTERNAL FACULTY

Dr. Hemakumar. V S

BOS - Incharge

3/2/26

HOD - ECE

Dr. S. Jana
Professor & Head of the Department
Electronics and Communication Engineering
Vel Tech
Rangarajan Dr. Sagunthala

Course Code	Course Title	L	T	P	C
10212EC150	**DIGITAL FORENSICS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The course will provide the Overview of digital investigation and digital evidence, Data acquisition of physical storage devices and Study of file systems, algorithms and tools for digital forensic.

c) Prerequisite

Nil

d) Related Courses

Data Communication Networks, Cyber Security for Wearable Devices, Ethical Hacking

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain appropriate instances for the application of computer forensics.	K2
CO2	Outline the inner workings of file systems.	K2
CO3	Summarize the concept of Digital investigation and digital evidence.	K2
CO4	Infer the application of computer forensics correctly collect and analyze computer forensic evidence.	K2
CO5	Interpret the essential and up-to-date concepts, algorithms, protocols, tools, and methodology of Computer Forensics.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	-	-	-	-	-	L	L	-	-	-	L
CO2	M	L	L	-	-	-	-	-	L	L	-	-	-	L
CO3	M	L	L	-	-	-	-	-	L	L	-	L	-	L
CO4	M	L	L	-	-	-	-	-	L	L	-	L	-	L
CO5	M	L	L	L	L	-	-	-	L	L	-	L	-	L

g) Course Content

UNIT I DIGITAL CRIMES 9

Introduction to Digital Forensics, Definition and types of cybercrimes, electronic evidence and handling, electronic media, collection, searching and storage of electronic media, introduction to internet crimes, hacking and cracking, credit card and ATM frauds, web technology.

UNIT II COMPUTER FORENSICS 9

Definition and Cardinal Rules, Data Acquisition and Authentication Process, Windows Systems-FAT12, FAT16, FAT32 and NTFS, UNIX file Systems, mac file systems, computer artifacts, Internet Artifacts, OS Artifacts and their forensic applications.

UNIT III DIGITAL INVESTIGATIONS 9

Understanding Computing Investigations – Procedure for corporate High-Tech investigations, understanding data recovery work station and software, conducting and investigations.

UNIT IV PROCESSING OF ELECTRONIC EVIDENCE 9

Processing of digital evidence, digital images, damaged SIM and data recovery, multimedia evidence, retrieving deleted data: desktops, laptops and mobiles, retrieving data from slack space, renamed file, ghosting and compressed files.

UNIT V FORENSIC TOOLS 9

Data acquisition- understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data acquisitions, performing RAID data acquisitions, remote network acquisition tools, other forensics acquisitions tools.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Warren G. Kruse II and Jay G. Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley, 2002.
2. Nelson, B, Phillips, A, Enfinger, F, Stuart, C., "Guide to Computer Forensics and Investigations, 2nd edition, Thomson Course Technology, 2006, ISBN: 0-619-21706-5.

Reference Books

1. C. Altheide& H. Carvey Digital Forensics with Open Source Tools, Syngress, 2011. ISBN: 9781597495868.
2. Holt, Bossler & Spellar, "Cybercrime and Digital Forensics : An Introduction", Routledge Publishers, 3rd Edition, 2022.
3. Gerard Johansen, "Digital Forensics and Incident Response: Incident response tools and techniques for effective cyber threat response" Packt Publishing, 3rd Edition, 2022.

Online Resources:

1. https://www.digitalforensicsmagazine.com/
2. https://www.nist.gov/itl/ssd/software-quality-group/computer-security/resource-center
3. https://onlinecourses.swayam2.ac.in/cec20_lb06/

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Course Code	Course Title	L	T	P	C
10212EC151	**CRYPTOGRAPHY FOR CYBER AND NETWORK SECURITY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course will provide students with an understanding on the concepts and protocols of cryptography for cyber security.

c) Prerequisite

Data Communication Networks

d) Related Courses

Network Security, Cyber Security for smart wearables, Automotive Cyber Security

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the basic concepts of cryptography, security issues and its need	K2
CO2	Explain the various symmetric and asymmetric algorithms used for cyber security.	K2
CO3	Summarize various message and entity authentication protocols.	K2
CO4	Illustrate the basic concepts of system security models.	K2
CO5	Infer the network security architecture and layer security issues related to 3G and 4G networks.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	L	L	-	-	-	L	L	L	-	-	-	-
CO2	M	M	L	L	-	-	-	L	L	L	-	-	-	L
CO3	M	M	L	-	-	-	-	L	L	L	-	L	-	L
CO4	M	-	-	-	L	L	-	L	L	L	-	L	-	L
CO5	M	-	-	-	L	L	L	L	L	L	-	L	-	L

g) Course Content

UNIT I INTRODUCTION TO CRYPTOGRAPHY 9

Basic Cryptography Concepts: Symmetric Encryption Algorithms, Purpose of Cryptography. Security issues: Security problems in computing - attacks - security services - Security mechanism - OSI security architecture - standard setting organizations- Need for Cryptographic techniques- Substitution - Transposition.

UNIT II SYMMETRIC AND ASYMMETRIC ENCRYPTION 9

Block ciphers: DES - Triple DES with two keys – AES, Stream cipher: RC4 – Blow Fish. Public Key Algorithm: RSA algorithm – Elliptic Curve Cryptography.

UNIT III MESSAGE AND ENTITY AUTHENTICATION 9

Message Authentication: Message Authentication Code (MAC), MD5, HASH algorithm-SHA 512 logic – Kerberos – PKI trust model. Entity Authentication: Digital signatures standards – Applications – Diffie Hellman key exchange - Elliptical curve digital signature algorithm.

UNIT IV SYSTEM SECURITY 9

Intruders and intrusion detection: Malicious software - viruses and related threats - virus counter measures - firewalls design principles- trusted systems. Android - based Smartphone Security, Stepping Stone Detection, Broken Authentication and Session Management Vulnerabilities, Computer Forensic Investigation, Cyber Terrorism.

UNIT V NETWORK SECURITY 9

Network Security: IP security overview - IP security architecture - authentication header-encapsulating security payload - combining security association - web security considerations - secure socket layer and transport layer security - secure electronic transaction - security in GSM - security in 3G and 4G.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Stallings W, "Cryptography and Network Security", 7th Edition, Prentice Hall, 2011.
2. William Stallings, "Network Security Essentials: Applications and Standards, PrenticeHall, 4th edition, 2010.

Reference Books

1. Behrouz A. Forouzan, "Cryptography and Network Security", 2nd Indian Edition, Mc Graw Hill Education, 2013.
2. David Wong, "Real World Cryptography", Manning Publishers, 2021.

Online Resources

1. https://blog.cryptographyengineering.com/useful-cryptography-resources/
2. https://www.youtube.com/watch?v=2aHkqB2-46k&list=PL2jrku-ebl3H50FiEPr4erSJiJHURM9BX
3. https://www.youtube.com/watch?v=-j80aA8q_IQ
4. https://www.youtube.com/watch?v=NQ1cvwEvh44

Course Code	Course Title	L	T	P	C
10212EC152	BLOCKCHAIN TECHNOLOGY	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course will provide students with an understanding of Blockchain technology, challenges and its applications towards cybersecurity.

c) Prerequisite

Nil

d) Related Courses

Cryptography for Cyber & Network Security, Cyber Security for smart wearables, Automotive Cyber Security

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the fundamental concepts of blockchain technology	K2
CO2	Explain the concepts of transaction network using bitcoin procedures and cryptocurrency.	K2
CO3	Summarize the concepts of consensus algorithms and mining process.	K2
CO4	Interpret the concepts of distribute consensus algorithm	K2
CO5	Infer the block chain platforms and their applications	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	-	-	-	-	-	-	L	L	-	-	-	L
CO2	M	L	L	L	-	-	-	-	L	L	-	L	-	L
CO3	M	L	L	L	-	-	-	-	L	L	-	L	-	L
CO4	M	L	L	L	-	-	-	-	L	L	-	L	-	L
CO5	M	L	L	L	-	-	-	-	L	L	-	L	L	M

g) Course Content

UNIT I FUNDAMENTALS OF BLOCKCHAIN 9

Evolution of Blockchain- Public Ledgers, Blockchain as Public Ledgers -Bitcoin, Blockchain 2.0, Smart Contracts, Block in a Blockchain, Transactions-Distributed Consensus, The Chain and the Longest Chain -Cryptocurrency to Blockchain 2.0 - Permissioned Model of Blockchain, Cryptographic -Hash Function, Properties of a hashfunction-Hash pointer and Merkle tree.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

A basic crypto currency, Creation of coins, Payments and double spending, FORTH – the precursor for Bitcoin scripting, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay, Consensus introduction, Distributed consensus in open environments-Consensus in a Bitcoin network.

UNIT III BITCOIN CONSENSUS 9

Bitcoin Consensus, Proof of Work (PoW)- Hashcash PoW, Bitcoin PoW, Attacks on PoW ,monopoly problem- Proof of Stake- Proof of Burn - Proof of Elapsed Time - Bitcoin Miner, Mining Difficulty, Mining Pool-Permissioned model and use cases, Design issues for Permissioned Blockchains, Execute contracts-Consensus models for permissioned blockchain-Distributed consensus in closed environment Paxos.

UNIT IV DISTRIBUTED CONSENSUS 9

RAFT Consensus-Byzantine general problem, Byzantine fault tolerant system-Agreement Protocol, Lamport-Shostak-Pease BFT Algorithm-BFT over Asynchronous systems, Practical Byzantine Fault Tolerance.

UNIT V PLATFORMS AND APPLICATIONS 9

Introduction to Blockchain platforms: Hyberledger-Ethereum-IOTA-EOS-Multichain- Bigchain, CORDA, Openchain, SOLIDITY, Smart contracts, Truffle Design and issues in cryptocurrency ,Mining, Distributed Applications (DApps), DAO Applications: Internet of Things-Medical Record Management System-Government Identity management –Auto executing contracts-Three signature esrow-Tripple entry accounting-Sidechain-Challenges and Research issues in blockchain.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Bonneau, Joseph. "Why buy when you can rent? Bribery attacks on bitcoin-style consensus." International Conference on Financial Cryptography and Data Security. Berlin, Heidelberg: Springer Berlin Heidelberg, 2016.
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Gold feder, 'Bitcoin and cryptocurrency technologies: a comprehensive introduction', Princeton University Press, 2016.

References Books

1. Antonopoulos, Andreas M. Mastering Bitcoin: unlocking digital cryptocurrencies. " O'Reilly Media, Inc.", 2014
2. Nakamoto, Satoshi. "Bitcoin: A peer-to-peer electronic cash system." Decentralized business review (2008).
3. DR. Gavin Wood, "ETHEREUM: A Secure Decentralized Transaction Ledger,"Yellow paper.2014.
4. Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, A survey of attacks on Ethereum smart contract, 2014
5. Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015.

Online Resources

1. https://nptel.ac.in/courses/106104220
2. https://archive.nptel.ac.in/courses/106/105/10610

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Course Code	Course Title	L	T	P	C
10212EC153	**AUTOMOTIVE CYBER SECURITY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The goal of the course is to introduce students to the potential threats of cyber-attacks on vehicles, especially connected and automated vehicles. The basics of cyber security threat models, high risk attack areas of vehicles, classes of attacks, and protecting vehicles from attacks are introduced. Standards and protocols related to automotive cyber security will be covered. Attacking connected vehicles will be discussed by reviewing in-vehicle network, vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communications and wireless access protocols. Potential attacks on vehicles are also described.

c) Prerequisite

Principles of Networking & Cyber security

d) Related Courses

Cyber security for smart wearable

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain appropriate instances for the application of computer forensics.	K2
CO2	Outline the inner workings of file systems.	K2
CO3	Summarize the concept of digital investigation and digital evidence.	K2
CO4	Interpret about Internet of vehicles and using machine learning to secure them	K2
CO5	Discuss the regulations, current challenges and future trends in automobiles	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	-	-	-	-	-	-	-	L	L	-	-	-	L
CO2	M	M	L	L	-	-	-	-	L	L	-	L	L	M
CO3	M	M	L	L	-	-	-	-	L	L	-	L	L	M
CO4	M	M	L	L	-	-	-	-	L	L	-	L	-	M
CO5	M	M	L	L	-	-	-	-	L	L	-	L	-	L

g) Course Content

UNIT I FUNDAMENTALS OF AUTOMOTIVE CYBER SECURITY 9

Evolution of Automotive Systems- Cyber Security in Automotive Technology- State of the Art Vehicle Technologies: Autonomous Vehicle-Connected Vehicle Technology - Market Demand of Automotive Cyber Security.

UNIT II IN-VEHICLE COMMUNICATION AND CYBER-SECURITY 9

In-Vehicle System: Vehicle Electronics/Electrical Systems- In-Vehicle Communication (IVC) - In-Vehicle Network Architecture and Topology- Functional Safety and Cybersecurity- In-Vehicle Cyber security Issues and Challenges-Cyber Security in In-Vehicle Network.

UNIT III INTER-VEHICLE COMMUNICATION AND CYBER-SECURITY 9

Connected Vehicles- VANET Technologies - Role of Edge Computing and SDN in V2X- Connected Vehicle Cyber Security- Connected Vehicle Cyber Security- Homomorphic Encryption in VANET- Blockchain in V2X Communication- Blockchain in V2X Communication.

UNIT IV INTERNET OF VEHICLES & MACHINE LEARNING 9

Internet of Vehicles (IoV): IoV Layered Architecture - Security in IoV- IoV Security Requirements and Attacks - Challenges in IoV- Machine Learning in Vehicular Networks: Types of Machine Learning Techniques-Type of ML in Vehicular Networks -Cybersecurity Solutions Based on ML-Attacks on Machine Learning/Deep Learning models -Application of Machine Learning in Vehicular Networks.

UNIT V V2X- STANDARDS AND CURRENT ISSUES 9

Standards, Regulations, and Legal Issues- Competition Over V2X Technology Adoption - V2X Use Cases - Current Trends and Future of Intelligent and Autonomous Vehicles.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Shiho Kim , Rakesh Shrestha, "Automotive Cyber Security", Springer, 2020
2. Dietmar P.F. Möller, Roland E. Haas, "Guide to Automotive Connectivity and Cybersecurity", Springer, 2019

Reference Books

1. Craig Gibbs, "Automotive Cybersecurity: Issues and Vulnerabilities", Nova Science Publisher, 2016
2. Yasir Imtiaz Khan, "Automotive Cyber Security Challenges A Beginner's, Amazon Kindle, 2020

Online Resources

1. https://www.udemy.com/course/automotive-cyber-security/
2. https://www.nhtsa.gov/technology-innovation/vehicle-cybersecurity

Course Code	Course Title	L	T	P	C
10212EC154	**CYBER SECURITY FOR SMART WEARABLES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The course deals with the highlights the new aspects of wearable and implanted sensor technology in the health sector and monitoring devices.

c) Prerequisite

Data Communication Networks

d) Related Courses

Cryptography for Cyber & Network Security, Principle of networking & Cyber security

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the purpose and scope of wearable devices and to learn its basic concepts.	K2
CO2	Outline the security issues in wearable devices.	K2
CO3	Illustrate the various management security issues in wearable technology.	K2
CO4	Explain the various applications of wearable devices for cyber security.	K2
CO5	Relate the cyber security issues related to wearable devices in real time scenarios.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	M	-	-	-	-	-	-	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	L	-	L
CO3	M	-	-	-	-	-	-	-	L	L	-	L	-	M
CO4	M	L	L	L	-	L	-	-	L	L	-	L	L	L
CO5	M	L	L	L	-	L	-	-	L	L	-	L	-	M

g) Course Content

UNIT I INTRODUCTION TO WEARABLE DEVICES 9

Purpose, Scope and Technical consideration of wearable consideration of wearable technologies – The promise and perils of wearable technologies – Wearable computers.

UNIT II SECURITY ISSUES IN WEARABLE DEVICES 9

Risks of wearable technology to individual and organization – Authenticity challenges of wearable technologies – Privacy dangers of wearables and the internet of things.

UNIT III MANAGEMENT OF SECURITY ISSUES IN WEARABLE 9

Ethical challenges and solution – Confidential data storage systems for wearable platform – Security, Privacy and ownership issues with the use of wearable health technologies.

UNIT IV APPLICATIONS 9

Optical Fiber technology for e healthcare – Innovative service and application in health care monitoring system – Smart textile as a creative environment to engage girls in technology – Health and Fitness wearables.

UNIT V CASE STUDIES 9

Study of real time cardio monitoring system: A comprehensive study – Signal adaptive analog to digital convertors for ULP wearable and Implantable medical devices – Securing the human cloud: Applying biometrics to wearable technology – A survey of recent trends in wireless communication standards, routing protocols and energy harvesting techniques in E – Health Applications.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Noushin Nasiri, Wearable Devices the Big Wave of Innovation, Intech Open, 9781838803421, 2019

Reference Books

1. Claus-Peter H. Ernst, The Drivers of Wearable Device Usage: Practice and Perspectives, Springer, ISBN: 9783319303741, 2016
2. Wearable Technologies: Concepts, Methodologies, Tools and Applications (3 Volumes) – Information Resources Management Association (USA) DOI: 10.4018/978-1-5225-5484-4, 2018

Online Resources

1. https://infosecawareness.in/concept/security-awareness-on-wearable-gadgets
2. https://clutch.co/it-services/resources/wearables-connect-internet-of-things-technology

Course Code	Course Title	L	T	P	C
10212EC222	PRINCIPLES OF NETWORKING AND CYBER SECURITY	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

Knowing how to install, configure, and troubleshoot a computer network is a highly marketable and exciting skill. This course first introduces the fundamental building blocks that form a modern network, such as protocols, topologies and hardware. It provides in-depth coverage of the most important concepts in contemporary networking, such as TCP/IP, Ethernet, wireless transmission, and security. Cyber Attacks and Prevention methods are also covered in fundamentals perspective. This course will prepare the students to design a network using hardware and software for specific environment. They will also have the knowledge to build them seconds.

c) Prerequisite

Nil

d) Related Courses

Cryptography for Cyber and Network Security, Cyber Security for Smart Wearables.

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the concepts of networking in wired and wireless networks	K2
CO2	Utilize the different troubleshooting a network using network utilities	K2
CO3	Illustrate the various information security and security threats in cyber security	K2
CO4	Infer various algorithms used to prevent cyber attacks	K2
CO5	Summarize the various cyber-attacks and their impacts	K2

f) Correlation of COs with POs & PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	L	L	L	-	-	-	L	L	-	-	-	L
CO2	M	M	L	L	L	-	-	-	L	L	-	L	-	L
CO3	M	L	L	-	L	-	-	-	L	L	-	L	-	L
CO4	M	L	L	-	L	-	-	-	L	L	-	L	-	L
CO5	M	L	L	-	L	-	-	-	L	L	-	L	-	L

g) Course Content

UNIT I NETWORK DESIGN & IMPLEMENTATION 6

Review of Network Basics: Network Design: Topologies- Network Plan- IP Addressing & Subnetting-IPv6- DCHP-DNS-Design: Access Network-LAN-WAN.
Network Implementation: Packet Tracer-Performance Analysis: Unicast-Multicast-Broadcast.

UNIT II NETWORK MANAGEMENT & TROUBLESHOOTING 6

Network Management: Network Monitoring: Performance monitoring-Fault monitoring-Account monitoring- Configuration and security management. Network Troubleshooting: Command Line Utilities: ipconfig, Ping, Tracert, nslookup-Network Analyser Tools: Wireshark- ipMonitor.

UNIT III INFORMATION SECURITY AND SECURITY THREATS 6

Cyber security Introduction and Overview-Threats to information system-Cyber security and security risk analysis-Information Assurance-Types of Computer Malware -Types of Cyber Attacks: Denial of Service, Distributed Denial of Service, Man in Middle Attack, Crypto-jacking, SQL Injection, Cyber-Stalking Cyber frauds and Forgery

UNIT IV CYBER ATTACK PREVENTION 6

Algorithms and Technique-Firewalls-Intrusion Detection & Prevention-Authentication using Hash-Multi-Factor Authentication- Secure Socket Layer- Virtual Private Network.

UNIT V RECENT ATTACKS AND IMPACTS 6

Equifax data theft – VPN filter cyber attack-Wannacry Ransom attack-Peta Cyber attack-US 2016 election manipulation-US power grid hacking-Shadow network attack-Github DDoS attack 2018

Total: 30 Hrs

h) Laboratory **Total: 30 Hrs**

List of experiments

Exp.No	Experiment Name	CO Level	Skill Level
1.	Getting acquainted with CISCO packet tracer	CO1	S2
2.	To design and configure a network using Cisco Packet Tracer.	CO1	S2
3.	Designing & Implementing LAN using subnetting	CO1	S2
4.	Designing a WAN network	CO1	S2
5.	Performance Analysis of a WAN Network (Uni/Multi/Broadcast)	CO1	S2
6.	Getting Acquainted with Windows Management Instrumentation (WMI).	CO2	S2
7.	Getting Acquainted with Simple Network Management Protocol using CISCO Packet tracer.	CO2	S2
8.	Getting Acquainted with troubleshooting a network (using network utilities) • Ipconfig • Ping • Tracert • Nslookup	CO2	S2
9.	Getting Acquainted with network management tool: Wireshark	CO2	S2
10.	Getting Acquainted with network management tool: ipMonitor	CO2	S2
11.	Study of the features of firewall in providing network security and to set Firewall Security in windows.	CO4	S2
12.	Understand the various intrusion detection system	CO4	S2

Total: 60 Hrs

i) Learning Resources

Text Books

1. James W. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach”, Pearson, 2021.
2. Douglas E. Comer, “Internetworking with TCP/IP Volume One, 6th edition”, Peasrson, 2013.

Reference Books

1. Robertazzi, Thomas, "Basics of Computer Networking", Springer,2012.
2. Tamara Dean, Network+ Guide to Networks, 5th Edition. Course Technology - Cengage Learning, 2010.
3. Doug Lowe, "Networking All-in-One for Dummies", Wiley, 2021.
4. Robert Shimonski, "The Wireshark Field Guide: Analyzing and Troubleshooting Network Traffic, Syngress, 2013.
5. Kutub Thakur, Al-Sakib Khan Pathan, "Cybersecurity Fundamentals-A Real-World Perspective", Taylor & Francis 2020.
6. ISACA, "CSX Cybersecurity Fundamentals Study Guide, ISACA,2015.

Online Resources

1. https://www.javatpoint.com/cyber-security-tutorial
2. https://nptel.ac.in/courses/106105031/40
3. https://nptel.ac.in/courses/106105031/39
4. https://nptel.ac.in/courses/106105031/38

Course Code	Course Title	L	T	P	C
10212EC223	**ETHICAL HACKING**	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

This Course introduces students to the principles and techniques of the Cyber Security practice known as penetration testing (pen testing), or ethical hacking will involve assessing target networks and hosts for security vulnerabilities. By studying this course, Students will learn hacking techniques within a controlled environment for the goal of better securing the IT resources of their rightful owners.

c) Prerequisite

Nil

d) Related Courses

Network Security, Cyber Security for smart wearables, Automotive Cyber Security

e) Course Outcomes

Upon the successful completion of the course, student will be able to:

CO Nos.	Course Outcomes	Knowledge Level(Based on Revised Bloom's Taxonomy)
CO1	Illustrate the hacker approaches and study the various types of attacks	K2
CO2	Outline the various concepts of hacker tools for foot printing and reconnaissance techniques	K2
CO3	Summarize the practices of enumeration and vulnerability analysis	K2
CO4	Infer the various vulnerabilities in web and wireless applications	K2
CO5	Explain the concept behind safeguarding and protecting legitimate systems.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO 2	PO 3	PO4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	L	L	L	-	L	-	-	L	L	L	-	-	-	-
CO2	M	L	L	-	L	-	-	L	L	L	-	L	-	-
CO3	M	L	L	-	L	-	-	L	L	L	-	L	-	-
CO4	M	L	L	-	L	-	-	L	L	L	-	L	-	-
CO5	M	L	L	-	L	-	-	L	L	L	-	L	L	L

g) Course Content

UNIT I ETHICAL HACKING OVERVIEW, NETWORK & COMPUTER ATTACKS **6**

Introduction to Ethical hacking-What you can do legally-What you cannot do legally-Various Attacks: Malware and its Protection-Intruder Attacks-Addressing Physical security.

UNIT II FOOT PRINTING AND RECONNAISSANCE **6**

Using Web tools for foot printing-Conducting competitive intelligence-Using Domain Name system zone transfers-Introduction to Port Scanning-Using port scanning tools-Conducting Ping Sweeps- Understanding Scripting.

UNIT III ENUMERATION AND VULNERABILITY ANALYSIS **6**

Enumeration concepts-NetBIOS Enumeration-SNMP Enumeration-SMTP-DNS Enumeration- Enumeration Countermeasures-Penetration Testing: Foot printing-port scanning-Enumeration.

UNIT IV HACKING WEB SERVERS AND WIRELESS NETWORKS **6**

Understanding Web applications and Vulnerabilities-Tools for Web attackers and Security testers- Wireless Technology- Wireless Network Standards-Authentication-Wardriving- Wireless Hacking.

UNIT V NETWORK PROTECTION SYSTEMS **6**

Routers: Routing Protocols-Basic Hardware routers-Access Control Lists -Firewalls: Technology- Implementation-Configuration and Risk Analysis tools-Intrusion Detection and Prevention Systems: Network based and Host based IDS and IPS-Honeypots

Total Theory 30 Hrs

Laboratory Experiments

S.No	Title of the Experiment	Course Outcomes
1.	Study of packet sniffer tools like wireshark, ethereal, tcpdump etc. Use the tools to do the following (a) Observer performance in promiscuous as well as non-promiscous mode. (b) Show that packets can be traced based on different filters.	CO1
2.	Detect ARP spoofing using open source tool ARPWATCH.	CO1
3.	Implement a code to simulate buffer overflow attack.	CO1
4.	Study of Techniques uses for Web Based Password Capturing.	CO1
5.	Study the use of network reconnaissance tools like WHOIS, dig, traceroute, nslookup to gatherinformation about networks and domain registrars.	CO2
6.	Download and install nmap. Use it with different options to scan open ports, perform OSfingerprinting, do a ping scan, tcp port scan, udp port scan, etc.	CO2
7.	Implement Passive scanning, active scanning, session hijacking, cookies extraction using Burp suit tool	CO2
8.	Use the Nessus tool to scan the network for vulnerabilities.	CO3
9.	Create a social networking website login page using phishing techniques	CO4
10.	Install rootkits and study variety of options.	CO4
11.	Set up IPSEC under LINUX.	CO5
12.	Install IDS (e.g. SNORT) and study the logs.	CO5
13.	Use of ip tables in linux to create firewalls.	CO5
14.	Setup a honey pot and monitor the honey pot on network.	CO5
15.	Mini Project.	CO5

Total 30Hrs
Total 60 hrs

h) Learning Resources:

Text Books:

1. Michael T. Simpson, Kent Backman, and James E. Corle, "Hands-On Ethical Hacking and Network Defense", 2nd Ed.,
2. Rafay Baloch," Ethical Hacking and Penetration Testing Guide", CRC Press,2015, ISBN:78-1-4822-3161-8.

Reference Books:

1. Jon Erickson, Hacking: The Art of Exploitation Jon Erickson SPD (2 ed.), No Starch Press, 2008. ISBN 978-1593271442.
2. Georgia Weidman, "Penetration Testing: A Hands-on Introduction to Hacking", No Startch Press, First Edition 2014. ISBN-13: 978-1593275648 ISBN-10: 1593275641.
3. Dr. Patrick Engebretson, "The Basics of Hacking and Penetration Testing", Syngress Publications Elseveir, 2013, ISBN: 978-0-12-411644-3.

Online Resources

1. https://freevideolectures.com/course/4070/nptel-ethical-hacking
2. https://www.udemy.com/course/indian-white-hat-ethical-hacking-course
3. https://repo.zenk-security.com/Magazine%20E-book/EN-Ethical%20Hacking.pdf

Course Code	Course Title	L	T	P	C
10212EC224	**ARTIFICIAL INTELLIGENCE FOR CYBER SECURITY**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course will provide students to familiarize fundamentals of AI and how AI can solve problems in the cyber security space.

c) Prerequisite

Nil

d) Related Courses

Cryptography for cyber & Network Security, Cyber Security for Smart Wearables

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the fundamentals of AI & search methods	K2
CO2	Infer the evolution of AI and python libraries for cyber security	K2
CO3	Outline the AI algorithms for detecting cyber security threats	K2
CO4	Explain various algorithms used for malware detection using AI	K2
CO5	Summarize the AI based fraud detection with cloud AI solutions	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	-	-	-	-	-	-	-	-	-	-	-	-
CO2	M	L	L	-	-	-	-	-	-	-	-	-	L	-
CO3	M	L	L	-	L	-	-	L	L	L	-	L	L	-
CO4	M	L	L	-	L	-	-	L	L	L	-	L	L	-
CO5	M	L	L	-	L	-	-	L	L	L	-	L	L	-

g) Course Content

UNIT I INTRODUCTION TO AI 6

AI problems, Agents and Environments, Structure of Agents, Problem Solving Agents Basic Search Strategies: Problem Spaces, Uninformed Search (Breadth-First, Depth-First Search, Depth-first with Iterative Deepening), Heuristic Search (Hill Climbing, Generic Best-First, A*), Constraint Satisfaction (Backtracking, Local Search)
Advanced Search: Constructing Search Trees, Stochastic Search, A* Search Implementation, Minimax Search, Alpha-Beta Pruning+

UNIT II AI FOR CYBER SECURITY 6

Evolution in AI: from expert systems to data mining AI problems, Types of machine learning, Algorithm training and optimization, Python's libraries for machine learning, AI in the context of cybersecurity, Python libraries for cybersecurity: Pefile, Volatility

UNIT III DETECTING CYBERSECURITY THREATS 6

Detecting Cyber security Threats with AI- Phishing detection with logistic regression and decision trees- Spam detection with SVMs - Spam detection with Naive Bayes- A Bayesian spam detector with NLT.

UNIT IV MALWARE THREAT DETECTION 6

Malware analysis at a glance- Artificial intelligence for malware detection- Malware goes by many names- Malware analysis tools of the trade- Malware detection strategies- Static malware analysis- Static analysis methodology- Difficulties of static malware analysis - Dynamic malware analysis-Extracting malware artifacts in a dataset - Clustering malware with K-Means - Random Forest Malware Classifier.

UNIT V FRAUD PREVENTION WITH CLOUD AI SOLUTIONS 6

Introducing fraud detection algorithms- Dealing with credit card fraud- Machine learning for fraud detection- Fraud detection and prevention systems- Expert-driven predictive models- Data-driven predictive models- Predictive analytics for credit card fraud detection- Embracing big data analytics in fraud detection, Ensemble Learning-Bagging, Boosting, Stacking

Total theory : 30 Hrs

Total : 30 Hrs

List of experiments

S.No.	Experiment	CO
1.	Phishing detection with logistic regression	CO3
2.	Phishing detection with decision trees	CO3
3.	Spam detection with SVM	CO3
4.	Spam detection with Naive Bayes	CO3
5.	Bayesian spam detector with NLTK	CO3
6.	Extracting malware artifacts in a dataset	CO4
7.	Clustering malware with K-Means	CO4
8.	Random Forest Malware Classifier	CO4
9.	Bagging, Boosting	CO5
10.	Mini project	CO5

Total : 60 Hrs

h) Learning Resources

Text Books

1. James Graham, Richard Howard and Ryan Otson, “Cyber Security Essentials”, CRC Press, Taylor & Francis Group, First Edition, 2011
2. Nina Godbole and Sunit Belpure, “Cyber Security Understanding Cyber Crimes, Computer Forensics and Legal Perspectives”, Wiley India (P) Ltd., 2011.
3. Alessandro Parisi, “Hands-On Artificial Intelligence for Cybersecurity: Implement smart AI systems for preventing cyber attacks and detecting threats and network anomalies”, Packt Publishing Ltd, 2019.

Online Resources

1. The Complete Artificial Intelligence for Cyber Security 2022 | Udemy
2. Artificial Intelligence for Cybersecurity (linkedin.com)

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Course Code	Course Title	L	T	P	C
10212EC155	**FUNDAMENTALS OF DATA SCIENCE**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The Purpose of the course is to provide strong foundation for data science and applications related to core concepts and emerging technologies.

c) Prerequisite

Nil

d) Related Courses

Tools for Data Science, Data Analysis and Visualization

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the concept of vector spaces, eigen values, eigen vectors and distance measures	K2
CO2	Interpret the fundamentals of process involved in data science	K2
CO3	Utilize visualization techniques to represent the data	K3
CO4	Describe various data modelling techniques and its evaluation	K2
CO5	Summarize the ethics surrounding privacy, data sharing and algorithmic decision-making	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	-	-	-	-	L	L	-	-	-	-
CO2	H	M	M	-	-	-	-	-	L	L	-	-	L	L
CO3	H	H	H	-	L	-	-	-	L	L	-	-	L	L
CO4	H	M	M	-	L	-	-	-	L	L	-	-	L	L
CO5	M	-	-	-	-	-	-	-	L	L	-	-	L	L

g) Course Content

UNIT I MATHEMATICS FOR DATA SCIENCE 9

Definition of Vector spaces, Subspaces, sums of Subspaces, Direct Sums, Eigenvalues and Eigenvectors - Eigenvectors and Upper Triangular matrices – Eigenspaces and Diagonal Matrices, Distance measures - Euclidean Distance, Manhattan Distance, Hamming Distance, Cosine Similarity.

UNIT II DATA SCIENCE PROCESS 9

Fundamentals of Data Science, Data Preparation: The Problem Understanding Phase, Data Preparation Phase, Adding an Index Field, Changing Misleading Field Values, Reexpression of Categorical Data as Numeric, Standardizing the Numeric Fields, Identifying Outliers.

UNIT III DATA VISUALIZATION 9

Introduction to data visualization, visualization techniques: scatter plots, line graphs, pie charts, bar charts, heat maps, area charts and histograms, case study: Survey on Covid-19 dataset.

UNIT IV DATA MODELING AND EVALUATION 9

Data Modeling: Partitioning the Data, validating your Partition, Balancing the Training Data Set, Establishing Baseline Model Performance, Model Evaluation: Classification Evaluation Measures, Sensitivity and Specificity, Precision, Recall, and F_β Scores, Method for Model Evaluation.

UNIT V ETHICS IN DATA SCIENCE 9

Importance of ethics in data science, doing good data science, data privacy – degrees of privacy, valuing different aspects of privacy, modern privacy risks, Getting informed consent, The Five Cs – consent, clarity, consistency and trust, control and transparency, consequences, Diversity, Inclusion, future trends.

Total 45 Hrs

h) Learning Resources

Text Books:

1. Sheldon Axler, “Linear algebra done right”, 3rd Edition, Springer,2015.
2. Chantal D. Larose, Daniel T. Larose, “Data Science Using Python and R”, John Wiley & Sons, Inc., First Edition, 2019.
3. D J Patil, Hilary Mason, Mike Loukides, “Ethics and Data Science” , O’ Reilly Media Publishers, 1st edition, 2018.

References:

1. E. Davis, “Linear algebra and probability for computer science applications”, CRC Press, 2012.
2. Dr. Ossama Embarak, “Data Analysis and Visualization using Python”, Apress, 2018,
3. Cathy O'Neil, Rachel Schutt, “Doing Data Science”, O’ Reilly media publishers, 1st edition, 2013

Online resources:

1. https://towardsdatascience.com/intro-to-data-science-31079c38b22?gi=1fb573279fdb
2. https://www.edureka.co/blog/what-is-data-science/
3. https://www.youtube.com/watch?v=KxryzSO1Fjs
4. https://www.simplilearn.com/tutorials/data-science-tutorial/introduction-to-data-science
5. https://cognitiveclass.ai/courses/data-science-101
6. https://towardsdatascience.com/introduction-to-machine-learning-for-beginners-eed6024fdb08
7. https://www.youtube.com/watch?v=njKP3FqW3Sk
8. https://www.analyticsvidhya.com/blog/2020/03/6-data-visualization-python-libraries/

Course Code	Course Title	L	T	P	C
10212EC156	**DATA ANALYSIS AND VISUALIZATION**	**3**	**0**	**0**	**3**

a) Course Category
Programme Elective

b) Preamble
This course will provide knowledge in examining and interpreting data to uncover meaningful insights. It encompasses techniques such as statistical analysis, data mining, and data visualization to extract valuable information and communicate it effectively and gain a competitive edge in various fields.

c) Prerequisite:
NIL

d) Related Courses
Principles of Data Science, Tools for Data Science

e) Course Outcomes
On successful completion of the course, students will be able to:

CO No.	Course Outcomes	Knowledge Level (Based on Revised Blooms Taxonomy)
CO1	Explain the basic concepts of data analysis and preprocessing techniques	K2
CO2	Apply association and cluster analysis techniques on real world applications.	K3
CO3	Make use of time series analysis methods and measure the related parameters.	K3
CO4	Summarize the basics, abstractions and principles of data visualization	K2
CO5	Describe the various data visualizing methods and tools.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	L	L	L	-	-	-	L	-	-	L	L	M
CO2	M	M	M	M	L	-	-	-	L	-	-	L	L	M
CO3	M	M	M	M	L	-	-	-	L	-	-	L	L	M
CO4	L	L	L	L	L	-	-	-	L	-	-	L	L	M
CO5	L	L	M	M	M	-	-	-	L	-	-	L	L	M

g) Course Content

UNIT 1 INTRODUCTION TO DATA ANALYSIS 9

Data Analysis Process – Data Types: Non-dependency & Dependency Oriented Data - Major Building Blocks- Scalability Issues - Data Type Portability - Data Cleaning - Data Reduction and Transformations.

UNIT 2 ASSOCIATION AND CLUSTER ANALYSIS 9

Association Analysis: The Frequent Pattern Mining Model - Association Rule Generation Framework - Frequent Itemset Mining Algorithms: Brute Force Algorithm, Apriori Algorithm - Statistical Coefficients: Correlation, $\chi 2$ Measure, Interest Ratio.

Cluster Analysis : Feature Selection for Clustering - Hierarchical Clustering Algorithms - Grid-Based Algorithms - DBSCAN Algorithm - Cluster Validation.

UNIT 3 TIME SERIES ANALYSIS 9

Introduction- Time Series Preparation and Similarity- Time Series Forecasting- Time Series Motifs - Time Series Clustering: Shape-Based Clustering, Time Series Outlier Detection- Time Series Classification -Similarity Measures.

UNIT 4 VISUALIZATION: ABSTRACTIONS & PRINCIPLES 9

Levels of Design- Threats and Validation- Data Abstractions: Types, Semantics- Attributes & Datasets. Visual Encoding: Marks and Channels, Channel Effectiveness & Characteristics. Interaction: Classes of Change, Latency & Feedback- Slogans & Guidelines: No Unjustified 3D

UNIT 5 DATA VISUALIZING METHODS & TOOLS 9

Making Views: Using Space- Value Attributes- Coordinating Views- Superimposing Layers, Reducting Items: Filtering-Aggregation-Navigation-Real Time Data Visualization Tools.

Total: 45 Hrs

h) Learning Resources

Text Books:

1. Caru C. Aggarwal "Data Mining: The Textbook" Springer, 2015. (Unit I,II & III)
2. Tamara Munzner, "Visualization Design and Analysis -Abstractions, Principles, and Methods" CRC Press, 2014. (Unit IV& V)

References:

1. Craig K. Enders, "Applied Missing Data Analysis", The Guilford Press, 2010.
2. Inge Koch, "Analysis of Multivariate and High dimensional data", Cambridge University Press, 2014.
3. Charu C. Aggarwal, "Data Classification Algorithms and Applications", CRC press, 2015.
4. Scott Murray, Interactive Data Visualization for the Web, O'Reilly, 2013.
5. Nathan Yau, Visualize This: The Flowing Data Guide to Design, Visualization and Statistics, John Wiley & Sons, 2011.

Online Resources

1. https://archive.nptel.ac.in/courses/106/105/106105174/ - Introduction to Data Analysis
2. https://www.geeksforgeeks.org/data-visualization-with-python/
3. https://www.tableau.com/learn/articles/data-visualization
4. https://www.ibm.com/topics/data-visualization

Course Code	Course Title	L	T	P	C
10212EC157	**SOFT COMPUTING**	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course provides a way to understand the concepts of Artificial Neural Network, Fuzzy systems, Genetic Algorithm, multi-objective optimization algorithm and its applications. Also it covers soft computing based solutions for real-world Engineering problems.

c) Prerequisite Courses

Nil

d) Related Courses

Machine Learning, Machine Vision

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Discuss the fundamental concepts of artificial neural network.	K2
CO2	Apply the fuzzy logic and reasoning to handle uncertainty in solving engineering problems.	K3
CO3	Interpret the genetic algorithm and its applications.	K2
CO4	Explain the hybridization of neural network, fuzzy and genetic algorithm.	K2
CO5	Describe the concepts of multi-objective optimization algorithm and its applications.	K2

f) Correlation of COs with POs and PSOs:

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	M	L	L	-	-	-	L	L	-	L	L	M
CO2	M	M	M	L	L	-	-	-	L	L	-	L	L	M
CO3	M	M	M	L	L	-	-	-	L	L	-	L	L	M
CO4	M	M	M	L	L	-	-	-	L	L	-	L	L	M
CO5	M	M	M	L	L	-	-	-	L	L	-	-	L	M

g) Course Content:

UNIT I: ARTIFICIAL NEURAL NETWORKS **9**

Biological neurons - Model of an artificial neuron- neural network architecture- characteristics of neural network- learning methods, Rosenblatt's perceptron, Adaline network, Madaline network- Back Propagation Networks (BPN)- Back Propagation learning, applications, effects of tuning and selection of various parameters in BPN.

UNIT II: FUZZY SYSTEMS **9**

Introduction to Fuzzy Logic, Classical Sets and Fuzzy Sets – Classical Relations and Fuzzy Relations -Membership Functions -Defuzzification – Fuzzy Arithmetic and Fuzzy Measures - Fuzzy Rule Base and Approximate Reasoning – Fuzzy Decision Making, Mamdani Fuzzy Models – Sugeno Fuzzy Models– Tsukamoto Fuzzy Models.

UNIT III: GENETIC ALGORITHMS **9**

Basic Concepts- Working Principles -Encoding- Fitness Function – Reproduction – Genetic modeling: Inheritance Operators – Cross Over – Inversion and Deletion -Mutation Operator – Bitwise Operators - Convergence of Genetic Algorithm - Multi-level optimization- Optimization algorithms: Ant colony optimization, Particle swarm optimization.

UNIT IV: HYBRID SYSTEMS **9**

Hybrid algorithms: Neuro fuzzy hybrids, neuro genetic hybrids, fuzzy genetic hybrids, GA Based Weight Determination – LR-Type Fuzzy Numbers – Fuzzy Neuron – Fuzzy BP Architecture – Learning in Fuzzy BP- Applications: Knowledge Base Evaluation, earthquake Damage Evaluation, Fuzzy Art Map: A Brief Introduction – Soft Computing Tools – GA in Fuzzy Logic Controller Design.

UNIT V: MULTI-OBJECTIVE OPTIMIZATION **9**

Multi-Objective Optimization: Problems, Principles- Classical methods: Weighted Sum method, ϵ -Constraint method- Concept of multi-objective optimization problems (MOOPs) and issues of solving them - Multi-Objective Evolutionary Algorithm (MOEA) - Non-Pareto approaches to solve MOOPs - Pareto-based approaches to solve MOOPs

Total: 45 Hrs

h) Learning Resources:

Text Books

1. S.N. Sivanandam, S.N. Deepa, "Principles of Soft Computing", Wiley India Pvt. Ltd., 2nd Edition, 2011.(Unit II)
2. S. Rajasekaran, G.A. Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications", PHI Learning Pvt. Ltd., 2017.(Unit I, III, IV)

References

1. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", Wiley, July 2001(Unit V)
2. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, "Neuro-Fuzzy and Soft Computing", Prentice-Hall of India, 2002.
3. Kwang H.Lee, "First course on Fuzzy Theory and Applications", Springer, 2005.
4. James A. Freeman and David M. Skapura, "Neural Networks Algorithms, Applications, and Programming Techniques", Addison Wesley, 2003.
5. Dan Simon, "Evolutionary Optimization Algorithms", John Wiley & Sons, 2013.

Online resources

1. www.cs.nthu.edu.tw/~jang/nfsc.htm - Neuro fuzzy and soft computing
2. https://nptel.ac.in/courses/106105173/2- Introduction to soft computing
3. https://nptel.ac.in/courses/117105084/ Introduction to Artificial Neural Networks

Course Code	Course Title	L	T	P	C
10212EC158	**STATISTICAL INFERENCE TECHNIQUES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the fundamentals of statistical models, linear models, and regression. Gives brief knowledge on probabilistic models with examples, Markov models, Markov processes, and tree-based models. This course is elaborated on statistical machine learning techniques and models, based on logistic regression and random forest techniques.

c) Prerequisite

Nil

d) Related Courses

AI in Speech Processing, Data Science and Visualization

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe the basics of statistical models, linear models, regression, and its real-time applications.	K2
CO2	Discuss probabilistic models with examples	K2
CO3	Explain markov models, markov processes, and tree-based models	K2
CO4	Elaborate on statistical machine learning techniques.	K2
CO5	Demonstrate model based on logistic regression and random forest techniques	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	L	-	-	-	-	L	L	-	-	-	-
CO2	M	L	L	L	L	-	-	-	L	L	-	-	L	-
CO3	M	L	L	L	L	-	-	-	L	L	-	-	L	L
CO4	M	L	L	L	L	-	-	-	L	L	-	-	L	L
CO5	H	L	M	L	M	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I FUNDAMENTALS OF STATISTICAL MODELS, LINEAR MODELS AND REGRESSION 9

Introduction: Basic concepts from statistics, definition and uses of models, real-time applications, key steps in the modelling process. Linear models and optimization - least square estimation - Revisiting regression models: analysis of variance model, interpretation of regression coefficients, R-squared and root mean squared error, fitting curves to data.

UNIT II PROBABILISTIC MODELS 9

Introduction to probabilistic models: some examples of probabilistic models, noisy channel model, source-channel model, joint source-channel models, Monte-Carlo Simulations, Building blocks of probability models, Various distributions, mixture models, bootstrap maximum likelihood methods, Bayesian method, expectation maximization.

UNIT III MARKOV MODELS, MARKOV PROCESSES AND TREE BASED MODELS 9

Markov-chain models, Hidden Markov model, Conditional random fields, tree-based models, decision trees, Latent variable probability models. Factor analysis, principal component analysis, Support vector machines, generalized linear discriminant analysis.

UNIT IV STATISTICAL MACHINE LEARNING TECHNIQUES 9

Statistical terminology for model building and validation -Machine Learning, Major differences between statistical modeling and machine learning - Steps in machine learning model development and deployment - Statistical fundamentals and terminology for model building and validation - Bias versus variance trade-off, Train and test data - Linear regression versus gradient descent

UNIT V LOGISTIC REGRESSION AND RANDOM FOREST TECHNIQUES 9

Logistic Regression - Terminology involved in logistic regression - Applying steps in logistic Regression modeling - Applying steps in logistic regression modeling using German credit data Random Forest algorithm, Grid search on random forest - Variable importance plot Comparison of logistic regression with random forest.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Sugiyama, M. (2015). Introduction to statistical machine learning. Morgan Kaufmann. (Units-I, II)
2. Hastie, T., Tibshirani, R., Friedman, J. H., & Friedman, J. H. (2009). The elements of statistical learning: data mining, inference, and prediction (Vol. 2, pp. 1-758). New York: springer. (Unit-III)
3. Dangeti, P. (2017). Statistics for machine learning. Packt Publishing Ltd. (Units-IV, V)

Reference Books

1. S.C. Gupta; "Fundamentals of Statistics 7th Edition"; Himalaya Publishing House Pvt. Ltd.
2. Abdul Hamid Khan, Manoj Kumar Srivastava, and Namita Srivastava; "Statistical Inference: Theory of Estimation"; PHI Learning.

Online Resources

1. Statistics tutorial- https://www.youtube.com/channel/ UCQKwruq0LY3cjvSx7
2. Inferential Statistics- https://www.youtube.com/watch?v=FtlH4svqx4&list

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Course Code	Course Title	L	T	P	C
10212EC159	**MACHINE VISION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the basic knowledge about implementation of various algorithms related to machine vision systems. In addition, students will also get an opportunity to know the fundamentals of calibrating machine vision systems.

c) Prerequisite

Nil

d) Related Courses

Machine Learning

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the geometric properties, and distance measures on binary images to facilitate pre-processing.	K3
CO2	Utilize the concept of region splitting and merging for segmentation of images.	K3
CO3	Implement the edge detection operators to extract and track relevant features from images and evaluate its performance	K3
CO4	Outline the approaches involved in geometrical optics and techniques for computing the depth from images	K2
CO5	Discuss dynamic vision and complexity of object recognition systems	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	M	-	M	-	-	L	H	L	-	L	L	-
CO2	M	L	-	L	M	-	-	L	H	-	-	M	M	M
CO3	M	L	-	L	M	-	-	L	H	-	-	H	M	M
CO4	L	L	M	L	-	-	L	-	M	L	-	L	L	L
CO5	L	L	M	L	-	-	L	-	M	L	-	M	L	L

g) Course Content

UNIT I INTRODUCTION TO MACHINE VISION & BINARY IMAGE PROCESSING TECHNIQUES 9

Machine Vision - Image definitions - Levels of computation- Binary image processing -Geometric properties, size, position & orientation - Component labeling -Binary Algorithms: Run length encoding - Size filter - Euler number - Region boundary - Area perimeter – compactness - Distance measures - Distance transforms - Medial axis - Morphological operators - Thinning- Expanding and Shrinking

UNIT II SEGMENTATION TECHNIQUES 9

Segmentation - Automatic thresholding - Limitations of Histogram methods - Region representation - array representation - Hierarchical representation - Region based segmentation: Split and merge - region merging - Removing weak edges - Region splitting - split and merge- Region growing

UNIT III EDGE DETECTION 9

Gradient - Steps in edge deduction – Robert's operator - Sobel operator - Prewitt operator - Second derivative operator - Laplacian operator - Gaussian edge Detection - Canny edge detector - Image Approximation - Subpixel location estimation - Edge detector performance- methods of Evaluating performance - Figure of merit

UNIT IV GEOMETRICAL OPTICS & DEPTH COMPUTING TECHNIQUES 9

Optics - Lens equation - Image resolution - Depth of Field -View volume -Exposure- Shading- Image Inductance - Illumination - Reflector - Surface orientation - Shape from shading depth - Stereo imaging - Cameras in arbitrary position and orientation - Stereo matching - Shape from X - Range imaging - Structural lighting - Imaging Radar- Active vision.

UNIT V DYNAMIC VISION & OBJECT RECOGNITION 9

Change detection - Difference pictures - Static segmentation and matching - object recognition system components - complexity of object recognition - object representation - observer centered & object centered representations - feature detection - recognition strategies – classification - Matching Feature indexing – verification - Template matching - morphological approach - symbolic analogical methods.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Ramesh Jain, Rangachar Kasturi and Brian G. Schunck, "Machine Vision," McGraw Hill International Edition, 2006 (Topics Covered: Unit-I to Unit-V)
2. Wataru Ohyama, Soon Ki Jung, "Frontiers of Computer Vision: 26th International Workshop , IW-FCV 2020, Ibusuki, Kagoshima, Japan, 2020

Reference Books

1. Gonzalez, Rafael C. and Woods, Richard Eugen, Digital Image Processing, 3rd Edition, Prentice Hall,2008
2. David Forsyth and Jean Ponce, Computer Vision: A modern Approach, Prentice Hall India 2004.

Online Resources

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-801-machine-vision-fall-2004/lecture-notes/
2. http://faculty.salina.k-state.edu/tim/mVision/Introduction.html
3. https://faculty.ucmerced.edu/mcarreira-perpinan/teaching/ee589/lecture-notes.pdf

Course Code	Course Title	L	T	P	C
10212EC174	**PRINCIPLES OF DATA SCIENCE**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The Purpose of the course is to provide strong foundation for data science and applications related to core concepts and emerging technologies. The course also provides exposure to various data science tools to solve real-world problems.

c) Prerequisite

Python Programming

d) Related Courses

Tools for Data Science, Data Analysis and Visualization

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the fundamental concepts of data science and the data science models used for business applications	K2
CO2	Apply SQL, No- SQL for data base management	K3
CO3	Illustrate the data visualization techniques	K3
CO4	Utilize open source data science tools to solve real-worldproblems.	K2
CO5	Summarize the commitment towards ethical practices for privacy, informed consent.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	-	-	-	-	-	-	-	L	L	L
CO2	H	M	M	L	H	-	-	-	L	L	-	L	L	L
CO3	H	M	M	M	H	-	-	-	L	L	L	L	L	L
CO4	H	H	M	M	H	-	-	-	L	L	-	L	L	L
CO5	M	L	L	-	-	H	M	H	-	L	L	-	L	L

g) Course Content

UNIT I INTRODUCTION TO DATA SCIENCE 9

Data Science: Benefits and uses – facets of data – Data Science Process: Overview – Defining research goals – Retrieving data – Data preparation – Cleansing integrating and transforming data -Exploratory Data analysis – Build the models– Presenting findings and building applications

UNIT II DATA BASES FOR DATA SCIENCE **9**

Structured Query Language (SQL): Basic Statistics - Data Munging – Filtering – Joins – Aggregation - Window Functions - Ordered Data preparing - No-SQL: Document Databases, Wide-column Databases and Graphical Databases**.**

UNIT III DATA VISUALIZATION **9**

Introduction to data visualization, visualization techniques: scatter plots, line graphs, pie charts, bar charts, heat maps, area charts – visualizing errors – density and contour plots – Histograms – legends – colors – subplots – text and annotation – customization – Three dimensional plotting - Geographic Data with Basemap – Visualization with Seaborn – Case study on Covid-19 dataset.

UNIT IV PLATFORM FOR DATA SCIENCE **9**

Python for Data Science –Python Libraries – Data Frame Manipulation with numpy and pandas – Exploration Data Analysis – Time Series Dataset – Clustering with Python –Dimensionality Reduction - Tableau Introduction – Dimensions, Measures, Descriptive Statistics, Basic Charts, Dashboard Design Principles, Special Chart Types, Integrate Tableau with Google Sheets.

UNIT V ETHICS IN DATA SCIENCE **9**

Importance of ethics in data science, doing good data science, data privacy – degrees of privacy, valuing different aspects of privacy, modern privacy risks, Getting informed consent, The Five Cs – consent, clarity, consistency and trust, control and transparency, consequences, Diversity, Inclusion, future trends.

Total 45 Hrs

h) Learning Resources

Text Books

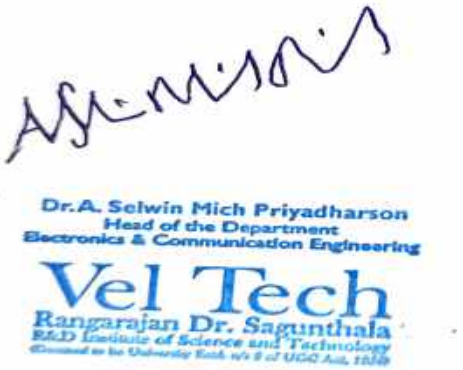
1. David Cielen, Arno D. B. Meysman, and Mohamed Ali, "Introducing Data Science", Manning Publications, 2016. (Unit 1)
2. Sanjeev Wagh, Manisha Bhende, Anuradha Thakare, 'Fundamentals of Data Science', CRC press, 2021. (Unit 2,4)

Reference Books

1. Dr. Ossama Embarak, "Data Analysis and Visualization using Python", Apress, 2018 (Unit3)
2. J Patil, Hilary Mason, Mike Loukides, "Ethics and Data Science" , O' Reilly Media Publishers, 1st edition, 2018. (Unit 5)
3. Avrim Blum, John Hopcroft, Ravindran Kannan, "Foundations of Data Science", Cambridge University Press, First Edition, 2020.
4. Cathy O'Neil, Rachel Schutt, "Doing Data Science", O' Reilly media publishers, 1st edition, 2013

Online Resources:

1. Introduction to Data Science | Towards Data Science
2. What Is Data Science and Why Is It Important? [With Examples] (edureka.co)
3. What is Data Science? | Introduction to Data Science | Data Science for Beginners | Simplilearn - YouTube



COURSE CODE	COURSE TITLE	L	T	P	C
10212EC225	TOOLS FOR DATA SCIENCE	1	0	4	3

a) Course Category:

Programme Elective

b) Preamble

This course is proposed to enable the students to learn various tools, algorithms, and machine learning principles with the goal of discovering hidden patterns from the raw data. This course also discovers the applicability of data science across fields and learn how data analysis can help to make data driven decisions.

c) Prerequisite:

Python Programming

d) Related Course

Data Analysis & Visualization

e) Course Outcomes:

On successful completion of the course the students will be able to

CO Nos	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Perform the process of data cleaning, preparation, wrangling with numpy and pandas for exploratory data analysis	S2
CO2	Simulate the basic data visualizations to interpret data and perform calculations on different data types, tables.	S2
CO3	Build advanced visualizations with tableau and power BI to make complex interprets.	S2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	H	H	M	H				L	L	L		L	L
CO2	M	H	H	M	H				L	L	L		M	L
CO3	M	M	H	L	H				L	L	L		M	L

g) Course Contents: Theory

Data Cleaning, Preparation, wrangling using Python: Filtering and replacing values, outlier detection, Merging, reshaping datasets.
Data visualization in Tableau: charts, maps, plots, case studies, calculations with Tableau.
Advanced visualization using Tableau: charts, plots, statistical data modeling- Power BI: Table operations, Budget allocation, DAX in data models.

Course Contents: Practical Exercises

LIST OF EXPERIMENTS		
Sl. No.	**Name of the Experiment**	**CO**
01	Perform the following operations using Python, connecting to databases. a. Handling missing data b. Filtering out & filling in missing data	CO1
02.	Perform the following operations using Python connecting to databases. a. Transpose a table b. Replace data from the tables c. Renaming axis indices, Detecting outliers, Random sampling.	CO1
03	Perform the following Data Wrangling operations using Python connecting to databases : Combining and merging datasets, Reshaping and pivoting.	CO1
04	Perform the following operations using Tableau a. Aggregate calculations, creating parameters. b. Detailed calculations	CO2
05	Perform the following basic visualizations of data, using Tableau connecting to databases: Bar charts, Bullet chart, highlight categories of interest, Date Parts, Gantt charts	CO2
06	Perform the following basic visualizations of data, using Tableau connecting to databases. a. Relating parts of data to whole- stacked bars b. tree maps, area charts c. visualizing distributions -circle charts	CO2
07	Perform the following Calculations using Tableau a. Row and column level calculations, Aggregate calculations b. Creating parameters c. Detailed calculations: Examples of fixed level of detail calculation	CO2
08	Perform the following Calculations using Tableau	CO2

	a. creating and editing table calculations b. addressing and partitioning c. meta table functions	
09	Perform the following visual analytics using Tableau connecting to databases. a. Exporting and explain statistical data, b. Clustering, Distributions.	CO3
10	Perform the following advanced visualizations of data using Tableau connecting to databases. a. Slope charts and Bump charts b. Step lines and Jump lines, Spark lines, c. Dumbbell charts d. Build Marimekko chart for UCBA admissions dataset	CO3
11	Perform the following tasks with Power BI a. Sharing the dashboard, Using Power BI desktop b. Getting data from services and content packs	CO3
12	Perform the following data building tasks with Power BI a. Loading Individual tables, creating calculated columns b. Integrating budget, reallocating budget. c. Using DAX in data models.	CO3

Total: 75 Hours

h) Learning Resources:

Text Books:

1. Wes McKinney, "Python for Data Analysis: Data Wrangling with Pandas, NumPy, and IPython", OReilly, 2nd Edition, 2018.
2. Joshua N. Milligan, "Learning Tableau 2020" Packt Publisher, 2020.
3. Alberto Ferrari and Marco Russo, "Introducing Power BI," Microsoft Press, 2016.

Reference Books:

1. Chirag Shah, "A Hands-on introduction to Data Science", Cambridge University Press, 2020.

Online Resources:

1. https://www.youtube.com/watch?v=TBVss5711QM – Power BI Tutorials for beginners
2. https://stat.ethz.ch/R-manual/R-patched/library/datasets/html/UCBAdmissions.html
   - PIMA Indian Diabetes dataset for case study.
3. https://stat.ethz.ch/R-manual/R-patched/library/datasets/html/UCBAdmissions.html
   - The UCBS admissions dataset for case study.

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Course Code	Course Title	L	T	P	C
10212EC226	**MACHINE LEARNING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course is proposed to meet a growing professional need of individuals skilled in artificial intelligence, data analytics, statistical programming and other software skills. The course integrates theory and practice to enable the student to gain the necessary knowledge to compete in the ever-changing work environment. This course covers the fundamental concepts of machine learning, core concepts of Bayesian decision theory, Linear regression, Logistic regression, Support Vector Machines, clustering and dimensionality reduction techniques along with hands-on problem solving using simple python programming

c) Prerequisite

Python Programming

d) Related Courses

Deep Learning

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the basic concepts of machine learning and implement using python programming	K2
CO2	Model bayesian decision theory principles, bayes classifier and estimator for classification and prediction	K3
CO3	Apply the various linear and logistic regression models and demonstrate using python	K3
CO4	Identify and apply the classification algorithms and implement using python.	K3
CO5	Make use of the clustering algorithms and dimensionality reduction techniques for developing applications and implement the algorithms using python.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	L	L	M	-	-	-	M	L	-	L	-	-
CO2	H	H	L	M	M	-	-	-	M	L	-	H	L	M
CO3	H	H	M	M	M	-	-	-	M	L	-	M	L	M
CO4	H	H	H	M	M	-	-	-	M	L	-	H	L	M
CO5	H	H	L	M	M	-	-	-	M	L	-	L	L	M

g) Course Content

UNIT I MACHINE LEARNING BASICS 6

Definition of learning systems - types of learning; Supervised, Unsupervised and Reinforcement learning - hypothesis space - General-to-specific ordering of hypotheses and inductive bias, evaluation, cross-validation, Find-S, List then eliminate algorithm, Candidate elimination algorithm

UNIT II BAYESIAN DECISION THEORY 6

Bayes rule – independence and conditional independence – Minimum error rate classification, Normal density and discriminant functions – Bayesian Concept learning - MAP estimation – Bayes Classifier - Maximum Likelihood and Bayesian Parameter Estimation for common loss functions, Naïve Bayes model.

UNIT III LINEAR AND LOGISTIC REGRESSION 6

Simple linear regression –Multiple linear regression– Least squares estimation – Coefficient of Determination (R-squared) and Adjusted R-Squared, Hypothesis Test for Regression Coefficients (t-Test), Ridge regression - Logistic Regression Model–Multiple logistic regression – Step wise Logistic Regression–Best Subset Logistic Regression

UNIT IV CLASSIFICATION ALGORITHMS 6

Introduction to Classification - k-Nearest Neighbor Algorithm - Decision Trees: Univariate, Multivariate trees, ID3 algorithm - Random Forests, Support Vector Machines.

UNIT V CLUSTERING AND DIMENSIONALITY REDUCTION 6

Introduction to clustering - Mixture densities - k-Means Clustering - Hierarchical Agglomerative Clustering - choosing number of clusters, Dimensionality Reduction - Need for Dimensionality Reduction – Subset Selection – Principal Component Analysis

LIST OF EXPERIMENTS

Hardware requirement:

- i5 Processor, 8GB RAM, & Internet Connection

Software Environment:

- IDE recommended PYCHARM (Recommended), JUPYTER

S.No.	Name of the Experiment	CO
1	Online Retail Case Study	CO1
2	Program to demonstrate Housing Price Prediction	CO1
3	Program to demonstrate on Prediction using Bayes Rule.	CO2
4	Program to demonstrate, classification/estimation using Bayes Rule.	CO2
5	Program to demonstrate Simple/Multiple Linear Regression	CO3
6	Program to demonstrate Binary and Multiple Logistic Regression	CO3
7	Program to demonstrate SVM based classification	CO4
8	Program to demonstrate the working of the decision tree based ID3 algorithm.	CO4
9	Program to implement the Random Forest classifier for a sample training data set stored as a .CSV file. Compute the accuracy of the classifier, considering few test data sets.	CO4
10	Program to cluster the medical data using hierarchical method. Use this model to demonstrate the diagnosis of heart patients using standard Heart Disease Data Set.	CO5
11	Program to demonstrate PCA on face recognition.	CO5
12	Program to demonstrate PCA on Iris dataset.	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.(Unit I – Unit IV)
2. Ethem Alpaydin, Introduction to Machine Learning, 2nd Edition, MIT Press 2010 (Unit V)
3. Richert & Coelho, Building Machine Learning Systems with Python, 3rd Edition, Packt Publishers, 2018

Reference Books

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Second edition Springer 2017.
2. Weisberg, Sanford, Applied Linear Regression, 4th Edition, John Wiley & Sons, 2014
3. David W. Hosmer Jr., Stanley Lemeshow, Rodney X. Sturdivant, Applied Logistic Regression, 3rd Edition John Wiley & Sons, 2013
4. Andreas C. Müller, Sarah Guido, Introduction to Machine Learning with Python, O'Reilly Media, Inc., 2016

Online Resources

1. AndrewNg,"MachineLearning",StanfordUniversity, https://www.coursera.org/learn/machine-learning/home/info

2. Sudeshna Sarkar**,** **"**Introduction to Machine Learning", IIT Kharagpur. https://nptel.ac.in/courses/106105152/1
3. Prof. Balaraman Ravindran, **"**Introduction to Machine Learning", IIT Madras. https://nptel.ac.in/courses/106106139/1
4. Machine Learning Tutorials, Machine Learning Tutorial (tutorialspoint.com)
5. Machine Learning Mastery, Best Machine Learning Resources for Getting Started (machinelearningmastery.com)

Course Code	Course Title	L	T	P	C
10212EC227	**DEEP LEARNING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

Deep Learning is one of the most attractive and promising areas of AI and machine learning and finds itself vastly applicable in Computer Vision tasks. This course covers the fundamentals from Artificial Neural Network to the current trending topic of Convolution Neural Network and adversarial deep networks. Thus, this course aims to provide basic knowledge on applying deep learning techniques to solve various real-life problems.

c) Prerequisite

Python Programming

d) Related Courses

Machine Learning

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Demonstrate the fundamentals of machine learning and deep learning concepts.	K2
CO2	Apply CNN models and transfer learning for different applications.	K3
CO3	Illustrate the architectural features of diverse deep CNN networks.	K3
CO4	Utilize various RNN network models for sequence and textprocessing applications.	K3
CO5	Employ autoencoders and adversarial network models for image processing applications.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	M	L	-	-	L	L	L	-	L	L	L
CO2	M	L	L	M	L	-	-	L	L	L	-	L	L	M
CO3	M	M	M	M	M	-	-	L	L	L	-	M	L	M
CO4	M	M	M	M	H	-	-	L	L	L	-	M	L	M
CO5	M	M	M	M	H	-	-	L	L	L	-	M	L	M

g) Course Content

UNIT I FOUNDATIONS OF DEEP LEARNING 6

Biological neuron – Perceptron – Multilayer feed-forward networks – backpropagation learning – parameters – loss functions – hyperparameters - capacity - estimators - bias and variance - overfitting and underfitting - Stochastic gradient descent - Need for deep learning - Deep Networks: Deep feed-forward networks - Regularization.

UNIT II CONVOLUTIONAL NEURAL NETWORKS 6

Convolution operation – variants with strides - Activation functions - Building blocks of Convolutional Neural Networks: Convolution Layers, Pooling Layers, Fully Connected Layers - Greedy layer wise training - CNN based deep learning - transfer learning based deep learning – Application of CNN model for character classification on MNIST Dataset.

UNIT III DEEP CONVOLUTION NEURAL NETWORKS 6

CNN architectures: LeNet, Alexnet, VGG, GoogleNet, Xception, Inception models - Application of transfer learning using Alexnet and Googlenet models for image classification tasks.

UNIT IV RECURRENT NEURAL NETWORKS 6

Support for sequences in Neural Networks - Recurrent Neural Networks: Basic architecture, variants of RNN models - LSTM architecture - GRU architecture - Application of RNN models for sequence and text processing.

UNIT V AUTOENCODERS AND ADVERSARIAL NETWORKS 6

Autoencoder models - Introduction to Generative Adversarial Networks: Generator, Discriminator Adversarial Networks - Application of autoencoder for dimensionality reduction and adversarial model for image processing.

i) List of Experiments

S. No	Name of the experiment	CO
1	a) Understanding and working with Keras and Tensorflow b) Design a dense neural network using Tensorflow c) Classification with Multilayer Perceptron using Scikit-learn (MNIST Dataset) (6 Hours)	CO1
2	a) Design and analysis of a simple CNN model for MNIST dataset b) Design and analysis of a deep CNN model for Cipher dataset c) Design and analysis of a CNN architecture for object recognition (6 Hours)	CO2
3	a) Use a pre-trained CNN architecture for image classification b) Design and analysis of any recent variant of CNN model for image classification (6 Hours)	CO3
4	a) Design and analysis of a simple LSTM model for sequence classification b) Design and analysis of a LSTM architecture for sentiment analysis c) Design and analysis of a RNN model for time-series prediction (6 Hours)	CO4
5	a) Design and analysis of an auto encoder for image generation and dimensionality reduction b) Design and analysis of a GAN model for synthetic image generation (6 Hours)	CO5

Total: 60 Hrs

h) Learning Resources

i) Text Books

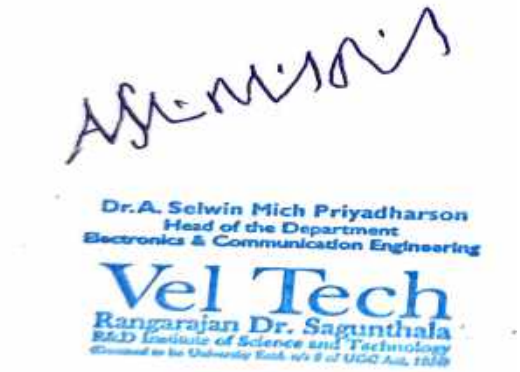
1. Ian Goodfellow, Yoshua Bengio and Aaron Courville, “Deep Learning”, MIT Press, 2017. (Units - I, II and V)
2. Josh Patterson, Adam Gibson "Deep Learning: A Practitioner's Approach", O'Reilly Media, 2017. (Units - III and IV)

Reference Books

1. Umberto Michelucci "Applied Deep Learning. A Case-based Approach to Understanding Deep Neural Networks" Apress, LLC: New York, NY, USA, 2018
2. Pattanayak, Santanu, Pattanayak, and Suresh John, "Pro deep learning with tensorflow", New York, NY, USA, Apress, 2017.
3. Chollet, Francois, "Deep learning with Python", Simon and Schuster, 2017.

Online Resources

1. http://neuralnetworksanddeeplearning.com/
2. https://machinelearningknowledge.ai/category/deep-learning/
3. https://onlinecourses.nptel.ac.in/noc20_cs62/preview (Deep Learning)
4. https://nptel.ac.in/courses/106/106/106106224/ (Deep Learning for Computer Vision)



Course Code	Course Title	L	T	P	C
10212EC160	**OPTIMIZATION TECHNIQUES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The area of optimization playing a critical role even in contemporary areas such as decision and control, signal processing, and machine learning. This course intends to present a thorough treatment of optimization techniques with specific emphasis on modern applications. This will provide students with a sound background in the area and benefit those who wish to pursue doctoral or master level theses in this subject, or apply these techniques to their own.

c) Prerequisite

Nil

d) Related Courses

Machine Learning, Deep Learning

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts of optimization	K2
CO2	Describe the concepts of convex optimization	K2
CO3	Summarize the application of optimization for machine learning	K2
CO4	Discuss the concepts of non-convex optimization	K2
CO5	Interpret special topics in optimization techniques	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	H	L	-	-	-	L	L	-	-	-	-
CO2	H	H	L	M	L	-	-	-	L	L	-	L	-	L
CO3	H	H	M	L	L	-	-	-	L	L	-	L	-	L
CO4	H	M	L	L	L	-	-	-	L	L	-	L	-	L
CO5	H	H	H	L	L	-	-	-	L	L	-	L	-	M

g) Course Content

UNIT I Introduction to Optimization **9**

Optimization Basics, Optimization Techniques, Optimal Problem Formulation, Sequences and Limits, Derivative Matrix, Level Sets and Gradients, Taylor Series, Linear Programming, Formulation of Problem, Graphical Method, Simplex Method, Dual Simplex Method

UNIT II Single-Variable Nonlinear Optimization **9**

Classical Method for Single-Variable Optimization, Exhaustive Search Method, Bounding Phase Method, Interval Halving Method, Fibonacci Search Method, Golden Section Search Method, Bisection Method, Newton Raphson Method, Secant Method, Successive Quadratic Point Estimation Method

UNIT III Multivariable Nonlinear Optimization **9**

Classical Method for Multivariable Optimization, Unconstrained Nonlinear Optimization, Unidirectional Search Method, Evolutionary Search Method, Simplex Search Method, Constrained Nonlinear Optimization, Equality and Inequality Constrained Optimization, Random Search Method, Complex Method, Penalty Function Method, Convex Programming Problem

.

UNIT IV Optimization Programming **9**

Geometric Programming – Constrained- Unconstrained, Dynamic Programming – Characteristics-Terminologies, Linear and Non-Linear Integer Programming, Multi-Objective Optimization

UNIT V Nature-Inspired Optimization and Applications **9**

Genetic Algorithm, Neural Network-based Optimization, Ant Colony Optimization, Particle Swarm Optimization, Optimization Methods for Deep Learning and Machine Learning

Total: 45 Hrs

h) Learning Resources

Text Books

1. Sukanta Nayak, "Fundamentals of Optimization Techniques with Algorithms" Academic Press (2020) (Unit – I, II, III, IV, V)
2. SuvritSra, Sebastian Nowozin and Stephen Wright (Editors), Optimization for Machine Learning, The MIT Press, Dec. 2011. (Unit-V)

Reference Books

1.Roberto Battiti, Mauro Brunato. The LION Way: Machine Learning plus Intelligent Optimization. Lionsolver, Inc. 2013.
2.Bubeck, Sebastien. "Theory of Convex Optimization for Machine Learning." arXiv preprint arXiv: 1405.4980, 2014.
3.D.E.Goldberg Addison "Genetic algorithms in Search, Optimization, and Machine learning" Wesley Publishers, 1989

Online Resources

1. http://simons.berkeley.edu/talks/peter-richtarik-2013-10-23.
2. Introduction to Convex Optimization in Machine Learning
3. Kristin Bennett, Emilio Parrado-Hernandez. Interplay of Optimization and Machine Learning Research, Journal of Machine Learning Research, 2006.

Course Code	Course Title	L	T	P	C
10212EC228	**DATA SCIENCE AND VISUALIZATION**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

Data science is one of the hottest professions of the decade, and the demand for data scientists who can analyze data and communicate results to inform data driven decisions has never been greater. This course will help in pursuing a career in data science or machine learning, develop career-relevant skills and experience in visualizing the data with programming tools.

c) Prerequisite

Python Programming

d) Related Courses

Machine Learning, Deep Learning

e) Course Outcome

On successful completion of the course, student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Demonstrate the different preprocessing techniques in data science	K2
CO2	Apply various classification and clustering techniques for problem solving using python	K3
CO3	Utilize data visualizations tools like numpy, pandas and matplotlib	K3
CO4	Illustrate data visualization techniques in various applications	K3
CO5	Implement visualization using python to solve real world problems	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	M	L	H	-	-	L	M	L	-	L	-	L
CO2	M	M	M	L	H	-	-	L	M	L	-	L	-	L
CO3	M	M	M	L	H	-	-	L	M	L	-	L	L	M
CO4	M	M	M	L	H	-	-	L	M	L	-	L	L	M
CO5	M	M	H	L	H	-	-	L	M	L	-	L	-	L

g) Course Content

UNIT I DATA SCIENCE FUNDAMENTALS 6

Need for Data Science – Exploring Data Engineering Pipelines and Infrastructure – Data Science Process Overview –Defining goals – Retrieving data – Data preparation – Data exploration – Data modeling.

UNIT II KNOWLEDGE EXTRACTION FROM DATA 6

Learning from Data with Machine - Math, Probability, and Statistical Modeling – Using Clustering to Subdivide Data - Modeling with Instances – Model Building.

UNIT III TOOLS FOR DATA SCIENCE 6

Python for Data science – Rows and Columns, Creating Data frames, Exploring Data frames, Accessing Columns in a Data frame - Excel, Knime, Data Munging: Reading a CSV Text File, Removing Rows and Columns, Renaming Rows and Columns, Cleaning up the Elements, Sorting data frames.

UNIT IV DATA VISUALIZATION 6

Principles of Data Visualization Design - D3.js for data Visualization, Web-Based Applications for Visualization - Exploring Best Practices in Dashboard Design – Making Maps from Spatial Data.

UNIT V DATA VISUALIZATION TOOLKIT 6

Basic principles, categorical and continuous variables, exploratory graphical analysis, Creating static graphs, animated visualizations, loops, GIFs and Videos, Data visualization in Python.

List of Experiments

S. No.	Experiments	CO
1	Generating random numbers using probability distributions a. Create an ordered factor from data consisting of the names of months. b. Get the statistical summary and nature of the data of a given data frame.	CO1
2	Generating random numbers using probability distributions a. Get the radius of a circle from the user and compute the area. b. Display your details like name, age, address in three different lines.	CO1
3	Programs based on Data aggression, Filtering and Transformation	CO2
4	Implement Model Building for Data Analytics	CO2
5	Programs based on appending / merging data. Create, manipulate, and plot the time series data using python for annual rainfall details.	CO3
6	Create a 2D Dummy array for student database perform indexing arrays by slicing and perform basic operations on the array	CO3
7	Creation of Basic Visualizations for Iris Dataset • Bar chart • Geographic map • Crosstab report • Scatter plot • Line chart	CO4
8	Create hierarchical and topographical Data Visualizations in Tableau	CO4
9	Removing outliers and filling missing values in a data frame using statistical characteristics	CO4
10	Create Interactive data visualization plots using Plotly and Cufflinks	CO5
11	Create Word cloud and Heat map using static graphs	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Lillian Pierson, Jake Porway, Data Science for Dummies, Wiley publication, 2017, ISBN: 978-1-119-32763-9. (Unit I - IV)
2. Charles D. Hansen and Chris R. Johnson, Visualization Handbook, Academic Press, 2000.

Reference Books

1. Rafael A. Irizarry, Introduction to Data Science: Data Analysis and Prediction Algorithms with R, CRC Press, 2020.
2. Noab Iliinsky, Julie Steele, Designing data visualizations, O' Reilly publishers, 2011.

Online Resources (Unit –V)

1. https://sscc.wisc.edu/sscc/pubs/DWE/book/3-3-sect-ggplot-categorical.html
2. https://bookdown.org/rdpeng/exdata/exploratory-graphs.html
3. https://www.algorithmic-solutions.info/leda_manual/static_graph.html
4. https://towardsdatascience.com/the-simplest-way-of-making-gifs-and-math-videos-with-python-aec41da74c6e
5. https://gilberttanner.com/blog/introduction-to-data-visualization-inpython/
6. https://towardsdatascience.com/intro-to-data-science-531079c38b2

Code	Course Title	L	T	P	C
10212EC229	**AI IN NATURAL LANGUAGE PROCESSING**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides a general introduction including the use of state automata for language processing, fundamentals of syntax including a basic parse, advanced feature like structures and realistic parsing methodologies basic concepts of remotes processing and typical natural language processing applications

c) Prerequisite

Machine Learning

d) Related Courses

Deep Learning

e) Course Outcome

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe the fundamental and applications of natural language processing	K2
CO2	Apply morphological analysis, inflective and derivational morphology, tree structure for dictionaries and speech tagging	K3
CO3	Model the various approaches on syntax in natural language processing	K3
CO4	Compare the differentiation of semantic and discourse in terms of natural language processing	K3
CO5	Implement an NLP system for various applications by using the tools for sentiment classification & chatbot systems	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	L	L	-	L	-	L	L	-	M	-	L
CO2	H	M	L	L	L	-	L	-	L	L	-	M	-	L
CO3	H	M	M	M	L	-	L	-	L	L	-	M	-	M
CO4	H	M	M	M	L	-	L	-	L	L	-	M	-	M
CO5	H	M	M	M	M	L	L	-	L	L	-	M	-	M

g) Course Content

UNIT I FUNDAMENTALS FOR NLP **06**

Introduction to NLP- Regular Expressions, Words, Corpora, Text Normalization, Minimum Edit distance, N gram Language Models- Evaluating Language Models, Smoothing.

UNIT II MORPHOLOGY AND PART OF SPEECH TAGGING **06**

Linguistic essentials - Lexical syntax- Morphology and Finite State Transducers - English Word Classes- The Penn Treebank Part of speech Tagging – Named Entities and Named Entity -HMM Part-of-Speech Tagging –Conditional Random Fields- Evaluation of Named Entity Recognition

UNIT III SYNTAX ANALYSIS **06**

Constituency Grammars-Context Free Grammars for English –Tree Banks-Lexicalized Grammars-Constituency Parsing-Dependency Parsing

UNIT IV SEMANTIC AND DISCOURSE ANALYSIS **06**

Representing Meaning – Semantic Analysis - Lexical semantics –Word-sense disambiguation - Supervised –Dictionary based and Unsupervised Approaches - Compositional semantics, Semantic Role Labeling and Semantic Parsing – Discourse Analysis.

UNIT V APPLICATIONS & CASE STUDIES **06**

Question Answering -Case Study of Sentiment Classification, Chatbots and Dialogue Systems

List of Experiments

SI. NO	CYCLE-1	CO mapping of Experiments
1	Generate regular expression for a given text	**CO1**
2	Demonstrate a bigram language model & trigram language model	**CO1**
3	N-Grams Smoothing, POS Tagging: Hidden Markov Model	**CO2**
4	Identify parts-of Speech using Penn Treebank tag set.	**CO2**
5	Implement HMM for POS tagging	**CO2**
6	Implementation of Antonyms from WordNet	**CO3**

	CYCLE-2	
7	Implementation of stemming non-English words	**CO3**
8	Word sense disambiguation by LSTM/GRU	**CO4**
9	Case study-based program (IBM) or Sentiment analysis	**CO4**
10	Implement POS Tagging or Word Embedding's.	**CO5**
11	Create a chatbot for VTU	**CO5**
12	Develop a Movie review system	**CO5**

Total: 60 Hours

h) Learning Resources

Text Book:

1. Daniel Jura sky, James H. Martin—Speech, and Language Processing: An Introduction to Natural Language Processing, Computational Linguistics and Speech, Pearson Publication, 2014. (UNIT 1,2,3, &5)
2. Christopher D. Manning, and Hinrich Schütze. Foundations of statistical natural language processing. First Edition, MIT press, 1999 (UNIT 4)

References:

1. Richard M Reese, ―Natural Language Processing with Java‖, O'Reilly Media, 2015
2. Yoav Goldberg, University of Toronto, Neural Network Methods for Natural language Processing, Morgan & Claypool, 2017.
3. Steven Bird, Ewan Klein, and Edward Loper, ―Natural Language Processing with Python‖, First Edition, O'Reilly Media, 2009
4. Nitin Indurkhya and Fred J. Damerau, ―Handbook of Natural Language Processing, Second Edition, Chapman, and Hall/CRC Press, 2010
5. Tanveer Siddiqui, U.S. Tiwary, ―Natural Language Processing and Information Retrieval‖, Oxford University Press, 2008

Online Resources:

1. https://blog.algorithmia.com/introduction-natural-language-processingnlp/
2. https://www.udacity.com/course/natural-language-processingnanodegree--nd892
3. https://www.coursera.org/learn/language-processing
4. https://towardsdatascience.com/a-practitioners-guide-to-naturallanguage-processing-part-i-processing-understanding-text-9f4abfd13e72
5. https://www.edx.org/course/natural-language-processin
6. NLTK – Natural Language Tool Kit - http://www.nltk.org/
7 https://www.cs.vassar.edu/~cs366/docs/Manning_Schuetze_StatisticalNLP.pdf

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Course Code	Course Title	L	T	P	C
10212EC230	**AI IN SPEECH PROCESSING**	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

AI in Speech Processing provides an understanding about concepts, methodology and analysis of speech signals and also the basic speech recognition techniques and distortion measures to analyze the speech signal. Also, it gives the knowledge about the persuade of Artificial Intelligence in Speech recognition.

c) Prerequisite

Python Progamming

d) Related Courses

AI in Natural Language Processing

e) Course Outcomes

On successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the basic concepts of speech signals and time domain representation in speech signal modelling	K3
CO2	Demonstrate the mathematical modeling for speech signal processing	K3
CO3	Illustrate the different speech recognition systems	K3
CO4	Utilize the AI methods for automatic speech recognition	K3
CO5	Develop a speech synthesis model by using AI techniques	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	-	-	M	-	-	-	M	L	-	-	-	-
CO2	H	H	L	-	M	-	-	-	-	-	-	-	-	-
CO3	M	M	L	-	M	-	-	-	M	L	-	-	-	M
CO4	M	L	L	-	M	-	-	-	M	L	-	-	-	M
CO5	M	L	-	-	M	L	-	-	M	L	-	-	-	M

g) Course Contents

UNIT I FUNDAMENTALS OF SPEECH PROCESSING 6

The process of speech production - Mechanism of Speech production - Acoustic phonetics - acoustic theory of speech production - Digital models for speech signals - representing speech in the Time and Frequency Domains - Speech sounds and features

UNIT II MATHEMATICAL MODELLING OF SPEECH SIGNAL 6

Features and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual models - Log Spectral Distance - Dynamic Time Warping - Multiple Time – Alignment Paths

UNIT III SPEECH RECOGNITION 6

Introduction to markov chain - Hidden Markov Model, definition - practical issues in using HMM - limitations, the generative model paradigm Speech Recognition - Speech Features - Auditory System as a Filter Bank - Cepstrum as a Spectral Analyzer - Linear Prediction

UNIT IV AUTOMATIC SPEECH RECOGNITION 6

Automatic Speech Recognition - Feature Extraction for ASR - Deterministic Sequence Recognition for ASR - Statistical Sequence Recognition -Evaluation methods

UNIT V AI TECHNIQUES IN SPEECH SYNTHESIS 6

Overview of Deep Neural Network - Deep Belief Network models for Music Synthesis - DBN for speech modeling · Acoustic Modeling Using Deep Belief Networks · DBN for Large Vocabulary and Speaker Verification - RNN-LSTM systems for speech recognition

List of Experiments

Sl. No.	Experiment Name	CO
1	Visualizing Audio Signals -Analyse an audio signal of 100 Hz, using Python	CO1
2	Generating Monotone Audio Signal using Python	CO1
3	Characterizing the Audio Signal using Python and convert it into frequency domain using Fourier Transform mathematical tool	CO2
4	Extract the MFCC features from speech signal	CO2
5	Isolated word recognition system	CO3
6	Silence determination in speech	CO3
7	Classification of Voiced/Unvoiced Speech	CO3
8	Transcribe continuous speech using online ASR	CO4
9	Pole Zero modelling of speech signal	CO4
10	Gender classification using pitch period analysis	CO5
11	Classification of happy and sad emotions in speech	CO5
12	LSTM, Deepspeech, Wav2vec use models for speech recognition	CO5

h) Learning sources

Text Books

1. "Digital Processing of Speech Signals" Lawrence Rabiner and Ronald W. Schafer Prentice Hall Inc, 2012 (ISBN: 978-81-317-0513-1) (Unit1,2)
2. "Speech and Language Processing , – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition" Daniel Jurafsky and James H Martin, Pearson Education (Unit3,4)

Reference Books

1. " Spoken Language Processing" by Xuedong Huang, Alex Acero and Hsiao-wuen Hon, Prentice Hall, 2001 (ISBN 0-13-22616-5)

Online Resources

1. https://arxiv.org/abs/1904.05862 (DBN model for music synthesis)
2. https://arxiv.org/abs/1412.5567 (DBN for speech modeling)
3. https://youtu.be/NO71kZBv30Q (DBN for acoustic modeling)
4. https://youtu.be/BJ2pAm2wBAU (DBN for Large Vocabulary and Speaker Verification)

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Course Code	Course Title	L	T	P	C
10212EC176	**INDUSTRY 4.0 AND IIOT**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

Smart factories are equipped with advanced sensors, embedded software and robotics that collect and analyze data and allow for better decision making. This Course will provide knowledge on the industry 4.0 design requirements, data analysis and applications of Internet of Things (IoT) in industries.

c) Prerequisite

Nil

d) Related Courses

Internet of Things

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the evolution of Industry 4.0 and design requirements of Industrial IoT (IIoT).	K2
CO2	Illustrate the functions of Industrial processes, business models, off-site on-site technologies	K2
CO3	Develop data acquisition system using instrumentation amplifier and mapping of IIOT analytics	K3
CO4	Interpret the plant safety and security features and benefits of inventory management system	K2
CO5	Outline the applications and challenges of IIoT.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	-	-	-	-	_	L	-	L	M	L
CO2	H	L	L	-	-	-	-	-	L	L	-	L	M	L
CO3	H	M	M	L	L	-	-	-	L	L	-	L	M	L
CO4	H	M	M	M	-	-	L	L	L	L	-	L	M	L
CO5	H	M	M	L	-	-	-	-	L	L	L	L	M	L

g) Course Content

UNIT I OVERVIEW OF INDUSTRY 4.0 9

Evolution of Industry 4.0-Environmental impacts of industrial revolution- Industrial Internet-Design requirements - Drivers of Industry 4.0 - sustainability assessment of Industries - Smart business perspective - cyber security - Cyber Physical System - impacts of Industry 4.0.

UNIT II BUSINESS MODELS AND REFERENCE ARCHITECTURE 9

Industrial process: Features, industrial plant- Business models: Categorization, Opportunities - reference architecture: categorization, Industrial Internet Reference Architecture (IIRA) framework - Off-site Technologies: Cloud Computing and Fog Computing for IIoT - On-site Technologies: Augmented Reality and Virtual Reality.

UNIT III INDUSTRIAL DATA ACQUISITION AND IIoT ANALYTICS 9

Industrial data acquisition: designing data acquisition using instrumentation amplifier-components of distributed control system, PLC basic programming, SCADA - IIoT analytics - necessity, categorization, usefulness, challenges, mapping of analytics with the architecture, deployment analytics.

UNIT IV INVENTORY MANAGEMENT, PLANT SAFETY AND SECURITY 9

Inventory management: types, benefits, quality control - Plant safety and security: IIoT applications for undertaking safety measures in plant, Software security, Network security, mobile device security.

UNIT V APPLICATIONS AND CHALLENGES 9

Health monitoring- IoT smart city - smart irrigation - UAVs in industries - manufacturing industry - automotive industry - mining industry - inventory management and quality control - challenges in Industrial IoT.

Total: 45 Hrs

h) Learning Resources

Text Books

1. S. Misra, C. Roy, A. Mukherjee, "Introduction to Industrial Internet of Things and Industry 4.0", CRC Press, 2020.
2. R. Anandan, Suseendran Gopalakrishnan, S. Pal, N. Zaman, "Industrial Internet of Things (IIoT): Intelligent Analytics for Predictive Maintenance", Wiley-Scrivener, 2022.

Reference Books

1. G.Veneri Antonio, "Hands-on Industrial Internet of Things", Packt Publication, 2018
2. Gilchrist, Alasdair, "Industry 4.0 The Industrial Internet of Things", Apress, 2017.
3. Zaigham Mahmood, "The Internet of Things in the Industrial Sector: Security and Device connectivity, smart environments and Industry 4.0", Springer, 2019.

Online Resources

1. Introduction to Industry 4.0 and Industrial Internet of Things - Course (nptel.ac.in) : https://onlinecourses.nptel.ac.in/noc20_cs69/preview
2. Introduction to internet of things: https://onlinecourses.nptel.ac.in/noc21_cs63/preview

Course Code	Course Title	L	T	P	C
10212EC177	**IOT SECURITY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course focuses on the principles and practices of securing Internet of Things (IoT) systems. It covers the security challenges, vulnerabilities, and threats in the IoT environment. The content provides in-depth knowledge to learn about various security mechanisms, protocols, and techniques to protect IoT devices, networks, and data. The training ingredients should enable the practical skills in implementing and evaluating IoT security solutions.

c) Prerequisite

Nil

d) Related Courses

Data Communication Network, Network Security.

e) Course Outcome

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the importance of security and privacy in IoT ecosystems.	K2
CO2	Outline the principles of device security, provisioning, and hardware-based security mechanisms.	K2
CO3	Infer the knowledge of data security principles and cloud storage.	K2
CO4	Summarize comprehensive threat intelligence and vulnerability assessments in IoT systems.	K3
CO5	Utilize the various privacy considerations and applications of IoT systems.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	L	L	-	-	L	-	-	L	L	-	L	-	L
CO2	H	L	L	-	-	L	-	-	L	L	-	L	-	L
CO3	H	H	L	-	M	L	-	-	L	L	-	M	-	L
CO4	H	L	L	L	M	L	-	-	L	L	-	M	-	L
CO5	H	H	L	-	-	L	-	-	L	L	-	L	-	L

g) Course Content

UNIT I FUNDAMENTALS OF IOT SECURITY **9**

Introduction to IoT, security concern: confidentiality, authentication, data integrity, cyber threats and their detection, threat mitigation, malware resistance - device manipulation, risk management - device, communication, cloud level security for IoT ecosystem.

UNIT II DEVICE AND NETWORK SECURITY **9**

Device security, secure bootstrapping and provisioning, hardware-based security, network security, intrusion detection and prevention systems, network architectures and network design, network segmentation and isolation.

UNIT III DATA AND CLOUD SECURITY **9**

Data security, data encryption and integrity, privacy-preserving techniques for IoT, secure data storage and transmission - cloud security - secure cloud storage and processing, identity and access management in the cloud, security challenges and best practices in cloud-based IoT deployments.

UNIT IV INTELLIGENT IOT SECURITY MECHANISMS **9**

Threat detection, trust mechanisms and key management, privacy preserving data aggregation, anonymization and pseudonymization, security monitoring techniques, threat intelligence and vulnerability assessment.

UNIT V EMERGING TRENDS IN IOT SECURITY **9**

Blockchain technology: Smart Contracts for IoT, ethical hacking and penetration testing - heterogeneous intelligent transportation systems: autonomous vehicle security - fog platforms: secure data aggregation and processing for IoT applications.

Total : 45 Hrs

h) Learning Resources

Text books

1. Shandilya, Shishir K., Chun, Soon Ae, Weippl, Edgar, "Internet of Things Security: Fundamentals, Techniques", River Publishers, 2018.
2. Brian Russell, Drew Van Duren, "Practical Internet of Things Security", Packt Publishing, 2016.
3. Alasdair Gilchrist, "IoT Security Issues", De Gruyter, 2017.

Reference Books

1. Aditya Gupta, "The IoT Hacker's Handbook: A Practical Guide to Hacking the Internet of Things", APress, 2019.
2. Fei Hu, "Security and Privacy in Internet of Things (IoTs): Models, Algorithms, and Implementations", CRC Press, 2016.
3. Brian Russell , Drew Van Duren, "Practical Internet of Things Security", Second Edition, Packt Publishing, 2018.
4. S. Velliangiri, Sathish A. P. Kumar, P. Karthikeyan, "Internet of Things: Integration and Security Challenges", CRC press, 2020.
5. Maciej Kranz, "Building the Internet of Things: Implement New Business Models, Disrupt Competitors, Transform Your Industry", Wiley, 2016.

Online resources

1. Introduction to Internet of Things, https://onlinecourses.nptel.ac.in/noc19_cs65/preview, Dr. Sudip Misra, NPTEL Course.
2. A Simple Explanation of the Internet of Things, https://www.forbes.com/sites/jacobmorgan/2014/05/13/simple-explanation-internet-things-that-anyone-can-understand/, Forbes.
3. Secure all the (Internet of) Things, https://www.techtarget.com/iotagenda/definition/Internet-of-Things-IoT, TechTarget.
4. Internet of things security is relevant to business, https://www.computerweekly.com/news/2240220811/Internet-of-things-security-is-relevant-to-business-says-researcher, ComputerWeekly.
5. The Internet of Things Brings Far-Reaching Security, https://www.cio.com/article/250268/mobile-security-the-internet-of-things-brings-far-reaching-security-threats.html, CIO.

Course Code	Course Title	L	T	P	C
10212EC178	ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

The objective of the course is to introduce the basics of Artificial Intelligence (AI) and expert systems to impart the knowledge of predictions. This course aims to explore artificial intelligence and Machine Learning (ML) tools and develop the various existing applications.
.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the different search strategies in artificial intelligence.	K2
CO2	Outline the knowledge representation issues and rules for artificial intelligence.	K2
CO3	Explain the fundamentals of machine learning and its types.	K2
CO4	Interpret the neural network and genetic algorithms principles.	K2
CO5	Experiment with various machine learning applications.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	L	L	-	-	-	L	L	-	-	L	M
CO2	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO4	H	M	M	M	L	-	-	-	L	L	-	-	L	M
CO5	H	M	M	M	L	-	-	-	L	L	-	-	L	M

g) Course Content

UNIT I FUNDAMENTALS OF AI 9

Evolution of AI- agents and environments- concept of rationality- nature of environments- structure of agents: problem solving agents, search algorithms, uninformed search strategies.

UNIT II KNOWLEDGE REPRESENTATION 9

Knowledge representation issues - predicate logic-logic programming- semantic nets- frames and inheritance - constraint propagation - representing knowledge using rules: rule-based deduction system.

UNIT III FUNDAMENTALS OF MACHINE LEARNING 9

Types of machine learning: Vapnik-Chervonenkis (VC) dimension, Probably Approximately Correct (PAC) learning- hypothesis spaces- inductive bias- generalization- bias variance trade-off.

UNIT IV NEURAL NETWORKS 9

Neural network representation: perceptron, feed forward, multilayer networks and back propagation, radial basis function network, recurrent neural networks, convolutional neural network.

UNIT V MACHINE LEARNING APPLICATIONS 9

Recommendation systems: weather prediction system, ML use cases in e-commerce, automated machine learning, diagnosis and disease identification, drug discovery, autonomous vehicle technology.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Deepak Khemani,"Artificial Intelligence", Tata Mc Graw Hill Education, 2013.
2. Bratko, Prolog "Programming for Artificial Intelligence", Fourth edition, Addison Wesley Educational Publishers, 2011.
3. Christopher Bishop, "Pattern Recognition and Machine Learning", Tata Mc Graw Hill Education, 2007.
4. Indranath Chatterjee, "Machine learning and its application", Benthom books, 2021.

Reference Books

1. S. Russell and P. Norvig, "Artificial Intelligence: A Modern Approach", Prentice Hall, Third edition, 2009.
2. M. Tim Jones, "Artificial Intelligence: A Systems Approach (Computer Science)", Jones and Bartlett Publishers, Inc., First edition, 2008.
3. Ethem Alpaydin, "Introduction to Machine Learning", Third edition, MIT Press, 2014.
4. Jason Bell, "Machine Learning-Hands on for Developers and Technical Professionals", First edition, Wiley, 2014.

Online Resources

1. An introduction to artificial intelligence-(NPTEL): https://onlinecourses.nptel.ac.in/noc22_cs56/preview
2. Machine Learning-(NPTEL): https://onlinecourses.nptel.ac.in/noc22_cs24/preview
3. Artificial intelligence lecture series: https://www.youtube.com/watch?v=kmeaG_BQZ7M&list=PLrjkTql3jnm_yol-ZK1QqPSn5YSg0NF9r

Course Code	Course Title	L	T	P	C
10212EC179	**FLEXIBLE AND WEARABLE SENSORS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course aims to impart the significance of these innovative technologies, providing a brief overview of wearable technology and exploring its profound impact on social life.

c) Prerequisite

Nil

d) Related Courses

IoT Security, Internet of Things

e) Course Outcome

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the processing steps involved in the fabrication of flexible electronic circuits.	K2
CO2	Discuss the fabrication techniques of thin film transistor.	K2
CO3	Compare various types of wearable haptics, bio and chemical sensors.	K2
CO4	Interpret the parameters obtained from various body-worn sensors.	K2
CO5	Identify the low power circuits for implementing wearable biopotential sensor systems.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	-	-	-	-	_	L	-	L	-	-
CO2	H	-	L	-	-	-	-	-	L	L	-	L	-	-
CO3	H	M	M	L	L	-	-	-	L	-	-	L	L	M
CO4	H	M	M	M	-	-	L	L	L	-	-	L	L	M
CO5	H	M	L	L	-	-	-	-	L	-	M	L	M	L

g) Course Content

UNIT I FUNDAMENTALS OF FLEXIBLE ELECTRONICS TECHNOLOGY **9**

Materials for flexible electronics: Nanowire and nanoparticle synthesis, transition metal oxides, amorphous thin films, polymeric semiconductors - structure and property relationships of thin-film deposition - processing methods for flexible devices: CVD, PECVD, PVD, etching, photolithography - low-temperature process integration.

UNIT II THIN FILM TRANSISTORS **8**

Materials and technologies- review of semiconductors employed in flexible electronics - thin film transistors based on amorphous indium gallium zinc oxide- plastic electronics for smart textiles.

UNIT III WORLD OF WEARABLE(WOW) AND HAPTICS **10**

Emergence of wearable computing and wearable electronics- attributes- Types of wearable sensors: invasive, non-invasive- intelligent clothing, healthcare, military, environment monitoring- wearable haptic devices: benefits, categories and tactile display- Wearable Bio and chemical sensors: system design, challenges in chemical biochemical sensing- application areas.

UNIT IV WEARABLE INERTIAL SENSORS AND APPLICATIONS **9**

Parameters and practical considerations for wearable inertial sensor applications in clinical practice- Measurement of energy expenditure by body-worn devices- design considerations.

UNIT V BIOPOTENTIAL SIGNALS CHARACTERISTICS **9**

Electrode-body interface and electrode noise- Measurement of energy expenditure by body-worn devices-design considerations - Low power analog/digital integrated circuit design techniques for wearable bio potential sensors- architectural design for low power bio potential acquisition- practical considerations.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Edward Sazonov and Michael R. Neuman, “Wearable Sensors Fundamentals, Implementation and Applications”, Elsevier Inc., 2014.
2. William S. Wong, Alberto Salleo, “Flexible Electronics: Materials and Applications", Springer, First edition, New York, 2011.

Reference Books

1. Aime Lay-Ekuakille and Subhas Chandra Mukhopadhyay, “Wearable and Autonomous Biomedical Devices and Systems for Smart Environment”, Springer, 2010.
2. Toshiyo Tamura and Wenxi Chen, “Seamless Healthcare Monitoring”, Springer, 2018.
3. Guozhen Shen, Zhiyong Fan, “Flexible Electronics: From Materials to Devices”, First edition, World Scientific Publishing Co, Singapore, 2015.

Online resources

1. IoT sensors for every application: https://www.youtube.com/watch?v=r9mZ42xmWfE
2. IoT sensors types used in industries - Finoit Technologies: https://www.youtube.com/watch?v=a_rhr4jtZtY

Course Code	Course Title	L	T	P	C
10212EC180	**AUTOMOTIVE SENSORS AND IN-VEHICLE NETWORKING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The integration of advanced sensors in automotive systems is crucial for enhancing vehicle body management, passenger convenience, safety, and security. This course aims to familiarize in various automotive sensor technologies and their applications, as well as the communication standards and protocols that support these systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the automotive sensors requirements and the integration in different automotive systems.	K2
CO2	Classify the various powertrain sensors for chassis management in vehicles.	K2
CO3	Outline the various sensors for vehicle body management, convenience and security systems.	K2
CO4	Discuss the various systems such as ABS, ESP, TCS for understanding vehicle dynamics and stability.	K2
CO5	Make use of the in-vehicle communication trends and automotive standards.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	L	L	-	-	-	L	L	-	-	L	L
CO2	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO4	H	M	M	M	L	-	-	-	L	L	-	-	L	M
CO5	H	M	M	M	L	-	-	-	L	L	-	-	L	M

g) Course Content

UNIT I FUNDAMENTALS OF AUTOMOTIVE SYSTEMS 8

Introduction to the modern advancements and essential role of electronics in automobiles - possibilities and challenges in the automotive industry - enabling technologies and industry trends - application areas of electronics in the automobiles.

UNIT II POWERTRAIN SENSORS FOR CHASSIS MANAGEMENT 10

Powertrain sensors: Lambda (λ), exhaust temperature, nitrogen oxides, particulate matter, fuel quality, level, torque, speed, mass flow, manifold pressure wheel speed /direction, steering position (multiturn), acceleration (inertia measurement), brake pneumatic pressure, electronic stability.

UNIT III AUTOMOTIVE SENSOR FOR VEHICLE CONVENIENCE AND SECURITY SYSTEMS 9

Gas sensors (CO_2), temperature/humidity sensor, air bag sensor, tire pressure monitoring systems, anti-lock braking system, traction control, accelerators and tilt sensors for sensing skidding and anti-collision, anti-collision techniques using ultrasonic doppler sensors.

UNIT IV AUTOMOTIVE PASSENGER CONVENIENCE SYSTEMS 9

Distributed front air bag sensing systems, single-point sensing systems, side-impact sensing, and future occupant protection systems - electromechanical seat, seat belt height, steering wheel, mirror adjustments, central locking systems, tire pressure control systems, electromechanical window drives.

UNIT V MODERN TRENDS AND TECHNICAL SOLUTIONS 9

In-vehicle communication standards of Controller Area Network (CAN) and Local Interconnect Network (LIN) - telematics solutions, embedded connectivity - endorsing dependability in drive-by- wire systems: Terminology and concepts - Wire by-wire, FLEXRAY, future of in - vehicle communication.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Automotive Electrics, "Automotive Electronics: Systems & Components", Fifth edition, BOSCH, 2014.
2. Automotive sensors handbook, BOSCH , Eighth edition, 2011.

Reference Books

1. John Turner, "Automotive Sensors", Momentum Press, First edition, New York, 2010.
2. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, Iwao Yokomori, "Sensors for Automotive Technology", Wiley, Fourth edition, New York, 2010.
3. Ernest O. Doebelin, "Measurement Systems – Application and Design", McGraw-Hill, Sixth edition, New Delhi, 2017.

Online Resources

1. Vehicle Networking and Communication Protocols: https://www.youtube.com/watch?v=PyxjlWnb6BA
2. CAN Bus- Serial Communication: https://www.youtube.com/watch?v=JZSCzRT9TTo

Course Code	Course Title	L	T	P	C
10212EC234	**IOT SYSTEM DESIGN AND DEVELOPMENT**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides hands-on experience in designing, developing, and deploying Internet of Things (IoT) systems using microcontrollers. It provides fundamental principles of IoT, working with various sensors and actuators, and implement communication protocols to create robust IoT solutions.

c) Prerequisite

Nil

d) Related Courses

Internet of Things

e) Course Outcome

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize different types of microcontrollers.	K2
CO2	Outline interfacing sensors and actuators with microcontrollers.	K2
CO3	Explain the various communication protocols for IoT connectivity.	K2
CO4	Discuss the power utilization and management process.	K2
CO5	Demonstrate the programming microcontrollers for IoT applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	-	-	-	-	-	L	L	-	-	-	M
CO2	H	M	M	L	-	-	-	-	L	L	-	-	-	M
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO4	H	M	M	M	L	-	-	-	L	L	-	-	M	M
CO5	H	M	M	M	-	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I MICROCONTROLLERS FOR IoT **6**

Selecting the right microcontroller for IoT projects - Overview of popular microcontrollers (Arduino, ESP8266/ESP32, STM32).

UNIT II SENSORS AND ACTUATORS **6**

Types of sensors and actuators - Interfacing sensors and actuators with microcontrollers.

UNIT III COMMUNICATION PROTOCOLS **6**

Overview of IoT communication protocols: HTTP, MQTT, CoAP- implementing Wi-Fi and bluetooth connectivity.

UNIT IV POWER MANAGEMENT **6**

Power requirements for IoT devices - Battery management and optimization - Energy harvesting techniques.

UNIT V APPLICATIONS OF IOT **6**

Industrial IoT (IIoT) in manufacturing - IoT in healthcare – IoT in smart home.

Total: 30 Hrs

Laboratory Experiments

S. No.	Practical Exercises	Course Outcome
1	Simulate the program to blink LEDs and read digital inputs.	**CO1**
2	Simulate the program to read sensor data and display it on a serial monitor or LCD.	**CO1**
3	Develop a web interface or mobile application to manage a LED or relay.	**CO2**
4	Design and implement a smart lighting system using motion sensors.	**CO2**
5	Develop a system to manage multiple appliances using a smartphone app.	**CO3**
6	Develop a system to monitor air quality parameters like CO2 and PM2.5.	**CO3**
7	Simulate the program for reading RFID tags and controlling access to a virtual system.	**CO4**
8	Simulate the program for measuring power consumption and visualizing data on a virtual platform.	**CO4**
9	Design and implement an irrigation facility based on soil moisture levels.	**CO5**
10	Simulate the program to interface temperature and humidity sensors.	**CO5**

Total: 30 Hrs

h) Learning Resources

Text Books

1. Jeremy Blum, “Exploring Arduino: Tools and Techniques for Engineering Wizardry", John Wiley & Sons, Inc, 2013.
2. Tero Karvinen, Kimmo Karvinen, Ville Valtokari, “Make: Sensors A Hands-On Primer for Monitoring the Real World with Arduino and Raspberry Pi”, Make Community, LLC, 2014.
3. Robert Faludi, “Building Wireless Sensor Networks With ZigBee, XBee, Arduino, and Processing”, O'Reilly Media, 2010.

Reference Books

1. Arshdeep Bahga and Vijay Madisetti, "Internet of Things: A Hands-On Approach", internetofthingsbook.com, 2014.
2. Elecia White, “Making Embedded Systems: Design Patterns for Great Software”, O'Reilly Media, 2020.
3. Michael Barr and Anthony Massa, “Programming Embedded Systems: With C and GNU Development Tools”, O'Reilly Media, 2022.

Online Resources

1. MIT Open Course Ware -Embedded Systems: https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6- Embedded Systems - Introduction to Embedded Systems Design/
2. C programming for Embedded applications: https://www.linkedin.com/learning/learning-embedded-systems-programming
3. Introduction to embedded systems software and development environment: https://www.coursera.org/learn/embedded-software-development

Course Code	Course Title	L	T	P	C
10212EC236	**ARM SYSTEM ARCHITECTURE**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces the fundamentals of ARM-based system architectures, focusing on processor core design, instruction sets, memory organization, interrupt mechanisms, and peripheral interfacing, enabling students to develop embedded solutions.

c) Prerequisite

Nil

d) Related Courses

Microprocessor and Microcontroller and Embedded Systems

e) Course Outcomes

On successful completion of this course students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT & Dave's Taxonomy)
CO1	Build and explain the ARM processor architecture and pipeline operation.	K3, S3
CO2	Utilize and outline the ARM and Thumb instruction sets and their applications.	K3, S3
CO3	Analyze and apply the memory hierarchy, protection, and management in ARM systems.	K4, S3
CO4	Develop and interpret an embedded applications using ARM peripherals and interfaces.	K3, S3
CO5	Make use of an exception handling and interrupt mechanisms in ARM cores.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	H	L	-	-	M	-	-	-	-	-	H	-	-
CO2	H	L	-	-	M	-	-	-	-	-	H	L	M
CO3	M	H	-	-		-	-	-	-	-	M	-	-
CO4	H	-	-	-	M	-	-	-	-	-	H	L	M
CO5	M	M	-	-		-	-	-	-	-	H	-	-

g) Course Content

UNIT I ARM ARCHITECTURE FUNDAMENTALS 6

Evolution of ARM architecture – RISC principles – ARM processor families – core and architecture features – registers and pipeline structure – processor modes and state transitions.

UNIT II ARM INSTRUCTION SET 6

ARM Instruction set – data processing, branch, load/store instructions – PSR and conditional execution – Introduction to thumb instruction set – Thumb vs ARM tradeoffs

UNIT III MEMORY MANAGEMENT AND PROTECTION 6

Memory system architecture – cache architecture – Memory protection unit (MPU) – Translation Lookaside Buffers (TLB) – virtual memory – address space partitioning.

UNIT IV PERIPHERALS AND INTERFACING 6

Advanced Microcontroller Bus Architecture (AMBA): History, bus types and protocol – UART, SPI, I2C, GPIO – timer, watchdog timer – interfacing memory and I/O devices – power management features.

UNIT V EXCEPTION AND INTERRUPT HANDLING 6

Exception types – vector table – interrupt latency and interrupt handling – fast interrupt requests and standard IRQ – Nested Vectored Interrupt Controller (NVIC).

Total: 30Hrs

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1	Familiarization with ARM development boards and tools.	CO1
2	Assembly Language Programming for basic arithmetic using ARM instructions.	CO2
3	Assembly Language Programming for pipeline effect on instruction execution.	CO1
4	Develop programs using ARM and Thumb instructions.	CO2
5	Implementation of simple memory protection scheme.	CO3
6	Interfacing GPIO peripherals with ARM processor.	CO4
7	Develop UART communication Assembly Language Programming between ARM board and PC.	CO4
8	Power management feature demonstration in ARM.	CO4
9	Timer and interrupt handling in ARM Cortex-M processor.	CO5
10	Simple embedded application development.	CO5

Total : 60 Hrs.

h) Learning Resources

References

1. William Hohl and Christopher Hinds, “ARM Assembly Language: Fundamentals and Techniques”, CRC Press,2nd Edition, 2014.
2. Mazidi, Naimi, and Naimi,"ARM Assembly Language Programming & Architecture", Microdigital , 2nd Edition, 2016.
3. Joseph Yiu, “The Definitive Guide to ARM® Cortex®-M3 and Cortex®-M4 processors”, Elsevier, 3rd Edition, 2013.

Online Resources

1. Embedded System Design with ARM - https://archive.nptel.ac.in/courses/106/105/106105193/
2. ARM based development - https://archive.nptel.ac.in/courses/117/106/117106111/
3. Lab Workshop on Embedded “C” and ARM Cortex Microcontrollers - https://elearn.nptel.ac.in/shop/completed-courses/short-term-programs-completed/lab-workshop-on-embedded-c-and-arm-cortex-microcontrollers/?v=c86ee0d9d7ed
4. Understanding AMBA Bus Architecture and Protocols - https://anysilicon.com/understanding-amba-bus-architecture-protocols/

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Course Code	Course Title	L	T	P	C
10212EC237	**EMBEDDED LINUX**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces students to the design, development, and deployment of embedded systems using the Linux operating system. It covers the architecture, kernel configuration, toolchain setup, boot loader, and real-time aspects, providing hands-on experience in building and deploying Embedded Linux on ARM-based boards.

c) Prerequisite

Nil

d) Related Courses

Microprocessor and Microcontroller

e) Course Outcomes

On successful completion of this course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT & Dave's Taxonomy)
CO1	Choose the fundamentals of embedded Linux and its system architecture. Organize and compile embedded Linux using cross-compilation toolchains.	K3, S3
CO2	Model and integrate board support packages for Embedded Linux systems.	K3, S3
CO3	Utilize the concept of embedded storage architecture. Apply skills in writing kernel modules and debugging kernel-level code.	K3, S3
CO4	Construct and optimize a root file system and embedded file systems.	K3, S3
CO5	Develop port applications to ARM boards in Embedded Linux environments and solve real-time features of Linux and compare with RTOS variants.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PSO 1	PSO 2
CO1	H	L	-	-	M	-	-	-	-	M	H	H	H
CO2	H	-	-	-	M	-	-	-	-	-	-	L	L
CO3	L	-	-	-	M	-	-	-	-	M	H	L	L
CO4	H	-	-	-	M	-	-	L	M	M	H	H	H
CO5	H	M	-	-	M	-	-	-	-	M	H	H	H

g) Course Content

UNIT I EMBEDDED LINUX FUNDAMENTALS 5

History of Embedded Linux, Embedded vs Desktop Linux, Embedded Linux Distributions, Linux Kernel Architecture, Linux Startup Sequence, GNU Cross-Platform.

UNIT II BOARD SUPPORT PACKAGE AND EMBEDDED STORAGE 6

BSP integration into kernel, Boot Loader Interface, Memory Map, Interrupt Management, PCI Subsystem, Timers, UART, Power Management. MTD Architecture, Flash Mapping Drivers, Embedded File Systems, Storage Space Optimization.

UNIT III EMBEDDED LINUX KERNEL AND DRIVERS 8

Kernel Features, Subsystems: Memory, Scheduler, Storage, I/O, Networking. Kernel Source Navigation, Configuration, Compilation. Booting with U-Boot, Module Compilation and Installation, Adding Device Drivers, Applying Kernel Patches. Drivers: Serial, Ethernet, I2C, USB Gadgets, Watchdog Timer

UNIT IV EMBEDDED FILE SYSTEM AND OPTIMIZATION 5

Embedded File Systems: RAMDisk, RAMFS, CRAMFS, JFFS, JFFS2, NFS, PROC. Kernel vs Application Space Optimization. Building RootFS and tuning for performance.

UNIT V LINUX DEVICE DRIVERS 6

Application Porting Roadmap, Programming with Pthreads, OS Porting Layer, Kernel API for Driver Porting. Linux as a Real-Time OS, Real-Time Programming Techniques, Comparison with RTOS variants like VxWorks, RT-Linux, Portable Software on Silicon (pSOS)

Total:30 Hrs.

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1	Linux shell and commands	CO1
2	Cross-compilation and toolchain setup	CO1
3	BSP setup and Bootloader configuration (U-Boot)	CO2
4	Kernel Configuration and Compilation	CO3
5	Kernel Module Development	CO3
6	Debugging Kernel and Module Logs using dmesg/gdb	CO3
7	File System Building and Optimization	CO4
8	ARM Board OS Porting and Booting	CO5
9	Application Porting to ARM using OSPL	CO5
10	Real-Time Scheduling and Kernel Patch Application	CO5

Total :60 Hrs.

h) Learning Resources

References

1. P. P. Raghavan, Amol Lad, Sriram Neelakandan, "Embedded Linux System Design and Development", CRC Press (Reprint), 2019.
2. Chris Simmonds," Mastering Embedded Linux Programming", 3rd Edition, Packt Publishing, 2021.
3. John Madieu, "Linux Device Driver Development: Everything You Need to Start with Device Driver Development for Linux Kernel and Embedded Linux ", Packt Publishing, 2021.
4. William Stallings, "Operating Systems: Internals and Design Principles", 9th Edition, Pearson, 2018.

Online Resources

1. Embedded Linux - https://elearn.nptel.ac.in/shop/partnering-courses/registration-ongoing/embedded-linux-batch-v/?v=c86ee0d9d7ed
2. Embedded System introduction - https://nptel.ac.in/courses/108102045
3. Embedded System Design Verification Test - https://nptel.ac.in/courses/108105102
4. Linux Kernel internals and development -https://nptel.ac.in/courses/106108101

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Course Code	Course Title	L	T	P	C
10212EC238	**SOC DESIGN AND VERIFICATION**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course covers the complete System-on-Chip (SOC) design flow, focusing on practical exposure to the front-end of the chip design cycle. It encompasses Verilog-based RTL (Register-Transfer Level) design, integration of digital and analog IPs (Intellectual Properties) in SOC design, RTL verification using simulation and formal methods and scripting languages such as TCL and Perl.

c) Prerequisite

Nil

d) Related Courses

FPGA Programming

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT& Dave's Taxonomy)
CO1	Apply the complete SOC chip design flow from conception to implementation and demonstrate proficiency in using EDA tools for chip design tasks.	K3, S3
CO2	Organize digital and analog IPs into a cohesive SOC design.	K3, S3
CO3	Utilize simulation techniques for thorough RTL verification and develop formal methods for rigorous verification of RTL designs.	K3, S3
CO4	Construct automation scripts to enhance design productivity and utilize scripting languages such as TCL and Perl for chip design automation.	K3, S3
CO5	Demonstrate the prototyping using FPGAs.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	-	H	-	-	-	L	L	-	-	M	-
CO2	H	M	M	L	H	-	-	-	L	L	-	-	L	-
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	-
CO4	H	M	M	M	L	-	-	-	L	L	-	-	M	-
CO5	H	M	M	M	M	-	-	-	L	L	-	-	M	-

g) Course Content

UNIT I INTRODUCTION TO SOC CHIP DESIGN FLOW 6

Introduction to SOCs, technology trends, design challenges, SOC chip design flow, Verilog syntax and constructs alternatives, FPGA design flow.

UNIT II INTEGRATION OF DIGITAL AND ANALOG IPs IN SOC DESIGN 6

Digital IPs – ARM Cortex-M3, UART, Analog IPs - PLLs, ADC, DAC, communication architectures - AMBA (AXI, AHB, APB), interfacing techniques and challenges.

UNIT III SOC VERIFICATION 6

Overview of verification techniques, verification levels: block-level, integration-level, SOC-level, test benches and assertions, introduction to Universal Verification Methodology (UVM).

UNIT IV SCRIPTING LANGUAGES FOR CHIP DESIGN AUTOMATION 6

Introduction to scripting languages (TCL and Perl), role of scripting in EDA tool flows, TCL basics – TCL syntax and data types, variables, procedures and file handling, Perl basics- Perl syntax and scripting style, scalars, arrays and hashes.

UNIT V RAPID PROTOTYPING WITH FPGAs AND EMULATION HARDWARE VALIDATION 6

Rapid prototyping using FPGAs, FPGA prototyping of hardware/software systems, validation of designs using emulation hardware.

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1.	Introduction to EDA tools: Synopsys, Cadence, Siemens and open-source.	CO1
2.	Hands-on lab work on Verilog-based digital system design.	CO1
3.	ASIC design flow using EDA tools with case studies,	CO1
4.	Integration of Analog and Digital IPs into a Simple SOC.	CO2
5.	Design and Verification of SOC Communication Architecture.	CO2
6.	Model Checking of RTL Design Using a Formal Tool chain.	CO3
7.	Introduction to Verification tools (UVM, SCV).	CO3
8.	Practical exercises on verification using EDA tools.	CO3
9.	Development of automation scripts for design tasks.	CO4
10.	Mini Projects using TCL and Perl Scripts.	CO4
11.	Individual or group projects demonstrating SoC design and verification skills.	CO5

Total: 60 Hrs.

i) Learning Resources

References

1. Khaled Salah Mohamed, "Heterogeneous SoC Design and Verification: HW/SW Co-Exploration, Co-Design, Co-Verification and Co-Debugging", Springer, 2024.
2. Cem Unsalan, Bora Tar, "Digital System Design with FPGA: Implementation using Verilog and VHDL", McGrawHill, First Edition, 2017.
3. Nekoogar, Farzad. "From ASICs to SOCs", Prentice Hall Professional, 2003.
4. Wolf, Wayne "Modern VLSI Design", Pearson Education, 2002.
5. Nekoogar, Farzad "From ASICs to SOCs", Prentice Hall Professional, 2003.

Online Resources

1. Design Verification and Test of Digital VLSI Circuits [NPTEL] https://archive.nptel.ac.in/courses/106/103/106103116/
2. Building a RISC-V from Scratch - Course (udemy.com)
3. SoC Design and Verification flow: https://www.youtube.com/watch?v=ACqMXurj0mU

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Course Code	Course Title	L	T	P	C
10212EC239	**SOC DESIGN THROUGH PHYSICAL IMPLEMENTATION LEADING TO TAPE-OUT**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

The course involves practical, hands-on experience with digital circuit implementations using cadence tools. The course gives insight on the full design flow from schematic entry and simulation to physical layout and verification.

c) Prerequisite

Nil

d) Related Courses

VLSI Design

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT & Dave's Taxonomy)
CO1	Design and simulate digital building blocks for SOC integration.	K3, S3
CO2	Develop and demonstrate memory-mapped interfaces for peripheral integration of software and hardware components.	K3, S3
CO3	Analyze the RTL coding and obtain the output for SOC digital modules.	K3, S3
CO4	Construct and demonstrate the building blocks of advanced SOC processors.	K3, S3
CO5	Apply and demonstrate the knowledge of EDA tools used in industry-standard SOC physical design workflows.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	-	-	-	-	-	L	L	-	-	-	M
CO2	H	M	M	L	-	-	-	-	L	L	-	-	-	M
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	M
CO4	H	M	M	M	L	-	-	-	L	L	-	-	M	M
CO5	H	M	M	M	-	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I OVERVIEW OF SYSTEM ON CHIP DESIGN PROCESS 6

Types of SOCs: Application-specific, Configurable, Programmable - SOC vs. ASIC vs. FPGA- design challenges and trends.

UNIT II SOC ARCHITECTURE AND PROCESSOR INTEGRATION 6

Components of SOC: CPU, memory, system buses: AHB, APB, AXI-clocking, resets, power domains SOC boot process and memory maps- integrating soft cores: micro blaze, Nios II.

UNIT III ADVANCED SOC PROCESSORS AND PERIPHERALS 6

ARM, RISC-V, and soft-core CPUs: PicoRV32, micro blaze-hardware design using Verilog-UART, SPI, I2C, GPIO.

UNIT IV SOC APPLICATIONS 6

Building a simple RISC-V SOC - integrating a CNN accelerator- audio/video processing SOC-sensor based embedded SOC.

UNIT V SOC ON PHYSICAL DESIGN 6

Physical design flow - floor planning: die size estimation, power planning and placement of macros and IO pads - power planning-placement: standard cell placement, congestion analysis and placement optimization -routing: global and detailed routing-clock tree synthesis: static timing analysis, setup and hold time checks.

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1.	Convert a Verilog RTL of 4-bit ALU into a synthesized gate-level netlist with constraints.	CO1
2.	Design and simulate 8-bit register and counter using INCISIVE simulator	CO1
3.	Design and simulate 8-bit barrel shifter using INCISIVE simulator.	CO1
4.	Implementation and RTL synthesis of APB protocol using Cadence Genus tool.	CO2
5.	Design and RTL synthesis of the AHB protocol using Cadence Genus tool.	CO2
6.	Implementation and RTL synthesis of UART controller using Cadence Genus tool.	CO3
7.	Design and simulate UART controller Using Cadence Genus tool.	CO3
8.	RTL to physical implementation and clock tree synthesis of a CNN accelerator architecture.	CO4
9.	RTL to physical implementation and clock tree synthesis of ROM memory.	CO4
10.	Perform floor planning, placement and routing for the physical implementation of a finite state machine.	CO5
11.	Perform floor planning, placement and routing for the physical implementation of a RAM memory.	CO5
12	Perform physical design steps including floor planning, placement, CTS, and routing for an 8-bit RISC processor.	CO5

Total: 60 Hrs.

i) Learning Resources

References

1. Sivananda R. Koteshwar, Veena S. Chakravarthi, "SoC Physical Design: A Comprehensive Guide Hardcover – Import", 2022.
2. Zainal Abedin Navabi "Verilog Digital System Design", Second edition, Mc Graw Hill Electronic Engineering, 2017.
3. R2. Samir Palnitkar; "Verilog HDL - Guide to Digital design and synthesis", Third edition, Pearson Education, 2003.
4. Stephen Brown & Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design", McGraw-Hill Education, Third Edition, 2023.
5. Perry Douglas L. & Vahid Frank, " VHDL and Verilog HDL Programming", Pearson Education, 2020.

Online Resources

1. VLSI Physical Design - Course - NPTEL - https://onlinecourses.nptel.ac.in/noc25_cs73/preview
2. HDL Design: http://asic-world.com/
3. HDL Design and Verification: https://www.chipverify.com/

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Course Code	Course Title	L	T	P	C
10212EC240	**CAD FOR VLSI**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces various CAD algorithms and tools used in VLSI design, physical design, partitioning, placement, routing, simulation and synthesis. It helps students understand the design cycle and current trends in VLSI CAD.

c) Prerequisite

Nil

d) Related Courses

AI and ML for VLSI CAD

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT& Dave's Taxonomy)
CO1	Apply the concepts of VLSI design methodologies and cycles, including physical design and automation tools to analyze and compare various VLSI design styles	K3, S3
CO2	Develop data structures and combinatorial optimization techniques to solve tractable logic synthesis problems using VLSI CAD algorithms.	K3, S3
CO3	Make use of suitable algorithms for layout compaction, partitioning, and placement to optimize VLSI circuit design	K3, S3
CO4	Demonstrate the use of floor planning and routing algorithms to effectively organize circuit modules and interconnections in VLSI design.	K3, S3
CO5	Utilize gate-level modeling, simulation techniques, and synthesis methods to verify and optimize digital circuits in VLSI design.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO2	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO3	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO4	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO5	H	M	M	L	-	-	-	-	-	-	M	-	M	-

g) Course Content

UNIT I VLSI DESIGN CYCLE 6

Introduction to VLSI design methodologies – top-down and bottom-up methodologies- VLSI design cycle — physical design cycle – design styles – VLSI design automation tools.

UNIT II VLSI CAD AND LOGIC SYNTHESIS ALGORITHM 6

Overview of CAD algorithms and tools in VLSI design. basics of data structures and algorithms – algorithmic graph theory and computational complexity – tractable and intractable problems – general purpose methods for optimization techniques in logic synthesis.

UNIT III PARTITIONING AND PLACEMENT 6

Layout compaction – problem formulation – algorithms for constraint graph compaction – partitioning – placement – placement algorithms.

UNIT IV FLOOR PLANNING AND ROUTING 6

Floor planning – problem formulation – floor planning algorithms – routing – area routing – global routing – detailed routing.

UNIT V MODELLING, SIMULATION AND SYNTHESIS 6

Simulation – gate level modeling and simulation – logic synthesis and verification – binary decision diagrams – high level synthesis.

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1.	RTL design and simulation using Verilog for a simple arithmetic circuit.	CO1
2.	FPGA Implementation of a 4-bit ALU using Xilinx Vivado/ISE.	CO1
3.	Implementing a Basic Logic Synthesis Flow using Verilog.	CO2
4.	Analyze Computational Complexity in a Sample Logic Optimization Problem.	CO2
5.	Design Partitioning using graph partitioning tools.	CO3
6.	Floor planning a simple circuit using VLSI CAD tool.	CO3
7.	Global Routing Simulation using Maze Routing Algorithm.	CO4
8.	Design a Routed Layout for a Combinational Circuit.	CO4
9.	Gate-Level Simulation of a 4-bit Multiplier using Verilog.	CO5
10.	Binary Decision Diagram (BDD) Construction for a Boolean Function.	CO5

Total: 60 Hrs.

i) Learning Resources

References

1. Sabih H. Gerez, “Algorithms for VLSI Design Automation”, Second Edition, Wiley-India, 2017.
2. Naveed A. Sherwani, “Algorithms for VLSI Physical Design Automation”, 3rd Edition, Springer, 2017.
3. Charles J. Alpert, Dinesh P. Mehta and Sachin S Sapatnekar, “Handbook of Algorithms for Physical Design Automation, 1st Edition, Auerbach Publications, 2008.
4. N.A. Sherwani, "Algorithms for VLSI Physical Design Automation", Kluwer Academic Publishers, 2002.

Online Resources

1. CAD for VLSI Design [NPTEL] https://archive.nptel.ac.in courses/106/106/106106088
2. VLSI CAD Part I: Logic [Coursera] https://www.coursera.org/learn/vlsi-cad-logic?msockid=380105f608d36d52318c160009616c73
3. VLSI CAD Part II: Layout [Coursera] https://www.coursera.org/learn/vlsi-cad-layout?msockid=380105f608d36d52318c160009616c73

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Course Code	Course Title	L	T	P	C
10212EC241	FPGA PROGRAMMING	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

This course provides an introduction to FPGA architecture, hardware description languages, and the design methodology for developing efficient digital systems. It equips the learners with the skills required to apply FPGA technology in domains such as embedded systems, signal processing and reconfigurable computing.

c) Prerequisite

Nil

d) Related Courses

Reconfigurable System Design

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT& Dave's Taxonomy)
CO1	Make use of the architecture and characteristics of FPGAs for various HDL modeling techniques using Verilog.	K3, S3
CO2	Construct and simulate FSM-based digital systems and RTL models with appropriate simulation and testbenches.	K3, S3
CO3	Apply and demonstrate FPGA design flow including synthesis, placement, routing and timing analysis.	K3, S3
CO4	Develop reusable custom IPs for external memories and peripherals using IP cores.	K3, S3
CO5	Utilize and demonstrate FPGA-based digital architectures to solve real time examples.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	L	-	-	-	-	-	M	-	M	-
CO2	H	M	M	M	L	-	-	-	-	-	M	-	M	-
CO3	H	M	M	M	L	-	-	-	-	-	M	-	M	-
CO4	H	M	M	M	L	-	-	-	-	-	M	-	M	-
CO5	H	M	M	M	L	-	-	-	-	-	M	-	M	-

g) Course Content

UNIT I FPGA AND HDL 6

Types of PLDs: PAL, GAL, CPLD, FPGA – FPGA Architecture: Xilinx Artix-7, Intel Cyclone - Verilog modelling styles: dataflow, behavioral, and structural modelling.

UNIT II RTL DESIGN AND SIMULATION 6

FSM design: Mealy and Moore machines - RTL coding in Verilog: blocking/non-blocking assignments - test bench development: stimulus generation, self-checking test benches.

UNIT III FPGA DESIGN FLOW AND TIMING 6

Synthesis fundamentals: HDL to gate-level netlist - FPGA implementation: mapping, placing, and routing - STA: setup and hold time - clocking resources: global and local clocks.

UNIT IV IP CORES AND MEMORY SYSTEMS 6

Memory interfacing: SRAM, DRAM, and Flash memory – peripheral interfacing protocols: UART, SPI - IP core integration and custom IP creation: using IP integrator in Vivado

UNIT V FPGA FOR REAL TIME APPLICATIONS 6

Traffic light controller, real time clock, vending machine using one hot controller - interfacing using FPGA: VGA, keyboard, LCD

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1.	Design and simulate a 4-bit ripple carry adder using Xilinx Vivado.	CO1
2.	Design and simulate a 4-bit multiplier using Xilinx Vivado.	CO1
3.	Design a 3-state traffic light FSM (Moore machine) and simulate in Verilog.	CO2
4.	Develop testbench for a 4-bit ALU performing arithmetic operations.	CO2
5.	Implement and synthesize a 4-bit counter using Xilinx Vivado and obtain the timing summary.	CO3
6.	Demonstrate the timing report of a shift register using setup/hold timing violations.	CO3
7.	Design and simulate UART communication using IP core in Vivado for byte transfer.	CO4
8.	Perform integration of a prebuilt SRAM controller IP core to access memory via FPGA logic.	CO4
9.	Implement a vending machine FSM using one-hot encoding in Verilog.	CO5
10.	Perform the task to interface 16x2 LCD display to FPGA via GPIO control (write "HELLO").	CO5
11.	Mini project: base design for image classification using prebuilt IP	CO5

Total: 60 Hrs.

i) Learning Resources

References

1. Stephen Brown & Zvonko Vranesic, "Fundamentals of Digital Logic with Verilog Design", McGraw-Hill Education, Third Edition, 2023.
2. Perry Douglas L. & Vahid Frank, "VHDL and Verilog HDL Programming", Pearson Education, 2020.
3. Peter Van Zant, " Microchip Fabrication: A Practical Guide to Semiconductor Processing", McGraw- Hill Professional, Sixth Edition, 2014.
4. Vaibbhav Taraate, "Digital Logic Design Using Verilog: Coding and RTL Synthesis", Springer, 2021
5. Simon Monk, "Programming FPGAs: Getting Started with Verilog", McGraw-Hill Education, 2016.
6. Michael John Sebastian Smith, "Application-Specific Integrated Circuits", Pearson, 2000.

Online Resources

1. Digital System Design with FPGA: https://archive.nptel.ac.in/courses/117/108/117108040/ [NPTEL Course]
2. FPGA Programming: https://in.mathworks.com/discovery/fpga-programming.html [Mathworks]
3. Intel FPGA Technical Training: https://www.intel.com/content/www/us/en/support/programmable/support-resources/fpga-training/overview.html [Intel]

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Course Code	Course Title	L	T	P	C
10212EC197	MICROFABRICATION SEMICONDUCTOR AND MATERIALS	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course provides an in-depth understanding of top-down device fabrication. It focus on the unit processes which typically used in micro fabrication of devices. Topics include crystal growth, doping, chemical vapor deposition, physical vapor deposition, photolithography, wet etching, dry etching and packaging.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Make use of the concepts of crystal structures, energy band theory, and material properties for select appropriate growth techniques for various semiconductor applications.	K3
CO2	Apply the principles of carrier transport, doping, and material properties to analyze current-voltage characteristics of p–n junctions in semiconductor devices	K3
CO3	Outline the semiconductor fabrication processes which involved in wafer preparation and device manufacturing	K3
CO4	Utilize the working principles of various semiconductor devices to analyze their structure and operational behavior.	K3
CO5	Organize the various microfabrication techniques to outline the process flow in integrated circuit fabrication and advanced CMOS technologies	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	L	L	L	-	M	-	-	-	-
CO2	H	M	M	M	-	-	-	-	-	L	-	-	L	-
CO3	H	M	M	L	-	-	L	-	L	L	-	-	L	-
CO4	H	M	M	L	L	-	-	-	L	M	-	-	L	-
CO5	H	M	M	L	L	L	L	-	L	M	L	-	L	-

g) Course Content

UNIT I SEMICONDUCTOR MATERIALS 9

Review of the basic crystal structures of semiconductors energy structures and energy bandgaps - group IV- group III-V - group II - VI semiconductors- alloyed semiconductor materials - wide bandgap semiconductors - newly emerging 2D semiconductors.

UNIT II PHYSICAL PROPERTIES OF SEMICONDUCTOR MATERIALS 9

Carrier-transport phenomena - drift and mobility - doping effects - optical and thermal properties of semiconductor materials - physical model and current-voltage curve of p–n junctions - metal-semiconductor contact- physical model and current-voltage curve of Schottky junctions.

UNIT III SEMICONDUCTOR FABRICATION 9

Semiconductor process- semiconductor technologies and trends- basic fabrication steps: oxidation - photolithography – etching - diffusion - Ion Implantation – metallization - clean room - safety requirements.

UNIT IV SEMICONDUCTOR DEVICES 9

BJT - structure and switching - working mechanism of FET - CMOS structure – FinFET-structure- charge coupled device - thin film transistors Phototransistor/detector - light- emitting diode-Laser diode.

UNIT V MICROFABRICATION TECHNOLOGY 9

Introduction to cleanroom - basic silicon wafer processing - Chemical vapor deposition (CVD) - Evaporation - sputter deposition- Ion implantation – photolithography - wet processing - plasma processing - advanced CMOS technologies - Introduction to integrated circuit designs - packaging technology for integrated circuits.

Total : 45 Hrs.

h) Learning Resources

References

1. Chenming Hu: "Modern Semiconductor Devices for Integrated Circuits", Pearson Education, 2021.
2. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", Tata McGraw- Hill Professional, Sixth Edition, 2014.
3. Dieter K. Schroder: Semiconductor Material and Device Characterization. (Wiley), 3rd Edition, 2015.
4. S. M. Sze: Physics of Semiconductor Devices. (John Wiley & Sons, Inc), 4th Edition, 2021.
5. Marc J. Madou, "Fundamentals of Microfabrication and Nanotechnology - Volume II", CRC Press, Third Edition, 2011.

Online Resources

1. Fundamentals of micro and nanofabrication –[NPTEL] https://archive.nptel.ac.in/courses/117/108/102108078/
2. Semiconductor Characterization Specialization – [Coursera] https://www.coursera.org/specializations/semiconductor-characterization
3. Fundamentals of semiconductor devices –[NPTEL] https://archive.nptel.ac.in/courses/108/108/108108122/

Course Code	Course Title	L	T	P	C
10212EC242	AI AND ML FOR VLSI CAD	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

This course explores the integration of Artificial Intelligence (AI) and Machine Learning (ML) techniques in the field of VLSI CAD. AI and ML methodologies can be applied to automate and enhance various stages of the VLSI design process. Case studies will illustrate the use of AI and ML in addressing challenges and improving the efficiency of VLSI CAD tools.

c) Prerequisite

Python

d) Related Courses

VLSI CAD

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge and Skill Level (Based on RBT& Dave's Taxonomy)
CO1	Organize the AI and ML techniques to establish their relevance in addressing VLSI CAD design challenges.	K3, S3
CO2	Make use of automation, synthesis, and optimization techniques integrated with ML in VLSI design tools.	K3, S3
CO3	Construct suitable AI algorithms for enhancing synthesis and optimization in VLSI CAD.	K3, S3
CO4	Develop ML-based solutions for automatic layout generation and design rule checking in VLSI design modelling.	K3, S3
CO5	Apply AI/ML techniques to solve real-time VLSI applications involving physical design and diagnostics.	K3, S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	-	-	-	-	-	M	-	M	M
CO2	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO3	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO4	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO5	H	M	M	L	-	-	H	-	-	-	M	-	M	M

g) Course Content

UNIT I AI AND ML IN VLSI CAD 6

Overview of AI and ML- need for AI / ML in VLSI- supervised and unsupervised learning - VLSI CAD: logic synthesis, timing correlation, placement and routing - benefits - challenges and limitations.

UNIT II AUTOMATION, SYNTHESIS AND OPTIMIZATION TECHNIQUES WITH ML 6

CAD tools: design automation - lithography - physical design – physical verification - mask synthesis – optimization: layout and system level – fault detection – diagnosis in VLSI circuits - automatic optimization.

UNIT III AI ALGORITHMS AND OPTIMIZATION IN VLSI CAD 6

Algorithms– Decision tree – Random Forest- Gradient Boosting - ensemble models Optimization algorithms: Genetic algorithm – Simulated annealing – particle swarm optimization - Design Challenges for Machine/Deep Learning Algorithm.

UNIT IV AUTOMATIC LAYOUT GENERATION AND DESIGN RULE CHECKING WITH ML 6

ML techniques - physical design automation - automated layout generation: area optimization, power reduction and signal integrity - design rule checking: classification and regression models -ML based layout optimization and AI enhanced DRC tools.

UNIT V APPLICATIONS AND CASE STUDY OF AI IN VLSI 6

Applications in data modelling, Physical design, and logic optimization- Case Study: health monitoring system, Safety alert system and CNN for Hardware Acceleration

h) List of Experiments

S.No.	Practical Exercises (30 Hours)	CO Mapping
1.	Simulate the supervised learning for logic gate classification	CO1
2.	Apply K-Means to cluster logic blocks by power or delay characteristics.	CO1
3.	Simulate stuck-at faults; build classifiers to detect them from test patterns.	CO2
4.	Use Q-learning to select logic transformations	CO2
5.	Apply GA to reduce gate count in logic expressions.	CO3
6.	Apply reinforcement learning for optimizing logic expressions.	CO3
7.	Simulate ML-based layout placement prediction using regression	CO4
8.	Detect DRC violations in layout images using a Convolutional Neural Network	CO4
9.	Simulate the timing violation prediction in physical design using ML	CO5
10.	Build and test a simple CNN using Tensor flow.	CO5

Total: 60 Hrs.

i) Learning Resources

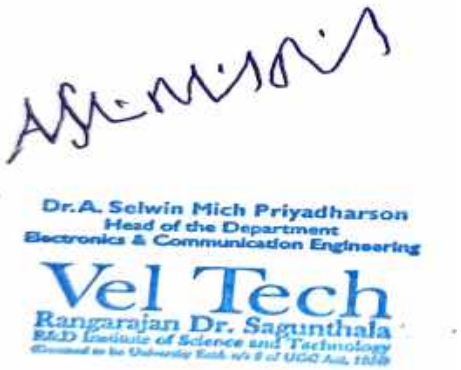
References

1. Abhishek Kumar, K. Srinivasa Rao , Suman Lata Tripathi, “Machine Learning Techniques for VLSI Chip Design” ,Wiley edition, July 2023.
2. Kahng, Andrew. “VLSI Physical Design: From Graph Partitioning to Timing Closure”. Springer Nature, 2022.

3. Ren, Hoaxing. "Machine Learning Applications in Electronic Design Automation". Springer Nature, 2023
4. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", McGraw- Hill Professional, Sixth Edition, 2014.
5. Ibrahim (Abe) M. Elfadel, Duane S. Boning , Xin Li, "Machine Learning in VLSI Computer-Aided Design", Springer edition, March 2019.

Online resources

1. CAD for VLSI [NPTEL] : https://www.udemy.com/course/vlsi-academy/
2. CAD for VLSI Design I [NPTEL] - Video Lectures & Resources | NPTELPrep
3. Introduction to Machine Learning [NPTEL]: https://archive.nptel.ac.in/courses/106/106/106106139/



Course Code	Course Title	L	T	P	C
10212EC198	DESIGN FOR TESTABILITY	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course focuses on the principles, methodologies, and techniques of designing electronic circuits with testability in mind. Students will explore strategies to enhance the ease and effectiveness of testing integrated circuits during manufacturing and throughout their operational life.

c) Prerequisite

Nil

d) Related Courses

VLSI Design

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the fundamental concepts of design for testability (DFT), fault models, and testing methodologies to analyze the importance of test strategies in modern electronic systems.	K3
CO2	Develop test generation methods for combinational and sequential circuits using both manual and automated approaches.	K3
CO3	Make use of built-in self-test architectures and appropriate test pattern generation techniques for memory and embedded RAMs.	K3
CO4	Construct scan chain architectures and automatic test pattern generation (ATPG) techniques to evaluate serial testing methods in digital systems.	K3
CO5	Model the fault diagnosis techniques using cause-effect and effect-cause analysis to identify and isolate faults at various levels.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO2	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO3	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO4	H	M	M	L	-	-	-	-	-	-	M	-	M	-
CO5	H	M	M	L	-	-	-	-	-	-	M	-	M	-

g) Course Content

UNIT I DESIGN FOR TESTABILITY 9

Importance of design for testability in modern electronic systems: Historical context and evolution of testability strategies. Introduction to key concepts: fault models, stuck-at faults, Bridging faults, intermittent faults testing methodologies, and industry standards.

UNIT II TEST GENERATION 9

Test generation for combinational logic circuits – manual test pattern generation, automatic test pattern generation- Testable combinational logic circuit design – test generation for sequential circuits – design of testable sequential circuits.

UNIT III BUILT IN SELF TEST 9

Principles and implementation of built-in self-test techniques, advantages and limitations of BIST in electronic circuit testing. built-in self-test – test pattern generation for BIST – circular BIST – BIST architectures – testable memory design – test algorithms – test generation for embedded RAMs

UNIT IV SCAN CHAINS AND SERIAL TESTING 9

Scan design, partial scan, use of scan chains, boundary scan, scan chain architecture, ATPG for scan, vector application in scan mode, shift-register based testing, trade-offs in serial vs. parallel scan

UNIT V FAULT DIAGNOSIS 9

Fault diagnosis: Fault models for diagnosis, cause-effect diagnosis, effect-cause diagnosis, logical level diagnosis – diagnosis by UUT reduction – fault diagnosis for combinational circuits – self-checking design – system level diagnosis.

Total: 45 Hrs.

h) Learning Resources

References

1. Tripathi, Suman. "Advanced VLSI Design and Testability Issues", CRC Press,2020.
2. Wang, Laung-Terng. VLSI Test Principles and Architectures. Morgan, 2006.
3. Huhn, Sebastian. "Design for Testability, Debug and Reliability", Springer Nature, 2021
4. N. Jha and S.D. Gupta, "Testing of Digital Systems", Cambridge, 2003.
5. W. W. Wen, "VLSI Test Principles and Architectures Design for Testability", Morgan Kaufmann Publishers. 2006.

Online Resources

1. Digital VLSI Testing [NPTEL] https://archive.nptel.ac.in/courses/117/105/117105137/
2. Design verification and test of digital VLSI circuits https://archive.nptel.ac.in/courses/106/103/106103116/
3. VLSI design verification and Test [NPTEL] https://nptel.ac.in/courses/106103016

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Course Code	Course Title	L	T	P	C
10212EC199	**AI CIRCUITS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course explores the intersection of artificial intelligence (AI) and integrated circuit design, delving into the principles, techniques and challenges associated with creating circuits tailored for AI applications. It provides the skills necessary to contribute to the rapidly evolving field of AI circuit design.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply AI algorithms, acceleration techniques, and neural architectures to design circuits for modern AI.	K3
CO2	Make use of design methodologies and optimization techniques to improve the performance of AI circuits.	K3
CO3	Identify the neuromorphic computing principles and the use of elements and accelerators for AI tasks.	K3
CO4	Select the processing architectures and apply techniques to develop 3-D parallel for AI applications.	K3
CO5	Solve optimization techniques for AI to improve fault tolerance, analyzing successful case study.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	-	-	-	-	-	-	L	L	-	-	-	-
CO2	H	M	M	L	-	-	-	-	L	L	-	-	-	-
CO3	H	M	M	L	L	-	-	-	L	L	-	-	L	L
CO4	H	M	M	M	L	-	-	-	L	L	-	-	M	L
CO5	H	M	M	M	-	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I AI CIRCUIT DESIGN **9**

Introduction - AI algorithms, acceleration, and neural network architectures - Overview of AI circuit design in modern technology - Neural networks in conventional integrated technology, Near-sensor computing, Neural network based on emerging non-volatile memory.

UNIT II AI CIRCUIT PRINCIPLES **9**

Principles of design methodologies for AI applications - Techniques for optimizing efficiency and performance in AI circuits - Directional Derivatives, Minima, Necessary Conditions, Newton's Method, Conjugate gradient method, The Levenberg-Marquardt algorithm.

UNIT III NEUROMORPHIC COMPUTING AND HARDWARE ACCELERATORS **9**

Neuromorphic computing principles - Memristive and CMOS devices for neuromorphic computing architectures, Multi-terminal transistors for neuromorphic applications, Bipolar analog memristors for neuromorphic computing - Hardware accelerators for AI tasks.

UNIT IV PARALLEL PROCESSING ARCHITECTURES FOR AI **9**

Principles of parallel processing architectures and their applications in AI circuits - VLSI design of a 3-D parallel message-passing architecture - Dataflow architecture for AI, Processing in-memory design - Design considerations and challenges in achieving parallelism for AI.

UNIT V OPTIMIZATION OF AI CIRCUITS **9**

Techniques for optimizing of AI circuits for efficiency - Computing algorithms, Arithmetic by table lookup - High-throughput arithmetic, Low-power arithmetic, Impact of hardware technology - Case study: Analyzing successful implementation of optimized AI circuits.

Total: 45 Hrs.

h) Learning Resources

References

1. Mohammad, Baker, "In-Memory Computing Hardware Accelerators for Data-Intensive Applications", Springer Nature, 2023.
2. Mishra, Ashutosh, "Artificial Intelligence and Hardware Accelerators", Springer Nature, 2023.
3. Munir, Arslan, "Accelerators for Convolutional Neural Networks", John Wiley & Sons, 2023.
4. Takano, Shigeyuki, "Thinking Machines", Academic Press, 2021.
5. Sze, Vivienne, "Efficient Processing of Deep Neural Networks", Morgan & Claypool Publishers, 2020.
6. Zheng, Nan, "Learning in Energy-Efficient Neuromorphic Computing: Algorithm and Architecture Co-Design", John Wiley & Sons, 2019.

Online Resources

1. Energy Efficient AI Hardware: neuromorphic circuits and tools https://www.youtube.com/watch?v=PT0TO2pTrMo
2. Intro to AI Series: Parallel Training Methods for AI https://www.youtube.com/watch?v=z1t_xmHTJeU
3. Applied Accelerated Artificial Intelligence http://acl.digimat.in/limesurvey/index.php/106106238 [NPTEL Course]

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Course Code	Course Title	L	T	P	C
10212EC902	IC PACKAGING	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course provides an in-depth look at modern technologies and methods used to manufacture semiconductor devices. Students will learn about advanced processes, equipment, and materials essential for producing integrated circuits (ICs).

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Build the fundamentals of various digital IC packaging technologies.	K3
CO2	Apply knowledge of packaging materials used in semiconductor packaging and interconnection technologies and their impact in electrical performance.	K3
CO3	Make use of the insights of single-chip and multi-chip IC packaging properties and their implications.	K3
CO4	Organize the thermal management strategies in IC packaging.	K3
CO5	Utilize the IC packaging and experimental tools and reliability for IC reliability analysis.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	L	-	-	-	-	-	L	-	L	-
CO2	H	M	M	L	L	-	-	-	-	-	L	-	L	-
CO3	H	M	H	M	L	-	-	-	-	-	L	-	L	-
CO4	H	M	L	L	M	-	-	-	-	-	L	-	L	-
CO5	H	M	H	L	L	-	-	-	-	-	L	-	L	-

g) Course Content

UNIT I INTRODUCTION TO IC PACKAGING 9

Evolution of IC Packaging, Performance, and Design for IC; Types of Integrated Circuits; IC Packaging; Semiconductor Roadmap; IC Packaging Challenges; Electronic Packaging Technologies.

UNIT II PACKAGING MATERIALS AND INTERCONNECTIONS 9

The Role of Materials in Microsystems Packaging, Packaging Materials and Properties, Materials Processes, Interconnections, Signal Distribution-Devices and Interconnections, Capacitive Delay Interconnections.

UNIT III SINGLE AND MULTI-CHIP PACKAGING 9

Functions of single-chip package, types of SIP, fundamentals of SIP, materials, processes, and properties, characteristics of single-chip packages, multi-chip modules, multi-chip modules and advantages, types of multi-chip module substrates—MCM-L, MCM-C, and MCM-D— and MCM design.

UNIT IV THERMAL MANAGEMENT AND IC ASSEMBLY 9

Fundamentals of thermal management, thermal management of IC and PWB packages, and electronic cooling methods - purpose of IC assembly, requirements for IC assembly, IC assembly technologies, wire bonding, tape automated bonding, flip chip.

UNIT V IC RELIABILITY 9

Fundamentals of thermomechanical reliability, importance of reliability, reliability meteorology, reliability qualifications, thermomechanical failure analysis, experimental methods and tools for reliability analysis, and integrated virtual reliability prediction.

Total: 45 Hrs.

h) Learning Resources

References

1. Rao Tummala, " Fundamentals of Devices and Systems Packaging and Applications", Second Edition, McGraw Hill, 2022.
2. King-Ning Tu, Chih Chen, and Hung-Ming Chen, " Electronic Packaging Science and Technology", Wiley, Edition One, 2022.
3. John H. Lau. Semiconductor Advanced Packaging, Springer, 2021.
4. William J. Greig, " Integrated Circuit Packaging, Assembly and Interconnections", Springer, Edition 2007.
5. Andrea Chen and Randy Hsiao-Yu Lo, "Semiconductor Packaging: Materials Interaction and Reliability", 1st edition, CRC Press, First Edition, 2016.
6. Rao R Tummala & Madhavan Swaminathan, " Introduction to System-on-Package", McGraw Hill, 2008.

Online Resources

1. Advanced Semiconductor Packaging
   https://www.coursera.org/learn/advanced-packaging (Coursera)
2. https://faculty.eng.ufl.edu/navid-asadi/teaching/ (Teaching - Navid Asadi)
3. Electronic Packaging and Manufacturing
   https://onlinecourses.nptel.ac.in/noc22_me61/preview (NPTEL)

Course Code	Course Title	L	T	P	C
10212EC903	**VERIFICATION TOOLS AND TECHNIQUES**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides a comprehensive exploration of verification tools and techniques employed in the design and validation of digital systems. It gives insights about the formal and industrial standard verification methodologies, simulation tools to ensure the correctness and reliability of digital designs.

c) Prerequisite

Nil

d) Related Courses

VLSI Design

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Develop a comprehensive understanding of verification methodologies used in digital system design.	K3
CO2	Make use of simulation tools for functional verification of digital designs and apply simulation techniques to identify and rectify design issues.	K3
CO3	Identify the principles and applications of formal verification techniques to use formal verification tools for design correctness.	K3
CO4	Experiment advanced verification strategies such as constrained-random testing and assertion-based verification.	K3
CO5	Apply tools and techniques based on experience with industry-standard verification tools to real-world digital design.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	H	L	-	-	-	-	-	-	-	-	-	M	-
CO2	H	H	L	-	-	-	-	-	-	-	-	-	M	-
CO3	H	H	M	-	M	-	-	-	-	-	-	-	M	-
CO4	H	H	H	-	M	-	-	-	-	-	-	-	M	-
CO5	H	H	M	-	M	-	-	-	-	-	-	-	M	-

g) Course Content

UNIT I SEQUENTIAL CIRCUIT DESIGN USING SYSTEMVERILOG 9

Synchronous and asynchronous sequential circuits – FSM: Adder, counter design – LUT concept – SystemVerilog programming.

UNIT II VERIFICATION IN DIGITAL DESIGN 9

Verification in digital system design – verification process: – verification plan – debug cycle – simulation – output data, test bench development – current verification techniques: HDL software simulators, accelerated simulation, process based accelerator techniques, FPGA prototyping.

UNIT III FORMAL VERIFICATION PRINCIPLES 9

Introduction, advantages of formal verification, bug hunting, exploring designs – formal verification algorithms: BDD (Binary decision diagrams), DAVIS PUTNAM SAT algorithm – SystemVerilog assertions – formal property verification.

UNIT IV INDUSTRY-STANDARD VERIFICATION TOOLS 9

Industry standard verification tool Questa, VCS – tool functionalities and features, examples – SystemVerilog verification, constructs

UNIT V CASE STUDIES AND REAL-WORLD APPLICATIONS 9

Case studies of verification challenges in real world digital designs: traffic light controller – creating design exercise plan – wiggling process – applying verification tools and techniques to real-world scenarios.

Total: 45 Hrs.

h) Learning Resources

References

1. Seligman, Erik. “Formal Verification”, Elsevier, 2023.
2. Perry, Douglas. “Applied Formal Verification”, McGraw Hill Professional, 2005.
3. Birtwistle, Graham. VLSI Specification, Verification and Synthesis. Springer Science & Business Media, 2012.
4. Shirshendu Roy, “ Advanced Digital System Design : A Practical Guide to Verilog Based FPGA and ASIC Implementation”, 2024.
5. Ashok B. Mehta, “ASIC/SoC Functional Design Verification A Comprehensive Guide to Technologies and Methodologies”, 2018.
6. Kropf, Thomas,” Introduction to Formal Hardware Verification. Springer Science & Business Media”, 2013.

Online Resources

1. Formal verification
   https://www.cl.cam.ac.uk/~jrh13/papers/mark10.pdf
2. System Verilog constructs
   https://docs.amd.com/r/en-US/ug901-vivado-synthesis/SystemVerilog-Constructs.
3. SoC design verification
   https://www.ece.ufl.edu/wp-content/uploads/sites/119/publications/ieeedt17a.pdf.

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC138	INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

This course gives introduction to the basic knowledge representation, problem solving, and learning methods of artificial intelligence. It also gives introduction to the basics of supervised learning, unsupervised learning, classification and regression in machine learning.

c) Prerequisite courses

Nil

d) Related Courses

Machine Learning for Wireless Communication, Artificial Intelligence based Wireless Network Design, Artificial Intelligence in Optical Communication

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Interpret artificial intelligence (AI) methods and describe their foundations.	K2
CO2	Apply search algorithms for problem-solving, inference, perception, knowledge representation, and learning.	K3
CO3	Demonstrate knowledge reasoning and knowledge representation for solving real-world problems.	K2
CO4	Model the characteristics of machine learning and binary classification	K3
CO5	Make use of different linear methods for classification and regression with their optimization through other regularization techniques.	K3

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	M	L	M	-	-	-	-	-	L	-	-	L	-	L
CO2	M	M	H	H	-	-	-	L	-	L	-	L	M	L
CO3	M	M	M	-	L	-	-	L	-	L	-	L	M	M
CO4	M	L	L	L	M	-	-	-	L	-	-	M	M	M
CO5	H	M	M	M	M	-	M	-	L	L	L	M	M	M

g) Course Content

UNIT I ARTIFICIAL INTELLIGENCE FUNDAMENTALS 9

Basic definitions and terminology - Foundation of AI - History of AI - The State of the Art - Intelligent Agent - How Agents should Act? Structure of Intelligent Agents - Environments.

UNIT II PROBLEM SOLVING 9

Problem solving Agents - Formulating problems – Examples - Searching for solutions - Search Strategies - Informed search methods - Best-first search - Heuristic Functions - Memory bounded search - Iterative improvement algorithms.

UNIT III KNOWLEDGE AND REASONING 9

Knowledge-based agent - Representation - Reasoning and Logic - Propositional logic -Inference in First-Order Logic - Forward and backward chaining - Logical Reasoning system- indexing - retrieval and unification.

UNIT IV MACHINE LEARNING FUNDAMENTALS 9

Ingredients of Machine Learning – Tasks – Models – Geometric – probabilistic – logical - grouping and grading – Features- construction and transformation - interaction between features - Types of Learning – Supervised - Unsupervised and Semi-Supervised Learning.

UNIT V CLASSIFICATION AND REGRESSION 9

Binary and Multiclass Classification - Handling more than two classes - Multiclass scores and probabilities – Regression - Unsupervised and descriptive learning - predictive and descriptive clustering.

Total: 45Hrs

h) Learning Resources

Text Books

1. Russell, S. and Norvig, P, "Artificial Intelligence - A Modern Approach", Prentice Hall, 4th edition, 2022
2. Peter Flach, "Machine Learning: The Art and Science of Algorithms that Make Sense of Data", Cambridge University Press, 2012.

References

1. Dan W Patterson, "Introduction to Artificial Intelligence & Expert Systems", PHI., 2010
2. S Kaushik, "Artificial Intelligence", Cengage Learning, 1st edition. 2011.
3. Ric, E., Knight, K and Shankar, B, "Artificial Intelligence", Tata McGraw Hill. 3rd edition, 2009
4. Luger, G.F, "Artificial Intelligence -Structures and Strategies for Complex Problem Solving", Pearson, 6th edition, 2008
5. Alpaydin, E, " Introduction to Machine Learning" MIT, 2nd edition, 2010

Online Resources

1. https://nptel.ac.in/courses/112/103/112103280
2. https://nptel.ac.in/courses/106/106/106106202
3. https://www.coursera.org/lecture/guided-tour-machine-learning-finance/artificial-intelligence-and-machine-learning-part-i-kgIR0

Course Code	Course Title	L	T	P	C
10212EC139	**WIRELESS COMMUNICATIONS AND NETWORKING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course imparts knowledge in recent wireless technologies and networks. It covers 5G wireless systems, massive multiuser system, wireless LAN, wireless protocols and advanced mobile networks.

c) Prerequisite

Wireless Communication

d) Related Courses

Microwave and Millimeter wave communication

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the evolution and requirements of the 5G wireless system	K2
CO2	Explain the massive MIMO technology and channel modeling of millimeter wave communication.	K2
CO3	Classify different wireless LAN technologies.	K2
CO4	Describe the network and transport layer solutions for wireless standards	K2
CO5	Discuss the current trends in advanced communication networks	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	M	M	M	M	-	M	L	L	-	M	H	-	-
CO2	H	H	M	L	L	-	-	-	L	-	-	H	H	-
CO3	H	H	M	M	L	-	-	-	L	-	-	H	-	-
CO4	H	H	M	M	L	-		-	L	-	-	H	M	-
CO5	M	M	H	M	M	H	M	-	L	M	-	H	-	-

g) Course Content

UNIT I OVERVIEW OF 5G 9

Development of LTE towards 5G – Extreme mobile broadband – 5G Architecture: Basics of RAN Architecture, High level requirements , 5G deployment – Waveform in 5G : OFDM, NOMA

UNIT II MASSIVE MIMO FOR 5G 9

Massive MIMO: Point to point MIMO, Multi User MIMO, Pilot design for massive MIMO – Resource allocation and transceiver algorithm- Channel modeling in mm wave communication- Large Scale Channel Model, MIMO Spatial Channel Model

.

UNIT III WLAN TECHNOLOGIES 9

WLAN technologies: IEEE802.11 – System architecture, 802.11a , 802.11b – HIPER LAN: HIPER LAN1, WATM, BRAN, HIPER LAN2 – Bluetooth – IEEE 802.11ad (60 GHz WLAN) – IEEE 802.15 PHY and MAC overview.

UNIT IV WIRELESS PROTOCOLS 9

Mobile network layer – Fundamentals of Mobile IP: data forwarding procedures in mobile IP, IPv4, IPv6, IP mobility management, IP addressing – DHCP – Mobile transport layer: Traditional TCP, congestion control, Indirect TCP, snooping TCP, Mobile TCP.

UNIT V ADVANCED MOBILE NETWORKS 9

Drone networking – Multi-UAV networks, Architectures, Protocols for micro UAVs, Connected and Autonomous Vehicles (CAV)– Wireless technologies for Vehicle-to-Infrastructure (V2I) and Vehicle-to-Vehicle (V2V) communications.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Suvra Sekhar Das, Ramjee Prasad, "Evolution of Air Interface Towards 5G Radio Access Technology and Performance Analysis", River Publications, 2018.
2. Asif Oseiran, Jose F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
3. Jochen Schiller, "Mobile Communications, Second Edition", Pearson Education 2012.
4. Kaveh Pahlavan, "Principles of wireless networks", Prentice-Hall of India, 2008.
5. Kamesh Namuduri, "UAV Networks and Communications", Cambridge University Press, 2017.

Reference Books

1. Hao Jiang, Guan Gui, "Channel modeling in 5G wireless communication systems", Springer, 2020.
2. R. Vannithamby and S. Talwar, "Towards 5G: Applications, Requirements and Candidate Technologies", John Willey & Sons, West Sussex, 2017.
3. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock, "Millimeter Wave Wireless Communication", Pearson Education, 2015.
4. Fei Hu, Dong Xiu Ou, Xin-lin Huang, "UAV Swarm Networks: Models, Protocols, and Systems",1st edition, CRC Press, 2021.

Online Resources

1. https://www.digimat.in/nptel/courses/video/106106167/L01.html
2. https://onlinecourses.nptel.ac.in/noc21_ee66/preview
3. https://youtu.be/SljXFf0vgvw
4. https://onlinecourses.nptel.ac.in/noc22_ee65/preview
5. https://archive.nptel.ac.in/courses/108/105/108105134/

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC140	MACHINE LEARNING FOR WIRELESS COMMUNICATIONS	3	0	0	3

a. Course Category:

Programme Elective

b. Preamble:

The aim of the course is to introduce students to the fundamentals of machine learning and to apply the advanced machine learning principles for the design and optimization of wireless communications systems

c. Prerequisite Courses:

Wireless Communication

d. Related Courses:

Cellular Mobile communication

e. Course Outcomes:

On successful completion of this course the student will be able to:

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Demonstrate various ML algorithms for spectrum sharing and channel allocation in a wireless system.	K2
CO2	Make use of the concepts of ML for resource allocation and system-level modeling.	K3
CO3	Apply the concept of ML-based signal modulation and coding techniques	K3
CO4	Solve the concept of ML-based channel coding and decoding algorithm	K3
CO5	Explain various ML-based optimization techniques in wireless communication systems.	K2

f). Correlation of COs with POs and PSOs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	H	H	L	M	-	-	L	L	-	-	-	-	L
CO2	M	H	M	H	L	M	L	L	-	-	L	L	-	L
CO3	H	M	L	M	H	L	L	-	L	L	-	L	L	M
CO4	M	H	L	L	L	M	-	-	L	L	L	-	-	M
CO5	M	L	M	H	M	-	-	L	-	-	L	-	-	L

g. Course Content:

UNIT I Machine Learning (ML) for Spectrum Access and channel Allocation 9

Machine Learning Algorithms for Opportunistic Spectrum Access, Background and Motivation, Learning Algorithms for Channel Allocation, System Model and Problem Formulation, Hybrid Solution Approach.

UNIT II Optimal Resource Allocation using ML 9

System Model, Resource Minimization Approaches, Numerical Results, Mobile Crowd sensing, ML-Based Context-Aware Data Transmission, Methodology for Real-World Performance Evaluation, Results of the Real-World Performance Evaluation.

UNIT III Machine Learning–Based Adaptive Modulation and Coding Techniques 9

SL-Assisted AMC, RL-Assisted AMC, Adaptive Learning for Symbol Detection: Preliminaries, System Model, Reproducing Kernel Hilbert Space Approach for symbol detection.

UNIT IV Joint Channel Equalization 9

Neural Network-Based Channel Equalization, Principles of Equalization and Detection, Performance of OFDM Systems with Neural Network-Based Equalization, Channel Coding with Deep Learning: Channel Coding and Deep Learning, DNNs for Channel Coding, CNNs for Decoding, RNNs for Decoding.

UNIT V Optimization Techniques 9

Self-Organizing Wireless Networks, Traffic Prediction and Machine Learning, Cognitive Radio and Machine Learning, Machine Learning optimization Techniques for Autonomous Network Management, Data-Driven Base-Station Sleeping optimization by Deep Reinforcement Learning.

Total: 45 Hrs

h. Learning Resources:

Text Books

1. FA-LONG LUO, Machine Learning for Future Wireless Communications, 1st Ed., Wiley IEEE Press, 2020.
2. Ruisi He and Zhiguo Ding, Applications of Machine Learning in Wireless Communications (Telecommunications), 2nd Ed., Institution of Engineering and Technology, 2019.

Reference Books:

1. Ioan-Sorin Comșa and Ramona Trestian, Next-Generation Wireless Networks Meet Advanced Machine Learning Applications, 2nd Ed., Global Information Science Reference, 2019.
2. K. Suganthi, R. Karthik, G. Rajesh and Peter Ho Chiung Ching, Machine Learning and Deep Learning Techniques in Wireless and Mobile Networking Systems, 1st Ed., CRC Press, 2021.

Online Resources

1. https://www.comsoc.org/publications/best-readings/machine-learning-communications
2. https://www.coursera.org/learn/machine-learning

Course Code	Course Title	L	T	P	C
10212EC141	**ARTIFICIAL INTELLIGENCE BASED WIRELESS NETWORK DESIGN**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the concept of Wireless Network Architecture, Network optimization concepts, game theory and game theory in Communication and networks and also it discuss about the applications of Artificial Intelligence based wireless system design

.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication

e) Course Outcomes

Upon the successful completion of the course students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Infers the basic concepts of wireless network architecture	K2
CO2	Discuss the network optimization concepts and applications	K2
CO3	Interpret the game theory concepts in networks	K2
CO4	Illustrate the game theory in communication and networks	K2
CO5	Explain the applications of AI-based wireless system design	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	M	L	-	-	M	-	-	M	L	-	-
CO2	H	H	M	-	-	-	L	-	-	-	-	-	L	-
CO3	M	L	L	-	-	-	-	-	-	M	-	-	-	-
CO4	M	M	-	-	-	L	-	-	-	-	-	M	-	L
CO5	M	L	-	-	L	-	L	-	-	-	M	L	-	-

g) Course Content

UNITI WIRELESS NETWORKS ARCHITECTURE 9

Review of wireless networks architecture - technology and standards - Introduction to LTE - Architecture of the LTE - Air Interface - Evolution from 4G to 5G - Enabling Technologies for5G

UNITII NETWORK OPTIMIZATION 9

Convex vs. non-convex problems, duality theory, decomposition methods for network utility maximization, multi-objective problems, and Pareto optimality. Applications to Cross-layer Optimization

UNITIII GAME THEORY 9

Basic Concept of Game Theory, History, Applied areas, Classification of Games, Cooperative Games - Non-cooperative Games, Evolutionary Games.

UNITIV GAME THEORY IN COMMUNICATION AND NETWORKING 9

Uplink power control in CDMA Networks: Single cell CDMA networks, Multicell Wireless CDMA networks, Resource allocation in single cell OFDMA networks, OFDMA resource Allocation modal, Power allocation in femto cell networks: Femto cell power control as a stackelberg game

UNITV APPLICATIONS 9

Applications of cognitive radio networks, Heterogeneous networks using supervised and unsupervised learning, Network intelligence in IoT design, 6G wireless networks.

Total : 45 Hours

h) Learning Resources

Text Books

1. S.Glisic, B.Lorenzo,"Advanced Wireless Networks: 4G Cognitive Opportunistic and Cooperative Technology",2nd Edition, John Wiley and Sons, 2009
2. Fa-Long Luo,"Machine Learning for Future Wireless Communications"John Wiley and Sons, 2019
3. Zhu Han, DusitNiyato, WalidSaad, Tamer Basar, Are Hjorungnes, "Game Theory in Wireless and Communication Networks- Theory, Models and Applications", Cambridge university press. 2012.

Reference Books

1. Elaine Rich, Kevin Knight and Shivashankar B Nair, "Artificial Intelligence", 3rd edition,TMH, 2009.
2. Stephen Boyd , Lieven Vandenberghe, "Convex Optimization", 1st Edition, Cambridge university press, 2004
3. Savo Glisic, "Advanced Wireless Networks: Technology And Business Models" 3rd Edition, John Wiley, 2016.
4. Jaime Lloret Mauri, Kayhan Zrar Ghafoor, Danda B. Rawat ,& Javier Manuel Aguiar Perez, "Cognitive Networks: Applications and Deployments", 1st edition, CRC Press, 2014.
5. Hsiao Hwa Chen, Mohsen Guizani, "Next-Generation Wireless Systems and Networks", John Wiley and Sons, 2006.
6. Ioan-Sorin Comşa, Ramona Trestian, "Next-Generation Wireless Networks Meet Advanced Machine Learning Applications", 2019

Online Resources

1. http://home.iitk.ac.in/~rohitbr/index_ml_course.html
2. http://aimaterials.blogspot.com/p/syllabus.html

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC142	OPTIMIZATION FOR WIRELESS AND MACHINE LEARNING	3	0	0	3

a. Course Category

Programme Elective

b. Preamble

This course enables students to understand various optimization methods that underlie machine learning techniques, discussions on their uses, as well as provide opportunities to develop the concepts in various communication systems.

c. Prerequisite courses

Nil

d. Related Courses

Machine learning for Wireless Communication, Introduction to artificial intelligence and machine learning

e. Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain the fundamentals of optimization and describe their applications.	K2
CO2	Solve convexity optimization problems in multi-user wireless systems.	K3
CO3	Apply quadratic optimization and duality principle in MIMO OFDM systems.	K3
CO4	Discuss optimization techniques for signal and channel estimation and apply convexity for PCA and SVM.	K2
CO5	Illustrate the concepts of geometric optimization for co-operative communication and radar systems.	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	H	M	-	-	-	-	-	L	L	-	-	-	-
CO2	H	M	H	L	-	L	L	-	L	L	L	-	L	-
CO3	H	M	M	-	-	L	L	L	L	L	L	-	L	-
CO4	M	H	L	L	L	-	-	L	L	L	-	L	L	-
CO5	H	M	L	-	L	-	M	L	L	L	-	L	-	-

g) Course Content

UNIT I BASICS OF OPTIMIZATION 9

Properties of Vectors - Norms - Positive - Semi-Definite matrices and Gaussian -Random Vectors. Introduction to Convex Optimization - Convex sets - Hyperplanes / Half-spaces etc - Application - Power constraints in Wireless Systems.

UNIT II CONVEX OPTIMIZATION 9

Convex / Concave Functions - Examples - Conditions for Convexity - Beamforming in Wireless Systems - Multi-User Wireless - Cognitive Radio Systems - Convex Optimization problems - Linear Program.

UNIT III QUADRATIC OPTIMIZATION AND DUALITY 9

Quadratically constrained quadratic program (QCQP) - Second order cone programming (SOCP) - Channel shortening for Wireless Equalization - Duality principle and KKT framework for optimization - Water-filling power allocation - Optimization for MIMO Systems - OFDM Systems and MIMO-OFDM systems.

UNIT IV SIGNAL AND CHANNEL ESTIMATION 9

Optimization for signal estimation - LS - WLS - Regularization - Wireless channel estimation - Convex optimization for Machine Learning - Principal Component Analysis (PCA) - Support Vector Machines.

UNIT V GEOMETRIC OPTIMIZATION 9

Cooperative Communication - Optimal Power Allocation - Geometric Program - Radar for target detection - Array Processing.

Total: 45 Hrs

h. Learning Resources

Text Books

1. Sra, Suvrit, Sebastian Nowozin, and Stephen J. Wright, eds. "Optimization for machine learning" Mit Press, 2012.
2. Stephen Boyd, Lieven Vandenberghe. "Convex Optimization", Cambridge university press, 2004
3. Bubeck, Sebastien. "Theory of Convex Optimization for Machine Learning." arXiv preprint arXiv:1405.4980, 2014.

Reference Books

1. Roberto Battiti, Mauro Brunato. The LION Way: "Machine Learning plus Intelligent Optimization". Lionsolver, Inc. 2013.
2. Kristin Bennett, Emilio Parrado-Hernandez. "Interplay of Optimization and Machine Learning Research", Journal of Machine Learning Research, 2006.
3. NatiSrebro, AmbujTewari. "Stochastic Optimization for Machine Learning", Tutorial at International Conference on Machine Learning, 2010.
4. Stephen Wright. "Optimization Methods in Machine Learning", Tutorial at Neural Information Processing Systems, 2010.
5. Clarkson, Kenneth L., EladHazan, and David P. Woodruff. "Sublinear optimization for machine learning". Journal of the ACM (JACM) 59.5 (2012)
6. Miclet, Laurent, and Antoine Cornuejols. "What is the place of Machine Learning between Pattern Recognition and Optimization?." TML Workshop 2008.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_ee59/preview
2. http://simons.berkeley.edu/talks/peter-richtarik-2013-10-23
3. Introduction to Convex Optimization in Machine Learning

Course Code	Course Title	L	T	P	C
10212EC143	**MICROWAVE AND MILLIMETER WAVE COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course will provide knowledge about the fundamentals of mm-Wave devices and its importance in the modern communication system. This course also teaches about the mm-Wave frequency bands in communication systems and antennas used for mm-wave systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the fundamentals of millimeter wave propagation channels.	K2
CO2	Interpret the various components of the millimeter-wave communications system.	K2
CO3	Explain mm-wave communication systems.	K2
CO4	Illustrate the mm-wave MIMO communication systems.	K2
CO5	Identify the antennas for the millimeter wave communication system	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	L	L	L	-	-	L	L	L	L	L	-	-
CO2	M	M	L	L	M	-	-	-	M	M	-	M	-	-
CO3	M	M	L	-	H	-	M	L	L	M	L	M	M	-
CO4	M	M	M	L	H	L	-	-	-	-	L	M	M	-
CO5	M	M	M	-	-	L	L	L	-	-	M	M	L	-

g) Course Content

UNIT I mm WAVE PROPAGATION CHANNEL 9

Millimeter wave characteristics- millimeter wave wireless- implementation challenges- Radio wave propagation for mm-wave: Large scale propagation channel effects- small scale channel effects- Outdoor and Indoor channel models- Emerging applications of millimeter wave communications.

UNIT II mm WAVE DEVICES AND CIRCUITS 9

Millimeter wave generation and amplification: Peniotrons- Ubitrons- Gyrotrons and Free electron lasers. HEMT- models for mm-wave Transistors- transistor configurations- Analog mm-wave components: Amplifiers- Mixers- VCO- PLL. Metrics for analog mm-wave devices- Consumption factor theory- Trends and architectures for mm-wave wireless- ADCs and DACs.

UNIT III mm WAVE COMMUNICATION SYSTEMS 9

Modulations for millimeter wave communications- Millimeter wave link budget- Transceiver architecture- Transceiver without mixer- Receiver without Oscillator- Millimeter wave calibration- production and manufacture- Millimeter wave design considerations.

UNIT IV mm WAVE MIMO SYSTEMS 9

Massive MIMO Communications- Spatial diversity of Antenna Arrays- Multiple Transceivers- Noise coupling in MIMO system- Potential benefits for mm-wave systems- Temporal and Frequency diversity- Dynamic spatial- frequency and modulation allocation.

UNIT V ANTENNAS FOR mm WAVE SYSTEMS 9

Antenna beamwidth- polarization- advanced beam steering and beam forming- mm wave design consideration- On-chip and In package mm-wave antennas- Techniques to improve the gain of on-chip antennas- Implementation for mm-wave in adaptive antenna arrays- Device to Device communications over 5G systems- Design techniques of 5G mobile.

Total 45 Hrs.

h) Learning Resources

Text Books

1. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.

Reference Books

1. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.
2. Chia-Chin Chong, Kiyoshi Hamaguchi, Peter F. M. Smulders and Su-Khiong, "Millimeter - Wave Wireless Communication Systems: Theory and Applications," Hindawi Publishing Corporation, 2007.
3. John S. Seybold "Introduction to RF propagation, "John Wiley and Sons, 2005.

Online Resources

1. https://link.springer.com/chapter/10.1007/978-3-030-92188-0_14

Course Code	Course Title	L	T	P	C
10212EC144	**ARTIFICIAL INTELLIGENCE IN OPTICAL COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The aim of the course is to provide introduction about the fundamentals of artificial intelligence in optical communication. This course also provides the information about the Optical Neural Network Architectures and Applications of AI in Optical Networks.

c) Prerequisite

Optical and Microwave Communication Systems

d) Related Courses

Advanced Optical Communication

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the emerging optical technologies for 5G communication	K2
CO2	Illustrate the basics of AI and techniques applied to optical networks	K2
CO3	Discuss the artificial intelligence concepts in optical communication	K2
CO4	Infer the optical neural network architecture	K2
CO5	Summarize the various applications of AI in optical networks and the challenges and opportunities of AI in optical.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	L	M	L	L	-	-	-	L	-	-	-	-
CO2	L	M	M	M	-	M	-	-	L	L	-	L	-	-
CO3	L	M	L	L	M	M	L	-	-	L	L	L	-	-
CO4	L	L	M	M	-	L	L	L	M	L	-	-	L	-
CO5	L	M	L	L	L	L	-	-	M	L	-	-	L	-

g) Course Content

UNIT I EMERGING OPTICAL COMMUNICATION TECHNOLOGIES FOR 5G 9

Optical interfaces for wireless - common public radio interface - Evolved CPRI - Next generation fronthaul interface - Optical transmission technologies for X-haul - Optical Transport Network - Software Defined Network Fundamentals - Industry standards and development for 5G oriented optical networks.

UNIT II INTRODUCTION TO ARTIFICIAL INTELLIGENCE 9

History of AI - Overview of Artificial Intelligence - Machine Learning and Deep Learning- Supervised and Unsupervised Learning - Reinforcement Learning - Key Technologies to make 5G in reality using AI - AI assisted networks - Transforming optical industries by AI - AI subfields and techniques applied to optical networks.

UNIT III ARTIFICIAL INTELLIGENCE IN OPTICAL COMMUNICATIONS 9

Convolutional neural network for Image data – Convolution – Polling - Down-sampling operation – Activation - Nonlinear operation - Recurrent neural network for sequential data - End to end for Joint Optimization With DL-Based Channel Model - Generative Adversarial Network for Data Augmentation - Deep Reinforcement Learning for Network Automation.

UNIT IV OPTICAL NEURAL NETWORK ARCHITECTURES 9

Optical realizations of perceptron - Perceptron pattern classification using Planar Interconnection Devices - Volume Holograms - Optical realizations of multilayer perceptron's - optoelectronic realizations of multilayer perceptron - All optical realizations of multilayer perceptron - Optical realizations of Self organizing neural networks - Coherent self-organized Kohonen networks - Optical realizations of Hopfield and Boltzman neural networks.

UNIT V APPLICATIONS OF AI IN OPTICAL NETWORKS 9

Applications of AI in optical transmission: Characterization and operation of transmitters - EDFA- Receivers and mitigation of nonlinearities - QoT estimation, Applications of AI in optical networking: Software defined networking - Optical burst switching - Passive optical networks - Intra-datacenter networking, New opportunities and challenges for the use of AI in optical networks: Optical transmission systems attack and intrusion detection - Automating network management operations - Applications in on-chip networks

Total : 45 Hrs

h) Learning Resources

Text Books

1. Alan E. Willner, "Optical Fiber Telecommunications VII", Elsevier Academic Press, 2020
2. Gurjit Kaur, Pradeep Tomar, Marcus Tanque, "Artificial Intelligence to Solve Pervasive Internet of Things Issues", Academic Press Publications, 2020
3. Dr.Ayman Elmaasarawy, " The Future Roles of Artificial Intelligence in Securing and Optimizing Services of 5G over Optical Transport Network", 2021
4. Haesik Kim, "Design and Optimization for 5G wireless Communications, IEEE Press John Wiley & Sons, 2020

Reference Books

1. George A.Vouros, "Methods and Applications of Artificial Intelligence" Springer, 2004
2. Danshi Wang and Min Zhang, "Artificial Intelligence in Optical Communication: From Machine Learning to Deep Learning", Review Article, Optical Communication Networks, 2021
3. Cornelia Denz, "Optical Neural Networks", Optics and Photonics, 1998

Online Resources

1. https://doi.org/10.3389/frcmn.2021.656786
2. https://www.youtube.com/watch?v=OZ0By39RpnI
3. https://www.youtube.com/watch?v=nClPAfPGgt0
4. https://www.youtube.com/watch?v=dWaKPc26-sw

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Course Code	Course Title	L	T	P	C
10212EC218	**SMART ANTENNAS FOR 5G COMMUNICATION**	**2**	**0**	**2**	**3**

a) Course Category

Programme Elective

b) Preamble

This course imparts knowledge on fundamental concepts of smart antennas and its beam forming principles. Also to understand the channel environment and design principles involved in modelling modern antennas for various applications.

c) Prerequisite

Antenna Theory

d) Related Courses

Electromagnetics and Transmission Lines

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the physical concept of antenna arrays.	K2
CO2	Model channel characteristics in the propagation medium.	K3
CO3	Compare the smart antennas and their architecture.	K2
CO4	Discuss various estimation algorithms to estimate AoA in smart antennas.	K2
CO5	Explain various beamforming techniques in smart antennas.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	H	L	L	L	-	-	L	L	L	L	M	L	-
CO2	H	M	H	M	M	-	-	M	-	-	-	L	-	-
CO3	L	L	H	H	H	-	H	L	L	L	L	H	M	-
CO4	L	L	H	H	H	-	H	-	-	L	-	M	M	-
CO5	L	L	-	-	-	L	M	-	-	-	-	-	-	L

g) Course Content

UNIT I ANTENNA ARRAY FUNDAMENTALS 6

Overview of Antenna Arrays- Beam steered Linear Array. Array Weighting – Binomial- Blackman- Hamming- Gaussian- Kaiser- Bessel. Circular Arrays- Beam steered Circular arrays- Rectangular planar arrays- Fixed Beam Arrays- Butler Matrices- Fixed side lobe cancelling- Retro directive arrays- Passive and active retro directive array.

UNIT II PROPAGATION CHANNEL CHARACTERISTICS 6

Flat Earth Model- Multi path Propagation mechanisms- Propagation channel basics – Fading- fast fading model- multipath with no direct path- multipath with direct path- motion in a fast fading channel- Channel impulse response- Power delay profile- Power angular profile- power delay – angular profile- Channel dispersion- Slow fading model.

UNIT III SMART ANTENNAS 6

Need for Smart Antennas- Smart antenna configurations- Switched beam antennas- Adaptive antenna approach- Space division multiple access- Architecture of smart antenna system- Basic principles- Mutual coupling effects.

UNIT IV ANGLE OF ARRIVAL ESTIMATION 6

Array Correlation Matrix- Angle of arrival (AOA) Estimation methods- Bartlett- Capon- Linear prediction- Maximum Entropy- Min-Norm- MUSIC- Root MUSIC- and ESPRIT.

UNIT V BEAMFORMING TECHNIQUES 6

Fixed weight beam forming- Maximum signal to interference ratio- Minimum mean square- Maximum likelihood- Minimum Variance. Adaptive beam forming- Least mean square- sample matrix inversion- recursive least squares- constant modulus- least squares constant modulus- conjugate gradient method- spreading sequence array weights- SDMA Receiver.

LIST OF EXPERIMENTS

S. No.	Practical Exercise (30 Hours)	COs
1.	Design of Broad Side and End fire array antennas	CO1
2.	Write a MATLAB code for Butler matrix labyrinth of phase shifters for N array elements	CO2
3.	Write a MATLAB code for Rayleigh distribution	CO3
4.	Write a MATLAB code for Fast fading effect with given velocity	CO3
5.	Write a MATLAB code for Minimum Mean square error for optimizing weights of smart antenna.	CO3
6.	Write a MATLAB code for Minimum Variance method for reducing array out noise variance.	CO3
7.	Write a MATLAB code for least mean square algorithm for array weights	CO3
8.	Analyze MUSIC AoA estimation algorithm using MATLAB	CO4
9.	Analyze Root MUSIC AoA estimation algorithm using MATLAB	CO4
10.	Analyze ESPRIT AoA estimation algorithm using MATLAB	CO4
11.	Write a MATAB code to construct the array steering vector for the angle of arrival	CO5
12.	Write a MATAB code for Least squares constant modulus Algorithm and calculate array steering vectors	CO5
13.	Write a MATAB code to calculate AoA using conjugate gradient method	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Frank Gross, "Smart antennas for wireless communications", McGraw-Hill Education, 2005.
2. Constantine A. Balanis, Panayiotis I. Ioannides, "Introduction to Smart Antennas (Synthesis Lectures on Antennas)", Morgan & Claypool Publishers, 2007.

Reference Books

1. T.S. Rappaport and J.C. Liberti, "Smart Antennas for Wireless Communications", Prentice Hall, 1999.
2. Tapan K Sarkar," Smart Antennas ", IEEE Press, John Wiley & Sons Publications, 2003.

Online Resources

1. https://asu.pure.elsevier.com/en/publications/introduction-to-smart-antennas

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Course Code	Course Title	L	T	P	C
10212EC145	**DIGITAL IC DESIGN**	**3**	**0**	**0**	**3**

a) Course Category
Programme Elective

b) Preamble
The course includes fundamentals of the issues in the digital integrated circuits design, the different implementation strategies, arithmetic blocks, the design of sequential circuits, memory cells and the timing concepts in latch and flip-flops are discussed.

c) Prerequisite
VLSI Design

d) Related Courses
Low Power VLSI Design

e) Course Outcomes
Up on the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Interpret the design metric and MOS physics	K2
CO2	Compare the different strategies involved in digital IC design.	K2
CO3	Illustrate the different arithmetic blocks for addition, multiplication and accumulation	K2
CO4	Summarize the basic sequential circuit's components and CMOS memory arrays.	K2
CO5	Explain the interconnect and clocking issues in digital IC design	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	L	-	-	-	-	-	-	-	H	M	-
CO2	H	L	M	H	-	-	-	-	-	-	-	L	H	-
CO3	M	L	H	M	-	-	-	-	-	-	-	L	L	-
CO4	H	H	M	H	-	-	-	-	-	-	-	M	M	L
CO5	M	M	H	H	-	-	-	-	-	-	-	H	L	L

g) Course Content

UNIT-1 INTRODUCTION 9

Issues in Digital IC Design- Quality Metrics of a Digital Design: Cost of an Integrated circuits, Functionality and Robustness, Performance, Power and Energy Consumptions-Packaging Integrated Circuits-Trends in Process Technology.

UNIT-2 IMPLEMENTATION STRATEGIES FOR DIGITAL ICs 9

Custom Circuit Design, Cell-Based Design Methodology, Standard Cell, Compiled Cells, Macro cells, Mega cells and Intellectual Property, Semi-Custom Design Flow, Array-Based Implementation Approaches, Pre-diffused (or Mask-Programmable) Arrays, Prewired Arrays.

UNIT-3 DESIGNING ARITHMETIC BUILDING BLOCKS 9

Data paths in Digital Processor Architecture-Adder: Definitions-Circuit design Circuit Design Considerations, Logic Design Considerations-Multiplier: Partial- Product Generation, Partial Product Accumulation, Final Addition, Multiplier Summary, The Shifter, Barrel Shifter, Logarithmic Shifter- Performance and power optimizations in data path structures.

UNIT-4 DESIGNING SEQUENTIAL LOGIC AND MEMORY DESIGN 9

Introduction - Static Latches and Registers - Dynamic Latches and Registers - Pulse Based Registers - Sense Amplifier based registers -Pipeline structures. Designing Memory & Array structures: SRAM and DRAM Memory Core – memory peripheral circuitry- Memory reliability and yield - Power dissipation in memories.

UNIT-5 INTERCONNECTS AND TIMING ISSUES 9

Interconnect Parameters: Resistive, Capacitive and Inductive Parasitic – Computation of R, L and C for given interconnects-Buffer Chains-Timing classification of digital systems-Synchronous Design-Origins of clockSkew/JitterandimpactonPerformance-ClockDistributionTechniques - Latch based clocking - Synchronizers and Arbiters -Clock Synthesis and Synchronization using a Phase Locked Loop.

Total: 45 Hrs

h) **Learning Resources**

Text Books

a. Jan M. Rabaey, Anantha Chadrakasan, Borivoje Nikolic, Digital Integrated Circuits: A Design Perspective, PHI, Second Edition, 2016.
b. Neil. H, E. Weste, David Harris, Ayan Banerjee, CMOS VLSI Design: A Circuit and Systems Perspective, Pearson Education, Fourth Edition, 2011.

Reference Books

1. Sung-Mo Kang, Yusuf Leblebici, CMOS Digital Integrated Circuits-Analysis and Design, McGraw-Hill, Fourth Edition, 2014.
2. Sorab K Gandhi, VLSI Fabrication Principles: Si and GaAs, John Wiley and Sons, Second Edition, 2010.

Online Resources

1. https://freevideolectures.com/course/3059/low-power-vlsi-circuits-and-systems
2. www.NPTEL/lectures/lowpowervlsi

Course Code	Course Title	L	T	P	C
10212EC146	**MIXED SIGNAL VLSI DESIGN**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course highlights the design of some important system blocks like Filters (Continuous, Discrete and Digital), Data Converters (ADC and DAC), Phased lock Loops, Interconnects in such systems and Mix signal Circuit Layout technique. The Course emphasizes on Techniques one needs to adopt for implementation of Mixed Signal System as Integrated Circuit. It presents a detailed information on various Blocks of such a system required and their conflicting demands on Technology. Analog, Digital and RF circuits form part of most modern systems and their coexistence on a single chip, presents a tough challenge to Chip Designers.

c) Prerequisite

VLSI Design

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic building blocks of analog design	K2
CO2	Classify the various filters	K2
CO3	Summarize the various comparator specifications.	K2
CO4	Illustrate the data converters in two different modes	K2
CO5	Interpret the concept of PLL and noise analysis in both time domain and frequency domain.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	L	-	-	-	-	-	-	-	H	M	-
CO2	H	L	M	H	-	-	-	-	-	-	-	L	H	-
CO3	M	L	H	M	-	-	-	-	-	-	-	L	L	-
CO4	H	H	M	H	-	-	-	-	-	-	-	M	M	-
CO5	M	M	H	H	-	-	-	-	-	-	-	H	L	-

g) Course Content

UNIT I BASIC BUILDING BLOCKS 9

Sample and hold and trans-linear circuits. Performance of sample-and-hold circuits – testing sample and holds, MOS sample-and-hold basics. Basic building blocks – op-amps, capacitors, switches, non-overlapping clocks, Basic operation and analysis of switched capacitor circuits, resistor equivalence of a switched capacitor.

UNIT II FILTERS 9

First-Order Filters – switch sharing, fully differential filters, biquad filters, low-Q biquad filter, high-Q biquad filter, Charge injection, switched-capacitor gain circuits, parallel resistor-capacitor circuit, resettable gain circuit, capacitive-reset gain circuit, correlated double-sampling techniques.

UNIT III COMPARATOR 9

Comparator specifications – input offset and noise, hysteresis , Op-amp as a comparator – input- offset voltage errors, charge-injection errors, making charge-injection signal independent, minimizing errors due to charge-injection, speed of multi-stage comparators, Latched comparators.

UNIT IV DATA CONVERTER 9

Ideal D/A converter, ideal A/D converter, quantization noise, deterministic approach, stochastic approach, signed codes, performance limitations, resolution, offset and gain error, accuracy and linearity Nyquist rate digital-to-analog converters.(DAC). Decoder-based converters – resistor string converters, folded resistor-string converters, multiple resistor-string converters.

UNIT V PHASE LOCKED LOOP 9

Basic phase-locked loop architecture, voltage controlled oscillator, divider, phase detector, loop filer, the PLL in lock, Linearized small-signal analysis – second-order PLL model, limitations of the second-order small-signal model, Jitter and phase noise.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Tony Chan Carusone, David A. Johns, Kenneth W. Martin "Analog Integrated Circuit Design" Second Edition, 2012.

Reference Books

1. Phillip Allen and Douglas R. Holberg ,"CMOS Analog Circuit Design", The Oxford Series in Electrical and Computer Engineering, 2016
2. Behzad Razavi, "Design of Analog CMOS Integrated Circuits" McGraw Hill, 33rd reprint ,2016
3. R.Jacob Baker "CMOS Circuit Design, Layout and Simulation" Wiley India, IEEE Press, Second Edition, reprint 2009.

Online Resources

1. https://www.youtube.com/playlist?list=PLLDC70psjvq5vtrb0EdII4xIKA15ec-Ij
2. https://www.youtube.com/watch?v=zVXzcUjOBjM&list=PLLDC70psjvq5vtrb0E dII4xIKA15ec-Ij&index=10&ab_channel=kashyapB

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Course Code	Course Title	L	T	P	C
10212EC147	**IC TECHNOLOGY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

To impart knowledge on fundamental principles of fabrication of VLSI devices and circuits

c) Prerequisite

Nil

d) Related Courses

VLSI Design, Solid State Devices, Nano Scale Transistors

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the fabrication steps of CMOS fabrication flow	K2
CO2	Compare the diffusion and oxidation mechanisms	K2
CO3	Interpret the various deposition methods and epitaxial growth	K2
CO4	Explain the various pattern transfer techniques	K2
CO5	Illustrate CMOS process integration to understand the IC processing	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	-	L	-	L	L	-	-	M	-	M	-	-
CO2	H	M	-	M	-	-	-	-	-	L	-	M	-	-
CO3	H	H	-	L	-	-	L	-	L	L	-	M	-	-
CO4	H	H	-	L	L	-	-	-	L	M	-	M	L	-
CO5	M	H	-	L	L	L	M	L	L	M	L	M	L	-

g) Course Content

UNIT I INTRODUCTION TO IC TECHNOLOGY 9

Brief History of Semiconductor technology, Silicon structure and properties, Czochralski Growth, Float Zone Growth, Characterization & evaluation of Crystals; Wafer Preparation-Silicon Shaping, Etching and Polishing, Chemical cleaning.

UNIT II DIFFUSION AND OXIDATION 9

Types of diffusion, Ficks laws, junction depth, Stopping mechanisms, Gaussian implantation profile, Variations to predicted distribution, Implantation damage and annealing, Oxidation growth mechanism, Structure of SiO2, Oxidation techniques and system, Oxide properties

UNIT III DEPOSITION AND EPITAXIAL GROWTH 9

Deposition requirements and techniques: Physical and Chemical Vapor deposition, Epitaxy-Vapour Phase Expitaxy, Defects in Epitaxial growth, Metal Organic Chemical Vapor Deposition, Molecular beam epitaxy.

UNIT IV PHOTOLITHOGRAPHY AND ETCHING 9

Introduction to photo/optical lithography, Contact/ proximity printers Projection printers, Mask generation, photo resists. Dry & Wet etching, methods for anisotropic etching, Plasma etching, Reaction ion etching (RIE)

UNIT V VLSI PROCESS INTEGRATION 9

Junction and Oxide Isolation, LOCOS methods, Trench Isolation, SOI; Metallization, Planarization. Fundamental consideration for IC Processing, NMOS IC Technology, CMOS IC Technology, Bipolar IC Technology

Total : 45 Hrs

h) Learning Resources

Text Books

1. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", Tata McGraw- Hill Professional, Sixth Edition, 2014
2. S.M. Sze, VLSI Technology, 2nd Edition,Tata McGraw Hill (2017).

Reference Books

1. Gary. S. May and S. M. Sze, “Fundamentals of semiconductor fabrication”, John Wiley, First Edition, 2003.
2. Marc J. Madou, “Fundamentals of Microfabrication and Nanotechnology - Volume II”, CRC Press, Third Edition, 2011.
3. James D. Plummer, Michael D. Deal, Peter B. Griffin, “Silicon VLSI Technology: Fundamentals, Practice and Modeling”, Prentice Hall India Private Limited, 2000.
4. Stephen Campbell, “Science of Microelectronic Fabrication”, Oxford University Press, 2001

Online Resources

1. C based VLSI Design: NPTEL Swayam Course

Course Code	Course Title	L	T	P	C
10212EC148	**TESTING OF VLSI CIRCUITS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the students to understand the VLSI testing mechanism, systems using existing test methodologies, equipment, and tools. This course also provides an in-depth understanding of the testing of faults affecting VLSI circuits and a basic idea on fault tolerance after testing. The aim of this course is to introduce the concepts of algorithm development for automatic test pattern generation for digital circuit and to discuss fundamentals of design for testability.

c) Prerequisite

VLSI Design

d) Related Courses

Low Power VLSI

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basics of testing and fault modeling	K2
CO2	Classify various test generation methods for CMOS logic circuits.	K2
CO3	Interpret the testability methods for combinational & sequential CMOS circuits.	K2
CO4	Illustrate the BIST techniques for improving testability.	K2
CO5	Summarize the design strategies for memory test and fault diagnosis	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	L	L	L	L	L	-	-	-	L	L	L	-
CO2	M	H	L	M	L	-	-	-	L	-	L	L	L	-
CO3	H	M	M	L	L	-	-	-	L	-	L	M	L	-
CO4	M	M	L	L	M	-	-	-	L	-	L	M	L	-
CO5	M	M	L	L	M	-	-	L	L	-	M	L	L	L

g) Course Content

UNIT – I TESTING AND FAULT MODELS **9**

Importance of testing, Challenges, Levels of abstractions and Functional vs. Structural approach to testing-Complexity of the testing problem-Software testing-Modelling of Fault, Logical Fault - Fault detection - Fault location - Fault dominance - Test optimization and fault coverage.

UNIT – II TEST GENERATION **9**

Digital Test Pattern Generation for logic circuits-Test generation for combinational logic circuits - Testable combinational logic circuit design - Test generation for sequential circuits - design of testable sequential circuits-IDDQ testing-The LFSRs and their use in random test generation and response compression.

UNIT – III DESIGN TESTABILITY **9**

Testability analysis-Scan cell design-Scan architectures-Scan design rules-Scan design flow-Special purpose scan designs Logic and fault simulation-Adhoc and structured approaches to DFT-Various kinds of scan design-Fault models for PLAs-Bridging and delay faults and their tests-Memory Testing.

UNIT – IV TEST ALGORITHMS **9**

Design rules-Logic BIST architectures Test compression - Pattern Generators-Estimation of test length-Test points to improve testability-Analysis of aliasing in linear compression-BIST methodologies-BIST for delay fault testing - Test algorithms - Test generation for Embedded RAMs.

UNIT–V MEMORY DESIGN TESTING AND FAULT DIAGNOSIS **9**

Memory Fault Modeling-testing and Memory Design for Testability and Fault Tolerance RAM Fault Modeling-Electrical Testing-Peusdo Random Testing-Megabit DRAM Testing-Nonvolatile Memory Modeling and Testing-Application Specific Memory Testing-Fault models for diagnosis: Cause-effect diagnosis, Effect-cause diagnosis.

Total: 45 Hrs

h) Learning Resources:

Text Books:

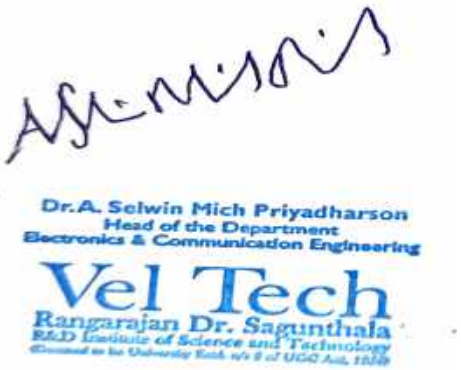
1. W. W. Wen, "VLSI Test Principles and Architectures Design for Testability", Morgan Kaufmann, Publishers. 2006
2. M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers. 2000
3. N. Jha & S.D. Gupta, "Testing of Digital Systems", Cambridge, 2003.
4. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002

Reference Books:

1. A.L.Crouch, "Design Test for Digital IC's and Embedded Core Systems", Prentice Hall International, 2002.
2. ZainalabeNavabi, "Digital System Test and Testable Design: Using HDL Models and Architectures", Springer, 2010

Online Resources:

1 https://archive.nptel.ac.in/courses/106/103/106103116/
2 https://nptel.ac.in/courses/106103016



Course Code	Course Title	L	T	P	C
10212EC149	**VLSI SIGNAL PROCESSING**	**3**	**0**	**0**	**3**

a) Course Category

Programme elective

b) Preamble

This Course provides the basic and design knowledge about VLSI Signal Processing which involves DSP Technology , Algorithmic and Numeric strength reduction and pipelining and parallel processing.

c) Prerequisite

Discrete Time Signal Processing and VLSI design

d) Related Courses

Low Power VLSI

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the design architectures for DSP algorithms.	K2
CO2	Apply retiming and algorithmic strength reduction technique optimize design parameters	K3
CO3	Identify the high level algorithm transformation to optimize design parameters	K3
CO4	Choose algorithmic strength reduction in filters and transforms	K3
CO5	Utilize pipelining and parallel processing in IIR and adaptive filters	K3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	L	L	L	-	L	-	-	L	-	-	L	-
CO2	M	H	M	M	L	-	-	-	-	-	-	-	L	L
CO3	M	H	M	M	M	-	-	-	L	M	-	M	L	L
CO4	H	M	M	M	H	L	-	-	L	L	-	M	M	L
CO5	M	H	M	H	M	L	-	L	L	L	L	M	L	L

g) Course Content

UNIT I INTRODUCTION TO DSP SYSTEMS 9

Introduction to DSP systems – Typical DSP algorithms, Data flow and Dependence graphs – critical path, Loop bound, iteration bound, Algorithm for computing Iteration bound: Longest path matrix algorithm. Minimum cycle mean algorithm

UNIT II PIPELINING AND PARALLEL PROCESSING, RETIMING AND UNFOLDING 9

Introduction to pipelining and parallel processing. Pipelining of FIR digital filters, parallel Processing –Pipelining and parallel processing for Low power - Retiming – definitions and properties, Unfolding – an algorithm for unfolding, properties of unfolding, sample period reduction

UNIT III FAST CONVOLUTION 9

Introduction – Lagrange's Interpolation formula: Cook-Toom algorithm - modified Cook-Toom algorithm, Chinese Reminder Theorem: Winograd algorithm, Cooley Tukey algorithm - Cyclic Convolution - Iterated Convolution

UNIT IV ALGORITHMIC AND NUMERICAL STRENGTH REDUCTION IN FILTERS AND TRANSFORMS 9

Algorithmic strength reduction in filters-Parallel FIR filter and parallel fast FIR filter – Fast Fourier transforms - Discrete cosine transforms –Sub-expression Elimination, Sub-expression Sharing in Digital Filters.

UNIT V PIPELINIG, PARALLEL PROCESSING IN RECURSIVE AND ADAPTIVE FILTERS 9

Introduction – pipelined interleaving in digital filters –pipelining in 1st order IIR digital filters and higher order IIR digital filters –parallel processing for IIR filter - low power IIR filter design using pipelining and parallel processing

Total: 45 Hrs

h) Learning Resources

Text Books

1. Keshab K.Parhi, "VLSI Digital Signal Processing Systems, Design and Implementation", John Wiley, Indian Reprint, 2007.
2. S.Y.Kuang, H.J. White house, T. Kailath, "VLSI and Modern Signal Processing", Prentice Hall, 1995

Reference Books

1. U. Meyer –Baese, "Digital Signal Processing with Field Programmable Arrays", Springer, Second Edition, Indian Reprint, 2007

Online Resource

1. https://books.google.co.in/books?isbn=8126510986
2. http://nptel.iitg.ernet.in /

Course Code	Course Title	L	T	P	C
10212EC219	**ANALOG CIRCUIT IC DESIGN**	**2**	**0**	**2**	**3**

a) Course Category

Programme elective

b) Preamble

The goal of this course is to understand the fundamentals of analog circuit IC design, analog CMOS sub circuit's single-stage amplifier, CMOS differential amplifier and CMOS operational amplifiers Circuits

c) Prerequisite

Analog Electronics and VLSI design

d) Related Courses

Low power VLSI

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom'sTaxonomy)
CO1	Interpret the characteristics of CMOS analog electronics circuits	K2
CO2	Explain the analog CMOS sub circuits like reference current source and current mirrors.	K2
CO3	Illustrate the CMOS single stage amplifiers in CMOS circuits	K2
CO4	Demonstrate the CMOS differential amplifier with current mirror load	K2
CO5	Summarize the two stage and cascade Op-Amps in CMOS circuits	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	-	-	-	-	-	-	-	-	-	-
CO2	H	L	L	L	M	-	-	L	L	-	-	L	L	-
CO3	M	H	H	H	M	-	L	L	-	-	-	L	L	-
CO4	M	M	L	L	M	-	-	L	-	-	-	L	L	-
CO5	M	L	L	L	M	-	-	L	-	L	-	L	L	-

g) Course Content

UNIT I INTRODUCTION AND CMOS DEVICE MODELING 6

Introduction to Analog Design - Challenges in analog design- characteristics large signal model – small signal model- single stage Amplifier-Source follower, Noise in MOSFET

UNIT II ANALOG CMOS SUB CIRCUITS 6

MOS Diode active resistor, Capacitors and resistors, current sinks and sources, Current mirrors, Current and voltage References, Bandgap Reference

UNIT III CMOS SINGLE STAGE AMPLIFIERS 6

Common-Source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration), common-gate stage, cascode stage, folded cascade stage. Frequency responses of CS stage, CD stage, CG stage, cascode stage

UNIT IV CMOS DIFFERENTIAL AMPLIFIER 6

Differential signaling, source coupled pair, Current source load, Common mode rejection ratio, CMOS Differential amplifier with current mirror load, Differential to single ended conversion.

UNIT V CMOS OPERATIONAL AMPLIFIER 6

Design of CMOS Op Amps, Compensation of Op Amps, Design Of two stage Op Amps, Power-supply Rejection Ratio of Two stage Op Amps, Cascode Op Amps.

h) List of experiments

S.No	Practical Exercises (30Hours)	CO Mapping
1.	Introduction to Software Tools	CO1
2.	Implementation of CMOS subcircuits cascode current mirror using SPICE	CO2
3.	Implementation of CMOS subcircuits Wilson and Widlar subcircuits using SPICE	CO2
4.	Frequency responses of CS stage, CD stage, CG stage amplifier using SPICE	CO3
5.	Frequency responses of CMOS Cascode amplifier using SPICE	CO3
6.	Quantitative analyses of common-mode response of Differential pair with MOS loads using SPICE	CO4
7.	Gain boosting, slew rate, power supply rejection of Two-stage CMOS op-amp using SPICE	CO5

Total: 60 Hrs

i) Learning Resources

Text Books

1. Philip E. Allen, Douglas R. Halberg, "CMOS Analog Circuit Design", Oxford University Press, 2nd Edition, 2003
2. Yannis Tsividis, "Mixed Analog-Digital VLSI Devices and Technology", McGraw-Hill Publication, 2nd Edition, 1999

Reference Books

1. Vineetha P.Gejji Analog and Mixed Mode Design - Prentice Hall, 1st Edition ,2011
2. JeyaGowriAnalogandMixedModeDesign-SapnapublishingHouse2011

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_ee26/preview/
2. https://www.youtube.com/watch?v=311XkpNGs8c

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Course Code	Course Title	L	T	P	C
10212EC220	**PHYSICAL DESIGN OF CMOS IC**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

The course focused on the Full Custom IC Design Flow and Semi-Custom IC Design Flow along with the usage of tools such as theVirtuoso Schematic Editor and Spectre, INCISIVE Simulator, GENUS and INNOVUS. It is an effective track for design and simulate designs Inverter, Basic Gates & Flip flops and 4bit Synchronous Counter. Functionality can be verified by incisive simulation and further verilog code, sdc constraints and library to synthesis and generate the gate level netlist, physical design process/Automatic Layout Generation with technology Node gpdk 90 / 45

c) Prerequisite

VLSI Design

d) Related Courses

VLSI Design Techniques, Low power VLSI

e) Course Outcomes

Upon the successful completion of the course, student will be able to:

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy/Blooms Taxonomy)
CO1	Demonstrate the issues at various stages of VLSI physical design	S3
CO2	Perform the work space creation & writing RTL code,design simulation using INCISIVE simulator and synthesis using GENUS tool	S3
CO3	Design and simulate a combinational circuit using pre-layout simulation/post synthesis simulation and physical design /automatic layout generation	S3

CO4	Demonstrate the sequential circuit using Pre- Layout Simulation/ Post Synthesis simulation and physical design /automatic Layout Generation	S3
CO5	Build analog circuit using full Custom IC Design with the usage of tools such as the Virtuoso Schematic Editor and Spectre	S3

f) Correlation of COs with POs and PSOs

	PO 1	**PO 2**	**PO 3**	**PO 4**	**PO 5**	**PO 6**	**PO 7**	**PO 8**	**PO 9**	**PO 10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	M	M	H	M	H	-	-	-	-	L	-	M	M	-
CO2	M	L	H	M	H	L	L	-	-	L	-	M	M	L
CO3	M	L	H	M	H	L	L	-	L	L	-	M	M	M
CO4	M	L	H	M	H	L	L	-	L	L	-	M	M	M
CO5	H	L	L	L	H	M	-	-	M	L	-	-	M	L

g) Course Content

Theory **15 Hrs**

Historical perspective and future trends in CMOS VLSI Circuits and system design, Overview of Physical Design flow, physical design requirements for VLSI: technology; chip performance and cost; technology updateability; reliability.

Physical design methodologies: algorithms in logic partitioning placement and routing interconnection parasitics and delays, Modeling and extraction of circuit parameters from physical layout.

Goals of CTS ,Types of Clock-tree, CTS Specification, Building clock tree, analyse the results, Fine-tuning the Clock-tree and Guidelines for best CTS results.

ECO Flow, Types of ECO, Timing & Functional ECO prep, rolling in the ECO, Performing the ECO placement and routing.

Sign-off Checks: Physical Verification(DRC,LVS,ERC), IR drop analysis, Electro-Migration Analysis, Cross-Talk (SI) analysis, Sign-off Timing analysis, Logical Equivalence checking.

h) List of experiments

S. No	CO Mapping	Practical Exercises(60 Hours)
1.	CO2	Introduction to Cadence Tools viz. Schematic and Layout Design
2.	CO2	Work Space Creation &Writing RTL Code for CMOS Inverter
3.	CO2	Semi-Custom Design of CMOS Inverter using the INCISIVE Simulator and GENUS Tool
4.	CO3	Work Space Creation & Writing RTL code and Design Simulation of CMOS AND/OR GATE
5.	CO3	Pre-Layout and Post Synthesis simulation of CMOS NAND/NOR/XOR GATE using GENUS Tool
6.	CO3	Analysis of power, area and timing by performing pre layout and post layout simulation using Cadence
7.	CO4	Design Simulation of SR/JK Flip Flop using the INCISIVE Simulator
8.	CO4	Design Synthesis of SR/JK Flip Flop using the GENUS Tool
9.	CO4	Physical Design/Automatic Layout Generation of 4 –bit Synchronous Counter
10.	CO4	Full-custom Design of a CMOS Inverting Amplifier
11.	CO5	Design and Simulate the Common Source Amplifier using analog simulator Spectre
12.	CO5	Design and Simulate the Common Gate Amplifier/ Common Drain Amplifiers
13.	CO5	Design and Simulate the Differential Amplifier
14.	CO5	Mini Project using Cadence

Total: 75 Hrs

i) Learning Resources

Text books

1. S.M.Sait,H. Youssef,"VLSI Physical Design Automation", World scientific, 1999.
2. M.Sarrafzadeh, "Introduction to VLSI Physical Design", McGrawHill(IE), 1996.
3. Wayne Wolf, "FPGA-Based System Design", Pearson Education, 1e, 2005.
4. N.A.Sherwani, "Algorithms for VLSI Physical Design Automation",(3/e),Kluwer,1999.

List of Major Equipment/Instrument/ Software with Broad Specifications

1. Cadence–Virtuoso Schematic Editor, Spectre, Virtuoso Layout Editorand Assura-Generic various nm (Licensed version)

List of Learning Websites

1. https://nptel.ac.in/courses/106/105/106105161/
2. https://www.youtube.com/watch?v=q3po_gNaTBw
3. http://www.verilog.com/

Course Code	Course Title	L	T	P	C
10212EC221	**RECONFIGURABLE COMPUTING WITH FPGA**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

Recent advances in VLSI technology have given upswing to a fresh class of computer architectures which take advantage of application-level parallelism. These reconfigurable computers can be quickly customized at the hardware level to perform exactly the computation required in hardware, overcoming the fixed hardware configurations found in many contemporary microprocessors. In this course, students will understand the state- of the-art in reconfigurable computing both from a hardware and software perspective.

c) Prerequisite

VLSI Design

d) Related Courses

System on Chip

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Dave's Taxonomy)
CO1	Build reconfigurable system using HDL and FPGAs.	S2
CO2	Perform partial reconfiguration for various applications using peripheral devices.	S3
CO3	Demonstrate an embedded system on FPGA using IP blocks.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	H	M	H	L	L	-	-	L	-	M	M	-
CO2	M	L	H	M	H	L	L	-	-	L	-	M	M	-
CO3	M	L	H	M	H	L	L	-	-	L	-	M	M	L

g) Course Content

Theory **15 Hours**

Reconfigurable Computing: Reconfigurable Computing Systems, Evolution and Characteristics, Advantages and Issues, Fundamental Concepts and Design Steps, Domain Specific Processors and Application Specific Processors.

Reconfigurable Architectures: Classification of Reconfigurable Architectures, FPGA Technology and Architectures, LUT devices and Mapping, Placement and Partitioning.

Interconnections in Reconfigurable Architectures: Routing and Switching concepts.

Programming Technology: HDL Based Programming and High level Synthesis using C, Partial Reconfiguration.

Intellectual Property Based Design: Soft core, Firm core and Hard Core, Software tools.

h) List of experiments

S. No	CO Mapping	Practical Exercises (60 Hours)
1.	CO1	Introduction to Software and Hardware Tools
2.	CO1	Design of VLSI Subsystems using Verilog HDL.
3.	CO1	Implementation of an Arithmetic and Logical Unit on FPGA.
4.	CO1	Design of Finite State Machine using Verilog HDL.
5.	CO2	Implementation and Analysis of VLSI Subsystems in FPGAs.

6.	CO2	Implementation of Filters.
7.	CO2	Interfacing GPIOs and PMODs with FPGA.
8.	CO2	Signal Generation and AD-DA Interfaces.
9.	CO2	Implementation of IP Cores in FPGA.
10.	CO2	Interfacing Sensors and Display Devices with FPGA.
11.	CO3	Study and Implementation of Micro blaze processor.
12.	CO3	Study and Implementation of Zynq Processing system.
13.	CO3	Design and Implementation of an Embedded System in FPGA.
14.	CO3	Image Processing using FPGA
15.	CO3	Interfacing GPS receiver, MEMS microphone, Pcam 5C: 5MP Fixed Focus Color Camera with FPGA.
16.	CO3	Mini Project using PMOD

Total: 75 Hrs.

i) Learning Resources

Text Books

1. S. Hauck,"Reconfigurable Computing: Theory and practice of FPGA based Computation", Morgan Kaufmann, 2008.
2. Simon,"Programming FPGA's : Getting started with Verilog:, McGraw – Hill Education,2016.
3. Wayne Wolf, "FPGA-Based System Design", Pearson Education, 1e, 2005.
4. S. Palnitkar, "Verilog HDL",Pearson Education, 1e, 2003.

Reference Books

1. Andrew Dehon , "Reconfigurable Computing – The theory and Practice of FPGA based Computing", 2008, Elsevier

Online Resources

1. Prof. Ken Eguro, University of Washington, Video lecture on Reconfigurable Computing, Sponsored by Microsoft Research
2. https://www.microsoft.com/en-us/research/video/candidate-talk reconfigurable-computingarchitectural-and-design-tool-challenges/
3. http://www.verilog.com/

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Course Code	Course Title	L	T	P	C
10212EC161	**SECURITY IN COMMUNICATION AND NETWORKING SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides basic information on fundamental concepts of security and learn about cryptosystems. Also, it aids to understand message identity, authentication and digital signature standards in network security and provide detailed study on security at different layers.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the security issues in communication systems.	K2
CO2	Discuss traditional and modern symmetric cipher	K2
CO3	Interpret network theory concepts and their application in asymmetric cipher.	K2
CO4	Summarize the message identity, authentication, and digital signature standards.	K2
CO5	Infer the security at different layers of the network.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	L	L	L	L	-	-	-	L	L	-	M	L	-
CO2	H	M	M	L	L	L	L	-	L	L	-	M	L	-
CO3	H	M	M	L	L	L	L	-	L	L	-	M	L	-
CO4	H	M	L	L	L	L	-	-	L	L	-	M	L	-
CO5	H	H	H	M	L	L	L	-	L	L	L	H	L	-

g) Course Content

UNIT I COMMUNICATION SYSTEM SECURITY 9

Physical Layer Security: Shannon's Perfect Secrecy-Wyner's Wiretap Channel-Wiretap Codes for Achievable Secrecy Using Parity Check Codes-Wiretap Codes for Achievable Secrecy Using Linear Codes. Spread-Spectrum Techniques for Anti-Jamming Attacks: Jamming Attacks-Code Division Multiple Access (CDMA) and Jamming Capacity-Bloom Filters and Channel Schemes.

UNIT II SYMMETRIC CIPHERS 9

Introduction on Security- Security Goals- OSI Security Architecture- Security Attacks- Security Services- Security Mechanisms- Substitution ciphers & its types- Transposition ciphers & its types.

UNIT III ASYMMETRIC CIPHERS 9

Number theory- Prime Number, testing of Primality, Chinese remainder theorem, Quadratic congruence. Principles of Public-Key Cryptosystems, RSA Algorithm, Diffie-Hellman Key Exchange, ElGamal Cryptosystem, Elliptic Curve Cryptography.

UNIT IV DATA INTEGRITY 9

Message Integrity & Message Authentication - Message Authentication Code (MAC)- Cryptographic Hash Functions- SHA-512 Digital Signatures- ElGamal and Schnorr Digital Signature Scheme- Digital Signature Standards.

UNIT V NETWORK AND INTERNET SECURITY 9

Transport Level Security: Web Security Issues- Transport Layer Security- HTTPS- Wireless Network Security: IEEE 802.11i Wireless LAN Security- Wireless Transport Layer Security- WAP End-to-End Security- Application Layer Security: PGP- S/MIME- IP Security- IP Security overview- IP Security Policy.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Lidong Chen, Guang Gong, "Communication System Security,"1st Edition, Routledge, 2012.
2. Behrouz A. Forouzan , Cryptography and Network security Tata McGraw-Hill, 2008
3. William Stallings, Cryptography and Network security: principles and practice", 5th Edition, Prentice Hall of India, New Delhi, 2011.
4. Frank Gross, "Smart antennas for wireless communications", McGraw-Hill Education, 2005.

Reference Books

1. S. Bose, and P. Vijaykumar , Cryptography and Network Security, Pearson India, 2016.
2. Atul Kahate, Cryptography and Network Security, 3e Tata McGraw-Hill Education, 2011.
3. Prakash C. Gupta, Cryptography and Network Security, PHI Learning Pvt. Ltd., 2014.

Online Resources

1. https://www.routledge.com/Communication-System-Security/Chen-Gong/p/book/9781439840368
2. https://dl.hiva-network.com/Library/security/Cryptography-and-network-security-principles-and-practice.pdf
3. https://gacbe.ac.in/images/E%20books/Cryptography%20and%20Network%20Security%20-%20Prins%20and%20Pract.%205th%20ed%20-%20W.%20Stallings%20(Pearson,%202011)%20BBSbb.pdf
4. https://resources.infosecinstitute.com/certification/communications-and-network-security/

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Course Code	Course Title	L	T	P	C
10212EC162	VEHICULAR COMMUNICATION AND INTERNETWORKING TECHNOLOGIES	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

The course will provide fundamentals of vehicular communication, security and privacy issues with mobility modelling techniques and different protocol architectures for the connectivity between the vehicle and the cloud. This course also helps to understand about the vehicular networks and its bus system and error handling.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the vehicular communication and its standards	K2
CO2	Illustrate the wireless propagation and channel characteristics in vehicular communication	K2
CO3	Interpret the fundamentals of vehicular networks	K2
CO4	Discuss the bus system and error handling in vehicular networks.	K2
CO5	Infer the security and safety issues in vehicular communication with mobility modeling techniques.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	L	L	L	L	L	L	-	L	H	L	L	L	L
CO2	H	L	L	L	L	L	L	-	L	M	L	L	L	-
CO3	H	L	L	L	-	-	-	L	-	M	-	L	-	-
CO4	H	L	M	L	L	-	-	-	L	H	-	L	L	-
CO5	H	L	M	L	-	L	L	L	-	H	-	L	L	-

g) Course Content

UNIT I VEHICULAR COMMUNICATION 9

Vehicular Communication Principles, Vehicle-to-X (V2X) Communication for Intelligent Transportation Systems, V2X communication regimes, Standards and Technologies – layered architecture – Infrastructure-based vs. infrastructure-less technologies – Long-Term Evolution, Dedicated Short Range Communication (DSRC), Wireless Access in Vehicular Environments (WAVE).

UNIT II WIRELESS CHANNEL CHARACTERISTICS 9

Fading: Path loss, shadowing, small-scale fading, delay spread and doppler spread, coherence bandwidth and coherence time, techniques for combating wireless channel impairments, Physical Layer: digital modulation schemes in DSRC, design of OFDM in DSRC (symbol time, sub-carrier spacing, pilot spacing), Medium Access Control (MAC): 802.11p EDCA, multi-channel operation in the WAVE MAC.

UNIT III VEHICULAR NETWORKS 9

Review of Vehicular Networks - Cross-System Functions, Requirements for Bus Systems, Classification of Bus Systems, Application of Vehicle, Coupling of Networks, Examples of Networked Vehicles.

UNIT IV BUS SYSTEM 9

CANFD Protocol: Overview of CANFD bus architecture – Physical Layer – Topology – frame architecture – CAN vs CANFD – Bit stuffing and CRC – Delay compensation – Error Handling – LIN Protocol: Frame Format – Bus Timing – Topology – Error detection – Sleep/Wake-up modes – Advanced Frames – MOST Protocol: Physical Layer – Network and Fault Management – Diagnostics – Interface Controller – Applications.

UNIT V SAFETY APPLICATION AND MOBILITY MODELLING 9

Safety and non-safety applications, Vehicular Network Simulation – bidirectionally coupled road traffic and communication network simulators for vehicular network simulation – mobility models – Random models, flow and traffic models, behavioral models, trace and survey-based models, joint transport and communication simulations

Total 45 Hours

h) Learning Resources

Text Books

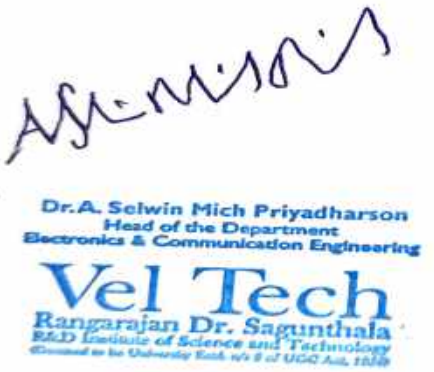
1. Christophe Sommer and Falko Dressler, "Vehicular Networking", Cambridge University Press, 2014.
2. Hannes Hartenstein and Kenneth Laberteaux (eds.), "VANET Vehicular Applications and Inter-networking Technologies", John Wiley & Sons, 2009.

Reference Books

1. Claudia Campolo, Antonella Molinaro and Riccardo Scopigno, "Vehicular ad hoc Networks: Standards, Solutions, and Research", Springer, 2015.
2. Theodore S. Rappaport, "Wireless Communications: Principles and Practice", Second Edition, Prentice Hall, 2001.
3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.
4. M. Emmelmann, B. Bochow and C. C. Kellum, Vehicular Networking: Automotive Applications and Beyond, Wiley, 2010.
5. Dominique Paret, "Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe-by-Wire", Wiley,2007.
6. M. Watfa, Advances in Vehicular Ad-Hoc Networks: Development and Challenges, Information Science Reference, 2010.
7. H. Moustafa, Y. Zhang, Vehicular Networks: Techniques, Standards, and Applications, CRC Press, 2009.

Online Resources

1. http://www.cs.odu.edu/~mweigle/courses/cs795-s07/
2. http://www.cs.odu.edu/~mweigle/courses/cs895-s07/



Course Code	Course Title	L	T	P	C
10212EC163	SENSORS AND WEARABLE TECHNOLOGY	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

In this course, students will learn the different types of sensors and their fundamentals, self-generating and smart sensors used in modern electronics. Students are also learning how sensors are used in wearable technology and its application to society.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basics of sensors and wearable technologies	K2
CO2	Discuss the various types of sensors.	K2
CO3	Illustrate the self generating sensors and smart sensors	K2
CO4	Summarize the importance of wearable technologies.	K2
CO5	Interpret the application of wearable devices in telecommunication and biomedical applications	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	-	-	-	-	L	-	-	L	L	-	-
CO2	H	M	M	M	-	-	-	-	-	-	-	L	-	-
CO3	M	M	M	-	-	-	L	L	-	-	-	L	M	-
CO4	M	M	M	-	-	-	-	-	-	-	-	L	M	-
CO5	M	M	M	-	L	L	L	L	L	-	L	L	M	-

g) Course Content

UNIT I SENSORS AND WEARABLE TECHNOLOGY 9

General concepts and terminology of Sensor Systems-Transducers classification-sensors and actuators-General input-output configurations-Static and dynamic characteristics of measurement system-Motivation for development of Wearable Devices –
Sensors for wearable systems-Inertia movement sensors - Respiration activity sensor - Inductive Plethysmography-Impedance plethysmography- pneumography- Wearable ground reaction force sensor- GSR- Radiant thermal sensor- Wearable motion sensors.

UNIT II RESISTIVE AND REACTIVE SENSORS 9

Resistive Sensors-Potentiometers-strain gages (piezo-resistive effect)- resistive temperature detectors (RTD)-Reactive Sensors - variable reluctance sensors - Hall effect - Eddy current sensors- Linear variable differential transformers (LVDT)-variable transformers-Self-generating Sensors- Mechanical Transducers-Smart Sensors.

UNIT III SELF GENERATING SENSORS AND SMART SENSORS 9

Thermoelectric sensors-piezoelectric sensors-pyroelectric sensors-photovoltaic sensors-electrochemical sensors - IEEE 1451 standard & Transducer Electronic Datasheets (TEDs)-Overview of various smart sensors- Digital temperature sensor (DS1621, TMP36GZ)-Humidity sensor (DHT11, DHT22, FC28)- IR sensor (FC51).

UNIT IV EMERGENCE OF WEARABLE DEVICES 9

The emergence of wearable computing and wearable electronics- Types of wearable sensors: Invasive- Non-invasive- Intelligent clothing- Industry sectors' overview – sports - healthcare-Fashion and entertainment- military- environment monitoring-mining industry- public sector and safety.

UNIT V APPLICATIONS OF WEARABLE SYSTEMS 9

Cameras in wearable devices- Applications in safety and security- navigation- Enhancing sports media- Automatic digital diary- Wearable devices with Global Positioning System (GPS) - integration for tracking and navigation. The Meta Wearables – Textiles and clothing- Social Aspects: Interpretation of Aesthetics- Adoption of Innovation-On-Body Interaction- Medical Diagnostics- Medical Monitoring-Patients with chronic disease- Hospital patients- Elderly patients- Multi parameter monitoring.

Total: 45Hrs

h) Learning Resources

Text Books

1. B. C. Nakra, K.K. Choudhury, "Instrumentation, Measurement and Analysis" 3 Edition, Tata McGraw, 2009.
2. Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2011.
3. Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian, "Body Area Networks Safety, Security, and Sustainability", Cambridge University Press, 2013.

Reference Books

1. Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 3rd ed., Springer, 2010.
2. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", Elsevier, 2014
3. Jon. S. Wilson, "Sensor Technology Hand Book", Elsevier Inc., 2005.
4. Subhas C. Mukhopadhyay, "Wearable Electronics Sensors-For Safe and Healthy Living", Springer International Publishing, 2015.
5. Hang, Yuan-Ting, "Wearable medical sensors and systems", Springer-2013.

Online Resources

1. Wearable Technologies and Sports Analytics | Coursera
2. https://www.te.com/usa-en/industries/sensor-solutions/applications/sensor-solutions-for-consumer-wearable-applications.html?tab=pgp-story
3. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC6540270/
4. https://www.nature.com/articles/s41746-019-0150-9
5. https://www.iotforall.com/sensors-that-matter-wearables

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Course Code	Course Title	L	T	P	C
10212EC164	**SENSORS FOR STRUCTURAL HEALTH MONITORING**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The course will provide the students with in-depth knowledge of technologies in Structural Health Monitoring (SHM) using smart materials as sensing and actuating elements to interrogate the structures. Damage detection techniques will be discussed and applied to different types of structures. Advanced signal processing techniques will be discussed to make the damage more quantifiable.

c) Prerequisite

Nil

d) Related Course

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the basics of structural health monitoring.	K2
CO2	Interpret the feasibility of present-day sensor technology used in SHM devices.	K2
CO3	Classify among the data acquisition and transmission methods used to determine the structural damage.	K2
CO4	Explain the pattern recognition and feature extraction techniques for damage identification.	K2
CO5	Demonstrate the strategies to identify the flaws and to detect them.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	L	L	-	-	L	M	L	H	M	M	-	-
CO2	H	M	H	L	-	H	H	H	-	H	M	L	H	-
CO3	H	M	H	L	L	L	H	L	-	H	M	L	L	H
CO4	H	M	H	L	L	L	L	H	-	H	M	L	L	H
CO5	H	M	H	H	L	L	H	H	-	H	M	H	-	H

g) Course Content

UNIT I STRUCTURAL HEALTH MONITORING **9**

Need of Structural Health Monitoring: Definition & Concept of SHM, SHM & Biomimetic Comparison of SHM with NDT, Types - Components of SHM - Procedure of SHM - Objectives & Operational Evaluations of SHM - Advantages of SHM

UNIT II SENSOR TECHNOLOGY 9

Sensors, Transducers & Actuators for SHM, Classification of Sensors, and Characteristics & Working, Principles of Various types of Sensors, Piezoelectric wafer active sensors Elastic waves in solid structures - Concept of Smart Materials & Smart Structures with SHM: Piezoelectric, Shape Memory Alloys, ER & MR Fluids.

UNIT III FEATURE EXTRACTION METHODS 9

Data Acquisition Systems: Types, Data acquisition and cleansing procedures, Hardware & its Components, Identifying damage sensitive properties - signal processing: Fourier and short-term Fourier transform, wavelet analysis.

UNIT IV PATTERN RECOGNITION 9

State-of-Art damage identification and pattern recognition methods, Neural Network Approach: Ideas of neural networks, Neural networks in damage detection, localization and quantification, Multi-layer Perceptron (MLP), Feature Extraction Algorithms.

UNIT V FLAW DETECTION 9

SHM based flaw detection in mechanical structures- Integrity and damage recognition in plates and pipes, defect identification in weld joints, Wear monitoring in cutting tools

Total: 45 Hrs

h) Learning Resources

Text Books

1. Daniel Balageas, Claus-Peter Fritzen and Alfredo Guemes, Structural Health Monitoring, John Wiley & Sons, 2006.
2. Victor Giurgiutiu, Structural Health Monitoring with Piezoelectric wafer Active Sensors, Academic Press, 2008.
3. Douglas E Adams, Health Monitoring of Structural Materials and Components Methods with Applications, John Wiley and Sons, 2007.

Reference Books

1. J. P. Ou, H. Li and Z. D. Duan, Structural Health Monitoring and Intelligent Infrastructure, Volume 1, Taylor and Francis Group, London, UK, 2006.
2. Tinh Quoc Bui, Le Thanh Cuong, and Samir Khatir, Structural Health Monitoring and Engineering Structures, Select proceedings of SHM and ES 2020, Springer, Edition 2, 2021.
3. Alexandre Cury, Diogo Ribeiro, Filippo Ubertini, Michael D. Todd, Structural Health Monitoring Based on Data Science Techniques, Springer, 2021.

Online Resources

1. https://archive.nptel.ac.in/courses/114/106/114106046/
2. https://research.csiro.au/data61/structural-health-monitoring
3. https://www.hindawi.com/journals/ace/2010/724962/
4. https://www.ndt.net/events/NDTCanada2014/app/content/Slides/40_Tamutus.pdf

Course Code	Course Title	L	T	P	C
10212EC165	**IOT IN AUTOMOTIVE SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides an introduction to the basic concepts of IoT and in-vehicle networking standards for communication between the various devices in the vehicle and requirement of sensors and their integration in different automotive systems.

c) Prerequisite

NIL

d) Related Courses

NIL

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe the evolution of internet technology and the basics of IoT	K2
CO2	Apply IoT protocols in cellular and industry applications.	K3
CO3	Discuss automotive parts and the importance of electronics in automotive systems.	K2
CO4	Explain the basic automotive parts and the need for sensor integration in different automotive systems	K2
CO5	Identify the modern trends and technical solutions in the automotive systems.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	L	-	-	L	-	-	L	-	-	-	-	-
CO2	H	M	L	-	-	L	-	-	L	-	-	L	-	-
CO3	M	H	L	-	-	L	-	-	L	-	-	-	-	L
CO4	H	H	L	-	-	L	-	-	L	-	-	L	-	M
CO5	L	H	L	-	-	L	-	-	L	-	-	M	L	L

g) Course Content

UNIT I EVOLUTION OF IOT **9**

Review of computer communication concepts: OSI layers, components- packet communication- Networks- TCP-IP, IPv4 addressing, IPv6 addressing - IoT architecture reference layer- Characteristics of IoT sensor nodes - Edge computing - cloud and peripheral cloud - single board computers - Open-source hardware - Examples of IoT infrastructure.

UNIT II IOT PROTOCOLS AND ITS APPLICATIONS **9**

UDP- MQTT brokers, publisher, subscriber models- HTTP- COAP -XMPP and gateway protocols - IoT Communication Pattern - IoT protocol Architecture - Selection of Wireless technologies : 6LoWPAN, Zigbee, WIFI, BT, BLE,SIG,NFC, LORA, LiFi, WiDi- IoT for smart cities , health care, agriculture - Smart meters- M2M- Web of things- Cellular IoT-Industrial IoT- Industry 4.0 -IoT standards.

UNIT III AUTOMOTIVE SYSTEMS **9**

Power-train - Combustion Engines, Transmission - Differential Gear, Braking Systems - Introduction to Modern Automotive Systems and need for electronics in Automobiles - Application areas of electronics in the automobiles - Possibilities and challenges in the automotive industry- Enabling technologies and Industry trends.

UNIT IV SENSORS IN AUTOMOTIVE SYSTEMS **9**

Lambda sensors- Exhaust temperature sensor- NOx sensor- PM sensor- Fuel quality sensor- Level sensor- Torque sensor- Speed sensor- Mass flow sensor- Manifold pressure sensor- Wheel speed sensors/direction sensors - Steering position sensor (multi turn)- Acceleration sensor (inertia measurement), Brake pneumatic pressure sensor, ABS sensor, Electronic stability sensor.

UNIT V MODERN TRENDS AND TECHNICAL SOLUTIONS 9

Enabling Connectivity by Networking: In vehicle communication standards, CAN and LIN, Telematic solutions, Portable or embedded connectivity- Endorsing Dependability in Drive-by wire systems: Terminology and concepts, Why by-wire, FLEXRAY, Requirements on cost and dependability, Drive-by-wire case studies- prototype development- Future of In vehicle communication.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016
2. Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.
3. Robert Bosch GmpH, "Automotive Electrics, Automotive Electronics: Systems & Components", 5th Edition, BOSCH, 2014.
4. John Turner, "Automotive Sensors", 1st Edition, Momentum Press, New York, 2010

Reference Books

1. LuYan, Yan Zhang, Laurence T. Yang, Huansheng Ning, The Internet of Things: From RFID to the Next-Generation Pervasive Network, Aurbach publications, March,2008.
2. Vijay Madisetti , Arshdeep Bahga, Adrian McEwen (Author), Hakim Cassimally "Internet of Things A Hands-on-Approach" Arshdeep Bahga & Vijay Madisetti, 2014.
3. Dipl Ing H.Bauer "Automotive Sensors Handbook", 8th Edition, Bentley Publishers, BOSCH, 2011
4. Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, IwaoYokomori, "Sensors for Automotive Technology", 4th Edition, Wiley, New York, 2010

Online Resources

1 https://archive.nptel.ac.in/courses/106/105/106105166/
2 https://onlinecourses.nptel.ac.in/noc21_ee85/preview
3 https://www.allaboutcircuits.com/technical-articles/internet-of-things-
4 communication-protocols-iot-data-protocols/
5 https://www.slideshare.net/abdulrabbasi33/sensors-actuators

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Course Code	Course Title	L	T	P	C
10212EC166	**M2M COMMUNICATION WITH IoT AND LTE**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The primary aim of this course is to understand the fundamental requirements and challenges of machine-to-machine (M2M) communication and the integration of such technologies into existing infrastructure with the implementation of internet of things (IoT) and long-term evolution (LTE) technologies.

c) Prerequisite

Nil

d) Related Courses

IoT in Automotive systems

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the fundamentals of M2M communication, its building blocks, and their characteristics.	K2
CO2	Explain the optimization principles and security constraints in M2M communication.	K2
CO3	Illustrate the internet of things fundamentals and its role in M2M communication.	K2
CO4	Infer the role of LTE in M2M communication	K2
CO5	Identify the various applications of M2M communication in industry and real-life scenarios.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	L	L	-	-	-	L	L	-	-	-	-
CO2	M	L	L	L	-	-	-	-	L	L	-	-	-	L
CO3	H	L	L	L	-	M	-	-	-	L	-	L	L	L
CO4	H	L	M	L	L	M	-	-	-	L	-	L	L	-
CO5	M	L	M	L	L	H	L	-	L	L	L	M	M	-

g) Course Content

UNIT I M2M COMMUNICATION 9

Machine to Machine Communication, M2M Standards, Architecture of M2M, High-Level System Architecture, ETSI M2M Service Capabilities, REST Architectural Style for M2M, Resource Based M2M Communication and Procedures, M2M Over a Telecommunications Network.

UNIT II M2M OPTIMIZATION AND SECURITY 9

M2M communication scenarios, Data connections for M2M Applications, 3GPP Standardization of Network Improvements for Machine Type Communications, M2M Value-Added Services, IPv6 for M2M, Security Characteristics of Cellular M2M, Standardization efforts on securing M2M and MTC Communication.

UNIT III INTERNET-OF-THINGS (IoT) FOR M2M 9

M2M towards IoT: General technology and scientific trends, M2M-IoT value chains, An emerging industrial structure for IoT, M2M to IoT – An architectural overview, M2M and IoT analytics – IoT reference model, Information model, Functional model, Communication model.

UNIT IV LONG TERM EVOLUTION (LTE) FOR M2M 9

M2M enhancements for LTE Networks, M2M over LTE: LTE-M, LTE-M Categories, LTE-A Pro: Requirements and implementation, Case study: LTE-A radio planning for Sensor devices deployment.

UNIT V M2M APPLICATIONS 9

Applications in Various Sectors: Automotive, Smart Telemetry, Smart cities, Healthcare, Safety and Surveillance, Agriculture, Supply Chain, M2M Industrial Automation – Case studies: Industrial automation, Agriculture, Healthcare.

Total: 45 Hrs

h) Learning Resources

Text Books

1. David Boswarthick, Omar Elloumi, and Oliver Hersent, " M2M Communications - A System Approach", Wiley Publications, 2012.
2. J. Holler, Vlasios Tsiatsis, Catherine Mulligan, Stefan Avesand, David Boyle Machine-to-Machine to the Internet of Things: Introduction to a New Age of Intelligence, Academic Press, 1st edition, 2014.
3. Erik Dahlman, Stefan Parkvall and Johan Skold", 4G: LTE advanced pro and the road to 5G", 3 rd Edition, Elsevier Publications, 2011.

Reference Books

1. Oliver Hersent, David Boswarthick, Omar Elloumi, "The Internet of Things: Key Applications and Protocols", 2nd Edition, Wiley Publications, 2012.
2. Erik Dahlman, Stefan Parkvall "5G NR: The Next Generation Wireless Access Technology", Elsevier Publications, 2018.
3. Bahga and V. Madisetti, "Internet of Things, A hands-on approach",1st edition, CreateSpace Independent Publishing Platform, 2014.
4. C. Anton-Haro and M. Dohler, Machine-to-machine (M2M) Communications: Architecture, Performance and Applications, Woodhead Publishing, 2015.

Online Resources

1. https://www.coursera.org/lecture/m2m-iot-interface-design-embedded-systems/introduction-to-m2m-and-iot-f78Vg
2. https://onlinecourses.nptel.ac.in/noc20_cs66
3. https://www.youtube.com/watch?v=Am9SW1T_Qvs

Course Code	Course Title	L	T	P	C
10212EC167	**FLEXIBLE ELECTRONICS FOR AUTOMOBILE APPLICATIONS**	**3**	**0**	**0**	**3**

a. Course Category:
Programme Elective

b. Preamble:
This course describes the role of electronics in automotive vehicles, materials, processing, substrates, device, and applications. Students will learn how science and technology are applied to the emerging flexible electronics area.

c. Prerequisite Courses:
Nil

d. Related Courses:
Nil

e. **Course Outcomes**:

On successful completion of this course, the student will be able to:

CO Nos.	Course Outcomes	Level of learning domain (Based on revised Bloom's)
CO1	Explain the electrical and electronic systems in the vehicle	K2
CO2	Describe the circuit fundamentals and basic test equipment	K2
CO3	Discuss the fundamentals of electronics.	K2
CO4	Demonstrate the digital instruments and their measurements.	K2
CO5	Illustrate the computer and microprocessors applied in automobile systems.	K2

f) Correlation of COs with POs and PSOs

COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	H	L	M	M	-	L	-	L	-	L	-	L	-
CO2	H	L	M	M	L	L	-	L	-	M	-	L	M	-
CO3	L	M	H	M	M	-	L	-	L	-	L	L	L	-
CO4	H	H	M	M	L	L	-	-	-	M	-	-	L	-
CO5	L	M	L	H	L	-	-	L	-	-	L	-	M	-

g) **Course Content**:

UNIT I: ELECTRICAL AND ELECTRONIC SYSTEMS IN THE VEHICLE 9

Motronic-engine management System, Electronic diesel control (EDC), Lighting technology, Electronic stability program (ESP), Sensors – measuring principles, sensor types. Actuators- working principles, types, Automotive networking.

UNIT II: CIRCUIT FUNDAMENTALS AND BASIC TEST EQUIPMENTS 9

Circuit fundamentals and basic test equipment: voltage, current, resistance, circuits components, series and parallel circuits, purpose of voltmeters, measuring voltage drop, connecting the voltmeter, types of ammeters, current probes, reading and interpreting ohmmeter readings, continuity testing. Vehicle circuits: circuit components, analyzing series and parallel circuits, control circuits, diagnosing open and short circuits.

UNIT III: ELECTRONIC FUNDAMENTALS 9

Solid state devices, electronic control input devices, diagnosing and servicing electronic control input devices, integrated circuits as input devices, diagnosing and servicing ICs, oxygen sensors, diagnosing and servicing oxygen sensors. Digital Storage Oscilloscope: voltage and time setting, DSO trigger and slope, using a current probe with DSO, using the DSO‟s multiple-trace capability.

UNIT IV: DIGITAL INSTRUMENTS AND MEASUREMENTS 9

Basic concept of Digital measurement in automobiles, Types of errors, standards, Device under calibration, calibration techniques, Analysis of measurement data, Instrumentation systems using sensors, Data acquisition systems using digital methods including PC based systems

UNIT V: COMPUTER AND MICROPROCESSORSIN AUTOMOBILE SYSTEMS 9

Computer and Microprocessors, Microprocessor and Microcomputer controlled devices in automobiles, Architecture of an ECU, Electronic engine control: Input, output devices, electronic fuel control system, engine control operating modes, Electronic ignition systems, and Spark advance correction schemes

Total: 45 Hrs

h) Learning Resources

Text Books

1. R BOSCH Gmbh., Bosch Automotive Electrics and Automotive Electronics, (5e), Springer Vieweg (eBook), 2007.
2. Al Santini, Automotive Technology, Electricity and Electronics, Cengage Publishers, 2011.
3. Douglas V Hall, Microprocessor and Interfacing: Programming and Hardware, 2ND Edition, TMH, 2003

Reference Books:

1. William B.Ribbens Butterworth, Heinemann, "Understanding Automotive Electronics", 5th Edition, 1998.
2. Ramesh S. Gaonkar , "Microprocessor Architecture, Programming, Applications with the 8085",5 November 1998

Online Resources

1. https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%2010.pdf
2. https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%209.pdf
3. https://www.ll.mit.edu/outreach/radar-introduction-radar-systems-online-course

Course Code	Course Title	L	T	P	C
10212EC168	BASICS OF EMBEDDED SYSTEM	3	0	0	3

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to acquire knowledge on complete design of an embedded system with functional requirements for hardware and software components including processor, sensors, and subsystem interfaces to connect real world applications systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify embedded systems based on their characteristics, including single-purpose systems, real-time systems, networked systems, and mobile systems.	K2
CO2	Summarize of 8051 microcontroller: architecture, memory, addressing, instruction set, interrupts, I/O ports, assembly language.	K2
CO3	Explain the peripheral interfacing required to design an embedded system.	K2
CO4	Relate various types of serial communication protocol.	K2
CO5	Outline the various aspects of complete embedded system design through applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CO2	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CO3	M	-	-	-	-	-	-	H	-	-	-	-	M	M
CO4	M	-	L	-	-	-	-	-	-	-	-	M	L	-
CO5	M	-	-	-	-	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I FUNDAMENTALS OF EMBEDDED SYSTEMS 8

Embedded system definition, classification of embedded system, embedded system design process, reset circuits.

UNIT II MICROCONTROLLER 10

Difference between microprocessor and microcontroller, Overview of the architecture of 8051 microcontroller, Memory organization, and special function registers, Addressing Modes, Instruction formats, Instruction set, Interrupt and Interrupt routines, I/O Ports, Assembly Language programming.

UNIT IIIINTERFACING PERIPHERALS USING EMBEDDED C 10

Embedded C Programming structure, logical operations, IO programming, delay programming, timer and counter programming, serial port programming, LCD interfacing, and keypad interfacing.

UNIT IV COMMUNICATION PROTOCOL 8

Communication Basics, Serial communication protocols: UART, RS232, RS485, SPI, USB, Introduction to I2C and CAN.

UNIT V APPLICATIONS 9

Smart Agriculture System, Intelligent Transportation Systems Autonomous Drone Navigation System.

Total: 45 Hours

h) Learning Resources

Text books

1. RajKamal, “Embedded Systems: Architecture, Programming and Design”, Second Edition, Tata Mc Graw-Hill Education, 2011.
2. Mohamed Ali Mazidi, Janice Mazidi, Rolin Mc Kinlay, “The 8051 Microcontroller

and Embedded Systems: Using Assembly and C", Second Edition, Pearson education, 2011.

Reference Books:

1. M.Natale, A.Ghosal, "Understanding the CAN Communication Protocol", Springer, 2012.
2. Don Anderson, "Universal Serial Bus System Architecture", Addison Wesley, 2007.

Online Resources

1 https://www.scribd.com/document/332179045/101535193-embedded-systems-by-rajkamal-pdf-pdf#

Course Code	Course Title	L	T	P	C
10212EC169	**SENSORS AND TRANSDUCERS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The purpose of this course is to acquire knowledge on complete design of an embedded system with functional requirements for hardware and software components including processor, sensors, and subsystem interfaces to connect real world applications systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the concepts of measurement technology.	K2
CO2	Illustrate the working principle and characteristics of motion, proximity and ranging sensors	K2
CO3	Infer the working principle and characteristics of force, magnetic and heading sensors	K2
CO4	Compare the working principle and characteristics of optical, pressure and temperature sensors	K2
CO5	Interpret the operation and applications of modern industrial transducers	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	L	M	L
CO2	M	L	M	L	L	-	-	L	-	-	-	L	M	L
CO3	M	L	-	M	-	-	L	-	L	L	-	-	L	L
CO4	M	L	L	M	M	-	-	L	L	L	-	-	M	L
CO5	M	L	M	M	M	-	-	L	-	-	-	L	M	L

g) Course Content

UNIT I FUNDAMENTALS OF MEASUREMENT SYSTEMS 9

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.

UNIT II MOTION, PROXIMITY AND RANGING SENSORS 9

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III FORCE, MAGNETIC AND HEADING SENSORS 9

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

UNIT IV OPTICAL, PRESSURE AND TEMPERATURE SENSORS 9

Photo conductive cell, photo voltaic, Photo resistive, Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors – Smart Sensors – Film sensor, MEMS & Nano Sensors, LASER sensors.

UNIT V ADVANCED TRANSDUCERS 9

Energy harvesting transducers– Hall Effect transducer – Magneto resistor -Digital displacement transducer– Fiber optic sensor - Introduction to SQUID sensor, Hyper spectral sensor, Touch screen sensor, Smart Transducer.

Total : 45 Hours

h) Learning Resources

Text Books

1) Ernest O. Doebelin,- Measurement system, 7th Edition, Tata McGraw Hill Education Private Ltd, New Delhi, 2019.
2) A.K. Sawhney, A course in Electrical & Electronic Measurement and Instrumentation, DhanpatRai and Company Private Limited, 2015.

Reference Books

1) D. Patranabis, Sensors and Transducers, 2nd Edition, Prentice Hall of India, 2010.
2) John P.Bentley, Principles of Measurement Systems, 4th Edition, Pearson Education, 2004.
3) Neubert H.K.P., ―Instrument Transducers – An Introduction to their Performance and Design, Oxford University Press, Cambridge, 2003.
4) Murthy D.V.S., ―Transducers and Instrumentation‖, 2nd Edition, Prentice Hall of India Private Limited, New Delhi, 2010.
5) S.Renganathan, ―Transducer Engineering, Allied Publishers, 2005.

Online Resources

1. Electro Schematics - Sensor Circuits Section:
   Website: https://www.electroschematics.com/category/sensors/
2. All about Circuits - Sensors Section:
   Website: https://www.allaboutcircuits.com/technical-articles/category/sensors/

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Course Code	Course Title	L	T	P	C
10212EC170	**EMBEDDED SECURITY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The course provides an overview principle of secure embedded systems, analysis of threats, and development of security policies from the system and threat analysis.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, student will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic concepts involved in embedded systems security.	K2
CO2	Relate how to architect a system for high assurance requirements.	K2
CO3	Interpret embedded hardware and firmware to detect vulnerabilities and opportunities for improving security.	K2
CO4	Summarize various data protection protocols for embedded systems.	K2
CO5	Outline the embedded system security issues in real time scenarios.	K2

f) Correlation of COs with POs and PSOs

COs	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	M	L	-	-	-	M	M	M	L	L	M
CO2	M	H	M	-	H	-	-	-	M	L	L	H	H	H
CO3	M	-	L	M	H	-	-	-	L	L	L	L	M	M
CO4	M	-	L	M	H	-	-	-	L	L	L	L	M	M
CO5	L	L	L	-	-	-	-	-	L	L	L	M	M	M

g) Course Content

UNIT I INTRODUCTION TO EMBEDDED SYSTEMS SECURITY 9

Security – Embedded systems – Embedded security trends – Security policies – Security threats – Multiple independent levels of security – Core embedded OS security requirements.

UNIT II SECURE EMBEDDED SOFTWARE DEVELOPMENT 9

Principles of High-Assurance Software Engineering – Minimal Implementation – Component Architecture: Runtime Componentization - Secure Development Process: Change Management, Development Tool Security, Secure Coding, Software Testing and Verification.

UNIT III EMBEDDED CRYPTOGRAPHY 9

Introduction – Cryptographic Modes – Block Ciphers – Authenticated Encryption – Public Key Cryptography – Key Agreement – Public Key Authentication – Cryptographic Hashes – Message Authentication codes – Key Management for Embedded Systems.

UNIT IV DATA PROTECTION PROTOCOLS FOR EMBEDDED SYSTEMS 9

Introduction –Generalized Model – Choosing the Network layer for Security – Ethernet Security Protocols – IPsec – SSL/TLS – Embedded VPN Clients – DTLS – SSH – Custom Network Security Protocols – Application of Cryptography within Network Security Protocols.

UNIT V EMBEDDED SECURITY APPLICATIONS 9

Embedded Network Transactions – Automotive Security – Secure Android – Next-Generation Software – Defined Radio.

Total: 45 Hours

h) Learning Resources

Text Books

1. David Kleidermacher , Mike Kleidermacher, 'Embedded systems security: practical methods for safe and secure software and systems', 2012.
2. William Stallings, 'Cryptography and network security principles and practice', Seventh edition, Pearson Education Limited 2017.
3. Bruce schneier, "Applied Cryptography", Second edition, John Wiley and Sons, 2012

Reference Book

1. Ross J. Anderson, 'Security Engineering: A Guide to Building Dependable Distributed Systems', 2nd Edition, 2012.

Online Resources

1. https://www.sciencedirect.com/book/9780123868862/embedded-systems-security
2. http://www.cs.vsb.cz/ochodkova/courses/kpb/cryptography-and-network-security_-principles-and-practice-7th-global-edition.pdf

Course Code	Course Title	L	T	P	C
10212EC171	**FLEXIBLE ELECTRONICS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the basic understanding of measurement and instrumentation systems and the insight of the resistive sensors and its applications in real life. This course also introduces the concept of classification of sensors such as reactive sensors and self-generating sensors and its applications in real life. It makes the students to get familiar with the characteristics, working principle and application of special purpose transducers. The course 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.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic idea of measurements, characteristics and the errors associated with measurements.	K2
CO2	Outline the concept of resistive sensors which can be employed for real life applications.	K2
CO3	Relate the concept of reactive sensors employed for real life applications.	K2
CO4	Compare the working principle of special purpose sensors and the need for developing smart sensors.	K2
CO5	Illustrate the wearable devices and its design constraints for measuring physical and biological signals.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO1	H	H	M	L	L	L	-	-	-	-	-	L	L	-
CO2	H	H	-	M	L	L	-	-	L	L	-	L	L	-
CO3	H	H	L	M	-	L	-	-	-	-	-	L	L	-
CO4	H	H	H	M	L	L	L	L	L	L	L	L	L	L
CO5	M	M	L	L	L	L	L	L	-	L	-	L	L	-

g) Course Content

UNIT I INTRODUCTION TO MEASUREMENTS 9

Functional Elements of a Measurement System and Instruments, Applications and Classification of Instruments, Types of measured Quantities, General concepts and terminology of Sensor systems, Transducers classification-sensors and actuators, General input-output configurations, Static and dynamic characteristics of measurement system.

UNIT II RESISTIVE SENSORS 9

Resistive sensors- Potentiometers, strain gages (piezo-resistive effect), resistive temperature detectors (RTD), thermistors, magneto resistors, light dependent resistor (LDR), resistive gas sensors. Wearable applications: Strain sensor for monitoring Physiological signals, body movement.

UNIT III REACTIVE SENSORS **9**

Inductive sensors - variable reluctance sensors, Hall effect, Eddy current sensors, Linear variable differential transformers (LVDT), variable transformers, magneto-elastic, magneto-resistive, and magnetostrictive sensors. Capacitive sensors- variable capacitor, differential capacitor. Wearable applications: Body/textile antennas for wireless data transmission.

UNIT IV SELF GENERATING SENSORS **9**

Thermoelectric sensors, piezoelectric sensors, pyro electric sensors, photovoltaic sensors, electrochemical sensors, Wearable applications: temperature sensitive fabric, electrochemical sensors.

UNIT V SCOPE OF WEARABLE DEVICES **9**

Role of Wearable, Challenges and Opportunities, Attributes of Wearable, The Meta Wearable – Textiles and clothing, Social Aspects: Interpretation of Aesthetics, Adoption of Innovation, On-Body Interaction; Case Study: Google Glass, health monitoring.

Total: 45 Hours

h) Learning Resources

Text Books

1. B. C. Nakra, K.K. Choudhury, "Instrumentation, Measurement and Analysis", 3rd Edition, Tata McGraw, 2009
2. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications", Elsevier, 2014

Reference Book

1. A.K. Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpatRai, Educational and Technical publications, 2021.

Online Resources

1. https://www.coursera.org/learn/wearable-technologies
2. https://www.youtube.com/watch?v=_iFIMyQJE84
3. https://www.youtube.com/watch?v=4qFW4zwXzLs
4. https://www.youtube.com/watch?v=vCvwPAZx_o0

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Course Code	Course Title	L	T	P	C
10212EC172	**SMART CITY**	3	**0**	**0**	**3**

a) Course Category

Programme elective

b)

Preamble

This course will help you to understand how to make the best of these smart technologies in your cities' legacy infrastructures

c) Prerequisite

Nil

d) Related Courses

Internet of Things

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the smart city essentials	K2
CO2	Relate the technologies used in smart city	K2
CO3	Illustrate smart objects for IoT centric products	K2
CO4	Compare the different methods to benchmark smart cities	K2
CO5	Explain the various smart city applications for village cluster project	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	H	H	-	-	-	-	-	L	-	-	-	-	-	-
CO 2	H	H	L	L	-	-	L	L	-	-	-	-	-	-
CO3	H	H	M	-	-	-	-	L	M	-	-	-	-	-
CO 4	H	H	-	-	-	-	L	L	-	-	-	-	M	-
CO 5	H	H	-	-	L	-	-	L	-	-	-	M	M	M

g) Course Content

UNIT I FUNDAMENTALS OF SMART CITY 9

Ideal Smart City loop, Socio-economic and environmental issues, Implications of Urbanization, Urbanization models and global trends, Urbanization in India, Criteria for smart cities, Smartness - Citizens, Living Environment, Mobility, Economy, Governance Pillars of Smart cities, Buildings, Utilities, Transportation and road Infrastructure, Health Care, Stake holders' perceptions, Sustainability issues.

UNIT II TECHNOLOGIES FOR SMART CITIES 9

Ubiquitous computing, Big Data, Networking, Internet of Things, Cloud computing, Service-oriented architectures, Cyber security architectures.

UNIT III SMART OBJECTS 9

Wired – Cables, hubs, Wireless – RFID, WiFi, Bluetooth, Functional building blocks of IOT architecture, Introduction to Artificial Intelligence, Machine Intelligence, Information Dynamics, Synergetic, Information Dynamics and Allometry in Smart Cities.

UNIT IV ICT FOR SMART CITIES 9

Complex Urban systems, ICT Infrastructure modeling, Typical Edge Environment, IoT Centric approach, IoT Protocols: 6LowPAN, Cellular, NFC, LoRa, Sigfox, Neul**.**

UNIT V SMART CITY APPLICATIONS 9

European Smart cities, Singapore, Taipei, Surabaya, Mumbai, New Delhi, Smart Village Clusters and Urbanization.

Total: 45 Hours

h) Learning Resources

Text Books

1. Carlo Ratti and Matthew Claudel, ―The City of Tomorrow: Sensors, Networks, Hackers, and the Future of Urban Life (The Future Series), Yale University Press, 2016.
2. Stephen Goldsmith, Susan Crawford, ―The Responsive City: Engaging Communities Through Data-Smart Governance‖, 1st Edition Jossey Bass – Wiley, 2014.

Online Resources

1. https://www.microsoft.com/en-in/industry/government/resources/smart-cities
2. https://www.twi-global.com/technical-knowledge/faqs/what-is-a-smart-city
3. https://www.youtube.com/watch?v=Br5aJa6MkBc

Course Code	Course Title	L	T	P	C
10212EC173	**INTEGRATED PRODUCT DEVELOPMENT**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

Understanding the global trends and development methodologies of various types of products and services Conceptualize, prototype and develop product management plan for a new product based on the type of the new product and development methodology integrating hot hardware, software, controls, electronics and mechanical systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon successful Completion of This course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the various global trends to develop the new product.	K3
CO2	Summarize the type of product requirements, product development methodologies and management.	K2
CO3	Identify the product of integrating hardware, software, controls, electronics and mechanical systems and detailed product design and testing.	K3
CO4	Illustrate product test specifications standards, validate the product and confirm its performance as per design specifications.	K2
CO5	Summarize the end product development process of trade off, IPR, security and configuration management.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	H	-	-	M	L	L	L	L	M	L	M	M
CO2	M	-	H	-	M	-	-	-	-	-	-	-	-	-
CO3	H	-	M	-	H	-	-	-	-	M	-	L	M	M
CO4	M	-	L	-	-	M	M	-	-	-	M	M	-	-
CO5	M	-	M	-	M	-	-	H	-	-	M	M	-	-

g) Course Content

UNIT I FUNDAMENTALS OF PRODUCT DEVELOPMENT 9

Analysis and Product decision -Social Trends -Technical Trends - Economic Trends - Environmental Trends-Political/ Policy Trends- Introduction to Product Development Methodologies and Management Overview of Products and Services- Types of Product Development- Overview of Product Development Methodologies- Product Life Cycle -Product Development Planning and Management

UNIT II REQUIREMENTS AND SYSTEM DESIGN 9

Types of Requirements - Requirement Engineering : Traceability Matrix and Analysis-Requirement Management-System. Design &Modeling-Introduction to System Modeling-System Optimization- System Specification- Sub-System Design -Interface Design

UNIT III DESIGN AND TESTING 9

Conceptualization - Industrial Design and User Interface Design - Introduction to Concept generation Techniques –Challenges in Integration of Engineering Disciplines - Concept Screening & Evaluation - Detailed Design- Component Design and Verification– Mechanical, Electronics Software Subsystems - High Level Design/ Low Level Design of S/W Program - Types of Prototypes, S/W Testing- Hardware Schematic, Component design, Layout and Hardware Testing – Prototyping - Introduction to Rapid Prototyping and Rapid Manufacturing-System Integration, Testing, Certification and Documentation

UNIT IV SUSTENANCE ENGINEERING AND END-OF-LIFE (EOL) SUPPORT 9

Introduction to Product Verification Processes Stages- Introduction to Product validation processes and stages-Product Testing standards and Certification- Product Documentation-

Sustenance- Maintenance and Repair– Enhancements- Product EoL- Obsolescence Management- Configuration Management- EoL Disposal.

UNIT V BUSINESS DYNAMICS ENGINEERING SERVICES INDUSTRY 9

The Industry - Engineering Services Industry - Product development in Industry versus Academia - The IPD Essentials- Introduction to vertical specific product development processes - Manufacturing/ Purchase and Assembly of Systems- Integration Mechanical, Embedded and S/W systems – Product development Trade-offs - Intellectual Property Rights and Confidentiality - Security and configuration management.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Karl TUl rich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, New Delhi, 2011
2. John W Newstormand Keith Davis, "Organizational Behavior", Tata McGraw Hill, Eleventh Edition, New Delhi, 2005.

Reference Books

1. Hiriyappa B, “Corporate Strategy –Managing the Business”, Author house, USA, 2013
2. Peter F Drucker, “People and Performance”, Butterworth–Heinemann [Elsevier], Oxford, UK, 2004.
3. Vinod Kumar Garg and Venkitakrishnan NK, “Enterprise Resource Planning–Concepts and Practice”, Prentice Hall India, New Delhi, 2003.
4. Karl TUl rich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, New Delhi, 2011

Online Resources

1. https://www.youtube.com/watch?v=P_PP76flZfw&list=PLyqSpQzTE6M_XM9cvjLLO_Azt1FkgPhpH&index=2

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Course Code	Course Title	L	T	P	C
10212EC206	**EMBEDDED SYSTEMS AND ROBOTICS**	**1**	**0**	**4**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces the embedded hardware design, programming and introduction of robotics with electronic processors and controllers, circuit development with practical knowledge of each module to give our student the best of robotics training for real-time applications.

c) Prerequisite

Microprocessor and Microcontroller

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Demonstrate the embedded system applications using PIC.	S3
CO2	Design arduino based real time embedded systems.	S3
CO3	Implement the robots using webots based on e-puck for the given specification.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	-	-	L	H	-	L	-	M	L	-	M	H	H
CO2	M	-	H	H	H	-	L	-	H	L	M	H	H	H
CO3	-	-	H	H	H	L	L	L	H	L	-	H	H	H

g) Course Content:

Theory **15 Hrs**

PIC - Architecture, pin diagram, ports, on chip peripherals. Microcontroller ATMEGA 328. Embedded C programming – General Structure, Data types. Arduino- Introduction, IDE, different Arduino Boards & shields. Analog I/O Serial and Parallel Communication. Seven Segment and LCD Display Driving motors Manual Robots and Autonomous Robots - fundamentals and its applications.

List of experiments

S. No	CO Mapping	Practical Exercises (60 Hours)
1.	CO1	Exploring the features of MPLAB X IDE
2.	CO1	Exploring the features of Proteus
3.	CO1	LED and seven segment display using PIC
4.	CO1	Keypad interface using PIC
5.	CO1	Serial communication using PIC
6.	CO1	Motor speed control using PIC
7.	CO2	Exploring the features of Arduino IDE and Boards
8.	CO2	LED Interfacing using Arduino
9.	CO2	LCD Interfacing using Arduino.
10.	CO2	LDR Interfacing using Arduino.
11.	CO2	IR sensor interfacing using Arduino
12.	CO2	Ultrasonic sensor interface using Arduino
13.	CO2	Temperature sensor interfacing using Arduino.
14.	CO2	Motor interface using Arduino
15.	CO2	Bluetooth Interfacing using Arduino
16.	CO2	GSM module Interfacing using Arduino

17.	CO3	Building and Programming the Robot Car using Arduino
18.	CO3	Exploring the features of Webots
19.	CO3	LED Control of e-puck Robot in Webots
20.	CO3	Motor Control of e-puck Robot in Webots
21.	CO3	Line Follower e-puck Robot in Webots
22.	CO2, CO3	Mini Project

Total: 75 Hrs

h) **Learning Resources**

Text Books:

1. Massimo Banzi, "Getting Started with Arduino" 3rd edition, O'Reilly, 2014.
2. Udayakumar, G.Kulkarni, " Arduino: A Begineer's Guide" 2017
3. DoganIbrahi, "Advanced PIC Microcontroller Projects in C", Newnes, 2008.
4. MykePredko, "Programming and customizing the PIC", 3rd edition, 2007.
5. Parab, V.G.Shelake and R.K.Kamat-"Exploring C for Microcontrollers: A Hands on Approach", Springer-2007.
6. M. ShohamA, 'Textbook of Robotics 1: Basic Concepts', Springer-2012.
7. Cameron Hughes, Tracey Hughes "Robot Programming: A Guide to Controlling Autonomous Robots", 1/e First Edition-2016.

Reference Books:

1. Kevin M. Lynch, Frank C. Park "Modern Robotics mechanics, planning, controls" Cambridge University Press, 2017.
2. John-David Warren, Josh Adams, Harald Molle, "Arduino Robotics" Apress, 1st edition, 2011.

Online Resources

1. https://www.arduino.cc//
2. https://www.tutorialspoint.com/arduino/index.html
3. http://microcontrollerslab.com/pic-microcontroller-compiler/
4. http://bobblick.com/techref/techref.html
5. http://www.microcontrollerboard.com/pic-microcontroller-books.html
6. http://www.nex-robotics.com/products/microcontroller-development-boards/atmega2560- microcontroller-socket.html
7. http://www.avr-asm-download.de/beginner_en

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Course Code	Course Title	L	T	P	C
10212EC231	EMBEDDED IoT	2	0	2	3

a) Course Category

Programme Elective

b) Preamble

The Purpose of the course is to make students to learn the different design platforms used for an embedded system for IoT applications using Arduino and Raspberry Pi. To provide an understanding of the technologies and the standards relating to Bluetooth device control, Think-speak and Amazon Web Services (AWS). To have knowledge about the IoT enabled technology.

c) Prerequisite

Nil

d) Related Courses

Internet of Things (IoT), Embedded System Design

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the various concept of the IoT and their technologies.	K2
CO2	Relate the IoT architecture application using different hardware platforms.	K2
CO3	Compare the physical devices in an embedded system using arduino and raspberry Pi.	K2
CO4	Outline the basic IoT protocols to design an embedded IoT.	K2
CO5	Summarize the IoT security application into cloud environment.	K2

e) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	-	-	-	-	-	-	-	-	-	-	H	-	-
CO2	L	H	H	L	H	-	-	L	M	M	H	H	H	H
CO3	L	M	-	L	-	-	-	-	-	-	-	-	-	-
CO4	L	-	-	L	-	-	-	-	-	-	-	L	-	-
CO5	L	M	H	L	H	-	-	L	M	M	H	H	H	H

f) Course Content

UNIT I FUNDAMENTALS OF EMBEDDED IoT 5

Introduction to Internet of Things (IoT)– Functional Characteristics – Recent Trends in the Adoption of IoT – Societal Benefits of IoT, - IoT Enabling Technologies-IoT and M2M.

UNIT II IoT ARCHITECTURE 8

M2M high-level ETSI architecture - IETF architecture for IoT - OGC architecture - IoT reference model - Domain model - information model - functional model - communication model - IoT reference architecture.

UNIT III PHYISCAL DEVICES 6

Ardiuno architecture, instruction set, input and output ports, interrupts, peripherals programming and board configuration, overview of ESP8266. Raspberry Pi 3: Architecture, instruction set, input and output ports, interrupts, peripherals programming, and board configuration

UNIT IV IoT PROTOCOLS 6

Protocol Standardization for IoT – Efforts – M2M and WSN Protocols – SCADA and RFID Protocols – Unified Data Standards – Protocols – IEEE 802.15.4 – BACNet Protocol – Modbus– Zigbee Architecture – Network layer – 6LowPAN - CoAP - Security.

UNIT V SECURITY & CLOUD ANALYTICS 5

IEEE 802.11 Wireless Networks Attacks: Basic Types, WEP Key Recovery Attacks, Keystream Recovery Attacks against WEP – Security Issues in ZigBEE: Eavesdropping Attacks, Encryption Attacks – Evolution of Cloud Computation, Commercial clouds and their features, open source IoT platforms, cloud dashboards, Big data analytics and Hadoop. Interfacing.

Total: 30 Hours

LIST OF EXPERIMENTS (20 Hours)

S.No	Name of the Experiment	CO
1	Arduino & Raspberry pi installation.	CO1
2	Blinking LED through Raspberry pi or Arduino.	CO2
3	IoT sensors interface with Raspberry pi or Arduino or nodeMCU (Temperature/Light sensors).	CO2
4	Integration of Actuators with Raspberry pi or Arduino (Servo motor/Relay).	CO2
5	Capture Image with Raspberry pi or Arduino.	CO2
6	Design Traffic control system: using Raspberry pi or Arduino.	CO2
7	IoT Networking: Connectivity technologies, Protocols and Interoperability in IoT.	CO3
8	Design Temperature dependent auto cooling system: Using Raspberry pi or Arduino.	CO3
9	IoT applications in home automation: Implementing IoT home application using Raspberry pi or Arduino.	CO4
10	Case study: Emergence of IoT Healthcare through Cloud Computing.	CO5

LIST OF PROJECTS (10 Hours)

1. IoT Based Humidity and Temperature Monitoring Using Arduino Uno
2. IoT Weather Reporting system using Raspberry pi.
3. IoT Connected Healthcare Applications.
4. IoT Based Intelligent Traffic Management System
5. IoT Based Smart Parking System Using RFID
6. Smart Irrigation System Using IoT.
7. Waste and water management using IoT
8. Smart Healthcare Solution using IoT
9. Automatic Herbicides Sprayers
10. Fish Feeder
11. Green Corridor
12. Trusted high-quality elderly care
13. Gesture controlled Iot Application

h) Learning Resources

Text Books

1. Ioana Culic, Alexandru Radovici, Cristian Rusu, “Commercial and Industrial Internet of Things Applications with the Raspberry Pi”, Apress Publishers, 2020.
2. Rajesh Singh, Anita Gehlot, Lovi Raj Gupta, Bhupendra Singh, and Mahendra Swain, “Internet of Things with Raspberry Pi and Arduino”, CRC Press, 2020.

3. Honbo Zhou, “The Internet of Things in the Cloud: A Middleware Perspective”, CRC Press 2012.

Reference Books

1. Marco Schwartz, “Internet of Things with the Arduino Yun”, Packt Publishing, 2014
2. Peter Waher, 'Learning Internet of Things', Packt Publishing, 2015
3. Francis daCosta, “Rethinking the Internet of Things: A Scalable Approach to Connecting Everything”, 1st Edition, Apress Publications, 2013

Online Resources:

1. https://www.emertxe.com/trainings/iot-courses/online-embedded-iot-course/
2. https://www.coursera.org/specializations/iot
3. https://www.youtube.com/watch?v=brve9zRlPqc

Course Code	Course Title	L	T	P	C
10212EC181	**WIRELESS COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course introduces the basic principles of wireless communication systems in general, and cellular systems in particular. It summarizes various radio wave propagation models, multiple access techniques, types and applications.

c) Prerequisite

Nil

d) Related Courses

5G Technology, 5G Networks

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the evolution, concepts and techniques to improve the capacity of cellular system.	K2
CO2	Summarize the radio wave propagation models and parameters of mobile multipath channels.	K2
CO3	Compare the contention free and contention based multiple access techniques.	K2
CO4	Infer the various wireless standards used around the world.	K2
CO5	Interpret the various types and applications of wireless communication.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	L	L	-	-	-	-	L	L	-	L	-	-
CO2	H	M	L	L	-	-	-	-	L	L	-	L	-	-
CO3	H	M	L	L	-	-	-	-	L	L	-	L	-	-
CO4	H	L	L	L	-	-	-	-	L	L	-	L	-	-
CO5	M	L	L	L	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I FUNDAMENTALS OF CELLULAR SYSTEM 9

Evolution of mobile radio communication – Cellular system: hexagonal geometry cell and concept of frequency reuse, channel assignment strategies, distance to frequency reuse ratio, channel and co-channel interference, handoff strategies – umbrella cell concept.

UNIT II RADIO WAVE PROPAGATION MODELS 9

Block diagram of wireless communication – large scale path loss – path loss models: free space and two-ray models – small scale fading- flat fading – frequency selective fading – fading due to doppler spread – fast fading – slow fading.

UNIT III MULTIPLE ACCESS TECHNIQUES 9

Contention-free multiple access schemes: Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), Space Division Multiple Access (SDMA) – contention-based multiple access schemes: ALOHA and Carrier Sense Multiple Access (CSMA).

UNIT IV WIRELESS STANDARDS 9

Global System for Mobile Communication (GSM) – Interim Standard 95 (IS-95) – General Packet Radio Service (GPRS) – Universal Mobile Telecommunications System (UMTS) – Wireless Local Area Network (WLAN).

UNIT V APPLICATIONS OF WIRELESS COMMUNICATION 9

Bluetooth – ZigBee – Wi – Fi- Long Term Evolution (LTE) – Overview of Internet of Things (IoT) – smart grids – health care – smart cities – smart agriculture.

Total: 45 Hrs

h) Learning Resources

Text books

1. T. S. Rappaport, "Wireless Communications", Second Edition, Prentice Hall, 2013.
2. Andrea Goldsmith, "Wireless Communications", First Edition, Cambridge University Press, 2005.

Reference books

1. Kamilo Feher, "Wireless digital communication", Prentice-Hall, 2017.
2. V. K. Garg, "Wireless Communications and Networking", Morgan Kaufmann, 2007.

Online resources

1. Introduction to Wireless and Cellular Communications (NPTEL)
   https://onlinecourses.nptel.ac.in/noc21_ee66/preview
2. Fundamentals of wireless communication (youtube.com)
   https://www.youtube.com/watch?v=8J3KOp6PR58
3. Wireless Communication (NPTEL)
   https://www.youtube.com/watch?v=SFIRXrvvXBQ
4. Wireless Communication (NPTEL)
   https://www.youtube.com/playlist?list=PLlQim6boihdgIdnLeVe34070cu899Le0c

Course Code	Course Title	L	T	P	C
10212EC182	**5G TECHNOLOGY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides the overview of 5G technology with advanced architecture like Multiple Input Multiple Output (MIMO) and Orthogonal Frequency Division Multiplexing (OFDM). This course also explains Non-Orthogonal Multiple Access (NOMA) concepts, making revolution on communication with transformative applications.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the landscape requirements and 5G network architecture.	K2
CO2	Summarize the radio resources and radio access deployment technologies.	K2
CO3	Outline the channel modeling, estimation and beam-forming for MIMO.	K2
CO4	Compare NOMA with different types and its radio access technique.	K2
CO5	Interpret the various applications of 5G technologies.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO2	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO3	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO4	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO5	H	L	L	L	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I FUNDAMENTALS OF 5G ARCHITECTURE 9

5G spectrum landscape and requirements – spectrum access modes and sharing scenario – 5G spectrum technologies – 5G services and performance metrics – 5G network architecture.

UNIT II RADIO-ACCESS TECHNOLOGIES 9

Radio resource and interference management – traffic offloading scenarios for networks – access design principles for multi-user communications: radio access for dense deployments, OFDM numerology for small-cell deployments, small-cell sub-frame structure.

UNIT III MIMO TECHNOLOGY 9

MIMO challenges: channel modeling, channel estimation and beam-forming – types of transceivers, merits and demerits – massive MIMO (Sub 6 GHz).

UNIT IV NON-ORTHOGONAL MULTIPLE ACCESS 9

NOMA types: Power domain NOMA, code domain NOMA, cooperative NOMA and hybrid NOMA –difference between orthogonal multiple accesses and NOMA.

UNIT V APPLICATIONS OF 5G 9

Robotic surgery – driverless car – industry-specific networks – home networks – space-air-ground networks – tactile internet – augmented reality and virtual reality.

Total: 45 Hrs

h) Learning Resources

Text books

1. Aditya k Jagannathan, "Principles of Modern Wireless communication systems", McGraw Hill Education, 1st Edition, 2016.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 1st Edition, 2014.

Reference books

1. R. Vannithamby and S. Talwar, "Towards 5G: Applications, Requirements and Candidate Technologies", John Willey & Sons, West Sussex, 2017.
2. Manish, M., Devendra, G., Pattanayak, P., Ha, N., "5G and Beyond Wireless Systems PHYLayer Perspective", Series in Wireless Technology Springer, 2021.
3. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock, "Millimeter Wave Wireless Communication", Pearson Education, 2015.
4. M. Vaezi, Z. Ding, and H. V. Poor, "Multiple Access techniques for 5G Wireless Networks and Beyond", Springer Nature, Switzerland, 2019.

Online resources

1. Requirements and operating scenarios of 5G (NPTEL)
   https://www.youtube.com/watch?v=khsqASfv2T4
2. Overview of 5G Technology (NPTEL)
   https://www.youtube.com/watch?v=aYJncUscfmk
3. MIMO Communication Systems (NPTEL)
   https://www.youtube.com/watch?v=TfHvr0N51ZE
4. MIMO Channel Characteristics (NPTEL)
   https://www.youtube.com/watch?v=Dxj7JikI6zQ
5. Optical Wireless Communications for Beyond 5G Networks and IoT (NPTEL)
   https://www.youtube.com/watch?v=tDgaxz-z6jM

Course Code	Course Title	L	T	P	C
10212EC183	**5G NEW RADIO ACCESS TECHNOLOGY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course provides an overview of 5G New Radio (NR) access technology, interface, waveforms, channel models, multi antenna transmission techniques covering wide range of technology options and protocols.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the characteristics, requirements, architecture and functionalities of 5G new radio.	K2
CO2	Interpret interface and protocol structure in new radio.	K2
CO3	Explain waveform design and channel models for 5G networks.	K2
CO4	Summarize various multi antenna uplink and downlink transmission techniques.	K2
CO5	Infer the concepts of 5G new radio in real time scenario.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	M	-	-	-	-	-	-	L	L	-	L	-	-
CO2	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO3	H	M	M	-	-	-	-	-	L	L	-	L	-	-
CO4	H	M	M	-	-	-	-	-	L	L	-	L	-	-
CO5	H	M	M	-	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I FUNDAMENTALS OF 5G NEW RADIO 9

5G characteristics and requirements – NR frame numerology – NR carrier aggregation – RAN architectures – 5G core network functions and services.

UNIT II NEW RADIO INTERFACE 9

High-frequency operation and spectrum flexibility, scheduling and data transmission, quality-of-service handling – radio protocol architecture: user-plane protocols, control-plane protocols.

UNIT III WAVEFORMS AND CHANNEL MODELS 9

5G radio access technologies: design principles – multi-carrier with filtering – radio access for dense deployments, V2X communication – METIS channel models.

UNIT IV MULTI-ANTENNA TRANSMISSION IN 5G NR 9

Uplink and downlink multi-antenna precoding – codebook-based transmission – non-codebook-based precoding – beam management.

UNIT V APPLICATIONS OF 5G NEW RADIO 9

Autonomous vehicles: smart traffic regulation – health sector – physical location tracking of life-saving equipment – smart cities: secure and controlled internet access for residents – industry.

Total: 45 Hrs

h) Learning Resources

Text books

1. Afif Osseiran, Jose.F. Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Erik Dahlman, Stefan Parkvall, Johan Sköld, "5G NR: The Next Generation Wireless Access Technology", Elsevier, 2nd Edition, 2020.

Reference books

1. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies, CRC Press, 1st Edition, 2019.
2. Wei Xiang, Kan Zheng, Xuemin (Sherman) Shen, "5G Mobile Communications", Springer, 2017.
3. Jonathan Rodriguez, "Fundamentals 5G Mobile Networks", John Wiley & Sons, 1st Edition, 2015.
4. Long Zhao, Hui Zhao, Kan Zheng, Wei Xiang, "Massive MIMO in 5G Networks: Selected Applications", Springer, 1st Edition, 2018.
5. Robert W. Heath Jr., Angel Lozano, "Foundations of MIMO Communication", Cambridge University Press, 1st Edition, 2019.

Online resources

1. 5G New Radio service and architecture (Coursera)
   https://www.coursera.org/learn/5g-network-fundamentals
2. Overview of 5G Mobile Networks (NPTEL)
   https://www.youtube.com/watch?v=Ztai5bS2d-k
3. Non-orthogonal multiple access (NPTEL)
   https://www.youtube.com/watch?v=aIjrJfkrZ6U
4. 5G NR (New Radio) Technical Training-A Deep Dive (NPTEL)
   https://www.udemy.com/course/5g-nr-new-radio-training-5g-ran-split-rat-beamforming-massive-mimo

Course Code	Course Title	L	T	P	C
10212EC184	**MILLIMETER WAVE TECHNOLOGY**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course will provide the overview of millimeter (mm) wave characteristics, models, devices, circuits, Multiple Input Multiple Output (MIMO) systems and applications of mm wave technology.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the characteristics, challenges of channel models and its effects.	K2
CO2	Explain the devices and components used in mm wave.	K2
CO3	Summarize various modulation techniques applied in communication systems.	K2
CO4	Infer the different diversity techniques in MIMO systems.	K2
CO5	Interpret the scenario relating to the applications of mm wave.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	L	L	-	-	-	-	-	-	-	-	L	-	-
CO2	H	L	L	-	-	-	-	-	-	-	-	L	-	-
CO3	H	L	L	-	-	-	-	-	-	-	-	L	-	-
CO4	H	L	L	-	-	-	-	-	-	-	-	L	-	-
CO5	H	L	L	L	-	-	-	-	-	-	-	L	L	-

g) Course Content

UNIT I CHARACTERISTICS AND MODEL 9

Millimeter wave characteristics - millimeter wave wireless - implementation challenges, design considerations, radio wave propagation for mm wave - outdoor and indoor channel models.

UNIT II DEVICES AND CIRCUITS 9

Millimeter wave generation and amplification: peniotrons, ubitrons, gyrotrons – free electron lasers – HEMT-models for mm wave transistors.

UNIT III COMMUNICATION SYSTEM 9

Modulations for millimeter wave communications: ON-OFF Keying, phase shift keying, frequency shift keying, quadrature amplitude modulation, orthogonal frequency-division multiplexing.

UNIT IV MIMO SYSTEM 9

Massive MIMO communications – spatial diversity of antenna arrays – multiple antennas – multiple transceivers – spatial, temporal and frequency diversity.

UNIT V APPLICATIONS OF MM WAVE TECHNOLOGY 9

Device to Device communications over 5G systems – mm wave for 5G mobiles and gyrotron technologies – optical technique of millimeter wave generation.

Total: 45 Hrs

h) Learning Resources

Text books

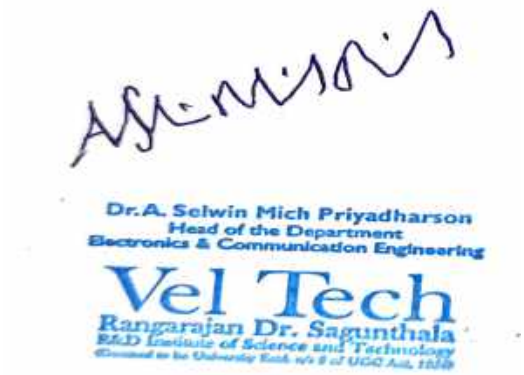
1. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Pearson Education, 2015.

Reference books

1. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications", Springer, 2016.
2. Awadhesh Kumar Shukla, "Advances in Millimeter Wave Technology", DRDO Monographs, 2019.

Online resources

1. Introduction to Millimeter-Wave Technology (NPTEL)
   https://youtu.be/DZdFXvZ5SOM?si=NjzlOOaeUwl47DKP
2. Millimeter Wave Active Devices (NPTEL)
   https://youtu.be/dIWsLh-MjOQ?si=RAonRJcdwt_XIVQN
3. Millimeter Wave (mmWave) Communication (NPTEL)
   https://youtu.be/Rt09KWCEUGg?si=6BHX1GXwxBZHyPnq
4. Hybrid beamforming (mmWave) (NPTEL)
   https://youtu.be/x1F5zft6Qtk?si=wBume81HM5MoDKwP



Course Code	Course Title	L	T	P	C
10212EC185	**5G NETWORKS**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

The advent of 5G networks marks a major advancement in wireless communication, offering unprecedented speed, capacity, and latency improvements. This fifth generation of mobile networks is set to transform sectors like healthcare, transportation, and entertainment.

c) Prerequisite

Nil

d) Related Courses

5G Technology, 6G Mobile Networks.

e) Course Outcomes

On the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the features, architecture and components of 5G networks.	K2
CO2	Illustrate the 5G network infrastructure and its role in smart cities development.	K2
CO3	Explain the influence of 5G on connected and autonomous transportation system.	K2
CO4	Interpret smart manufacturing and predictive maintenance over industry 4.0.	K2
CO5	Infer the security, privacy issues and future trends in 5G network services and its applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	-	-	-	-	-	-	L	L	-	L	-	-
CO2	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO3	H	L	L	L	-	-	-	-	L	L	-	L	-	-
CO4	H	L	L	L	-	-	-	-	L	L	-	L	-	-
CO5	H	L	L	L	-	-	-	-	L	L	L	L	-	-

g) Course Content

UNIT I FUNDAMENTALS OF 5G **9**

Evolution of wireless communication evolution – Key features of 5G networks: speed, latency, capacity, and reliability – 5G architecture and components: small cells, macro cells, and beamforming – spectrum and frequency bands for 5G.

UNIT II 5G NETWORK INFRASTRUCTURE **9**

Mobility Massive MIMO (Multiple Input Multiple Output)-Network slicing and virtualization – Edge computing and its relevance to 5G – Role of 5G in smart city development – Applications in traffic management and autonomous vehicles – 5G-enabled infrastructure monitoring and maintenance.

UNIT III 5G IN TRANSPORTATION SYSTEM **9**

Impact of 5G on connected and autonomous vehicles – Vehicle-to-everything (V2X) communication – 5G applications in railways and public transportation – Safety and security considerations.

UNIT IV 5G IN MANUFACTURING AND INDUSTRY 4.0 **9**

Manufacturing and Industry 4.0: Overview of Industry 4.0 and smart manufacturing – Role in industrial automation and robotics – 5G-enabled predictive maintenance and IoT – Case studies of 5G in manufacturing.

UNIT V CHALLENGES AND FUTURE TRENDS **9**

Security and privacy issues in 5G networks – Regulatory and standardization aspects – Future trends in 5G and beyond (6G, etc.) – 5G applications in real-time data collection and analysis.

Total: 45 Hrs

h) Learning Resources

Text books

1. Rodriguez, Jonathan, "Fundamentals of 5G mobile networks", John Wiley & Sons, 2015.
2. Dahlman, Erik, Stefan Parkvall, and Johan Skold, "5G NR: The next generation wireless access technology", Academic Press, 2020.

Reference books

1. Saro Velrajan, "An Introduction to 5G Wireless Networks: Technology, Concepts and Use-Cases", Notion Press, 1st Edition, 2020.
2. Long Zhao, Hui Zhao, Kan Zheng, Wei Xiang, "Massive MIMO in 5G Networks: Selected Applications", Springer, 1st Edition, 2018.
3. Robert W. Heath Jr., Angel Lozano, "Foundations of MIMO Communication", Cambridge University Press, 1st Edition, 2019.
4. R. Vannithamby and S. Talwar, "Towards 5G: Applications, Requirements and Candidate Technologies", John Willey & Sons, 1st Edition, 2017.

Online resources

1. 5G for everyone (Coursera)
   https://www.coursera.org/learn/5g-training
2. Optical Wireless Communications for beyond 5G Networks and IoT (NPTEL)
   http://acl.digimat.in/nptel/courses/video/108106190/L01.html
3. Linux Foundation X: Business Considerations for 5G with Edge, IoT, and AI (EDX)
   https://www.edx.org/learn/5g
4. 5G for Absolute Beginners (UDEMY)
   https://www.udemy.com/course/5g-for-absolute-beginners/

Course Code	Course Title	L	T	P	C
10212EC186	**MIMO WIRELESS COMMUNICATION**	**3**	**0**	**0**	**3**

a) Course Category

Programme Elective

b) Preamble

This course covers the fundamentals of Multiple Input Multiple Output (MIMO) based wireless communication systems. MIMO is an essential part of modern wireless communication systems. MIMO brings to the domain of wireless communications, spectral efficiency and reliability gains. MIMO is one of the enabler of 5G communication systems.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the diversity schemes involved in MIMO with advantages, channel models and power allocation.	K2
CO2	Illustrate the capacity of deterministic and random MIMO and fading channels.	K2
CO3	Explain the various space time coding techniques and its performance.	K2
CO4	Interpret various algorithms used to detect the received signal in MIMO systems.	K2
CO5	Infer the advances in MIMO communication systems.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	L	-	-	-	-	-	L	L	-	L	-	-
CO2	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO3	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO4	H	L	L	-	-	-	-	-	L	L	-	L	-	-
CO5	H	L	L	-	-	-	-	-	L	L	-	L	L	-

g) Course Content

UNIT I FUNDAMENTALS OF MIMO CHANNEL MODELS 9

Diversity – multiplexing trade-off, transmit diversity schemes of MIMO systems, fading channel models: uncorrelated – fully correlated – separately correlated – keyhole MIMO fading models, parallel decomposition of MIMO channel.

UNIT II MIMO AND FADING CHANNEL MODELS 9

Capacity for deterministic and random MIMO channels – capacity of independent identically distributed channels – capacity of separately correlated rayleigh fading MIMO channels.

UNIT III SPACE-TIME CODES 9

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.

UNIT IV MIMO DETECTION TECHNIQUES 9

Maximum likelihood – zero forcing-minimum mean square error-zero forcing equalization with successive interference cancellation – minimum mean square error successive interference cancellation.

UNIT V ADVANCES IN MIMO 9

Spatial modulation – MIMO based cooperative communication and cognitive radio – multiuser MIMO-MIMO systems for 5G wireless – MIMO applications in RADAR and satellite communication.

Total: 45 Hrs

h) **Learning Resources**

Text books

1. Tolga M.Duman and Ali Ghrayeb, "Coding for MIMO Communication Systems", John Wiley & Sons Ltd.,2007.
2. Ezio Biglieri, Robert Calderbank and Anthony Constantinides. "MIMO Wireless Communications" Cambridge University Press, 2007.
3. R. S. Kshetrimayum, "Fundamentals of MIMO Wireless Communications", Cambridge University Press, 2017.

Reference books

1. B. Kumbhani and R. S. Kshetrimayum, "MIMO Wireless Communications over Generalized Fading Channels", CRC Press, 2017.
2. T. L. Marze a, E. G. Larsson, H. Yang and H. Q. Ngo, "Fundamentals of Massive MIMO", Cambridge University Press, 2016.

Online resources

1. Fundamentals of MIMO Wireless Communication (NPTEL)
   http://nptel.ac.in/courses/117105132
2. MIMO channel model (NPTEL)
   https://onlinecourses.nptel.ac.in/noc22_ee65/preview
3. Foundations of Advanced Wireless Communication (Coursera)
   https://www.coursera.org/learn/foundations-of-advanced-wireless-communication
4. Multiple Antenna Communications (NPTEL)
   https://www.classcentral.com/course/swayam-fundamentals-of-mimo-wirelesscommunication-6702

Course Code	Course Title	L	T	P	C
10212EC187	**5G SECURITY**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

This course deals with the underlying principles of 5G network security. It aims to introduce students in implementing secure network communication.

c) Prerequisite

Nil

d) Related Courses

Wireless Communication

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the fundamental concepts of cyber security and techniques.	K2
CO2	Illustrate the various security protocols and standards.	K2
CO3	Infer the various challenges in 5G security.	K2
CO4	Interpret the threat detection and mitigation in 5G networks.	K2
CO5	Summarize the 5G security applications in various emerging technologies.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	L	-	-	-	-	-	L	L	-	-	-	L
CO2	M	L	L	-	-	-	-	-	L	L	-	L	-	L
CO3	M	L	L	L	-	-	-	-	L	L	-	L	-	L
CO4	M	L	L	-	-	-	-	-	L	L	-	L	-	L
CO5	M	L	L	-	-	-	-	-	L	L	-	L	-	L

g) Course Content

UNIT I FUNDAMENTALS OF CYBERSECURITY 9

Basic concepts in cybersecurity: confidentiality, integrity, availability, threats, vulnerabilities, and risks – cryptography – symmetric and asymmetric encryption – key management – network security – firewalls – VPN – IDS/IPS.

UNIT II SECURITY PROTOCOLS AND STANDARDS 9

3GPP security specifications – authentication and key agreement (aka) – secure access to the network, network slicing security – isolation of network slices – security considerations for network slicing – transport layer security – secure communication channels – use of TLS in 5G.

UNIT III 5G SECURITY CHALLENGES 9

Threat landscape – potential attack vectors in 5G – impact of 5G on traditional security models – privacy concerns – data privacy issues in 5G networks – regulatory requirements – GDPR-CCPA.

UNIT IV THREAT DETECTION AND MITIGATION IN 5G NETWORKS 9

Intrusion detection systems (IDS) – types of IDS – IDS in 5G networks – anomaly detection techniques for detecting anomalies – machine learning approaches in anomaly detection-incident response – steps in incident response – tools and techniques for incident management.

UNIT V SECURITY IN 5G APPLICATIONS 9

IoT security – security challenges in IoT within 5G – best practices for securing IoT devices. mobile edge computing (MEC) security – security challenges and solutions for securing MEC environments – cloud security – integrating 5G with cloud services – security considerations for cloud-based 5G applications.

Total: 45 Hrs

h) Learning Resources

Text books

1. Madhusanka Liyanage, Ijaz Ahmad, Ahmed Bux Abro, "A Comprehensive Guide to 5G Security", First Edition, John Wiley & Sons Ltd, 2018.
2. Bhunia Swarup, "Hardware Security –A Hands on Approach, Morgan Kaufmann", First edition, 2018.

Reference books

1. Saad Z. Asif, "5G Mobile Communications Concepts and Technologies", CRC Press, 1st Edition, 2019.
2. Erik Dahlman, Stefan Parkvall, Johan Skold, "5G NR: The Next Generation Wireless Access Technology", First Edition, Elsevier, 2016.
3. Afif Osseiran, Jose F. Monserrat, Patrick Marsch, 5G Mobile and Wireless Communications Technology, Second Edition, Cambridge University Press, 2011.
4. Jonathan Rodriguez , "Fundamentals of 5G Mobile Networks", First Edition, Wiley, 2010.

Online resources

1. Evolution of Air Interface Towards 5G (NPTEL)
   https://nptel.ac.in/courses/108105134
2. Cryptography and Network Security (NPTEL)
   https://onlinecourses.nptel.ac.in/noc22_cs90/preview
3. 5G Wireless Standard Design (NPTEL)
   https://onlinecourses.nptel.ac.in/noc24_ee152/preview
4. Optical Wireless Communications for Beyond 5G Networks and IoT (NPTEL)
   https://onlinecourses.nptel.ac.in/noc24_ee59/preview
5. Basics of Software Defined Radios and Practical Applications (NPTEL)
   https://onlinecourses.nptel.ac.in/noc24_ee79/preview

Course Code	Course Title	L	T	P	C
10212EC188	**6G MOBILE NETWORKS**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

This course addresses the fundamentals of 6G mobile networks and provides an overview of emerging 6G wireless communication techniques, exposes physical layer, transport layer, Cloudnet and applications of 6G wireless networks.

c) Prerequisite

Nil

d) Related Courses

5G Networks, 5G Technology

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the use cases, requirements, performance metrics and enabling technologies.	K2
CO2	Illustrate the physical layer and architecture for artificial intelligence / machine learning in 6G physical layer.	K2
CO3	Outline the transport layer and machine type communications in 6G wireless networks.	K2
CO4	Infer the concepts of intelligent networks and 6G network architecture.	K2
CO5	Interpret the applications of 6G in super-smart society, autonomous systems and healthcare.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	-	-	-	-	-	-	-	L	L	-	L	-	-
CO2	M	L	L	-	-	-	-	-	L	L	-	L	-	L
CO3	M	L	L	-	-	-	-	-	L	L	-	L	-	-
CO4	M	L	L	-	-	-	-	-	L	L	-	L	-	L
CO5	M	L	L	L	-	-	-	-	L	L	-	L	-	M

g) Course Content

UNIT I FUNDAMENTALS OF 6G **9**

Need for 6G – requirements and metrics: requirements and KPI targets of 6G – performance metrics – 6G use cases – 6G enabling technologies: novel wireless paradigms and frequencies above 100 GHz – multi-dimensional network architectures.

UNIT II PHYSICAL LAYER **9**

Role of PHY layer in 6G – 6G PHY at terahertz (THz) band – artificial intelligence / machine learning in 6G PHY: hardware architectures for AI in radio – security issues at 6G PHY – physical layer design challenges in reconfigurable intelligent surface aided 6G (Qualitative Treatment only).

UNIT III TRANSPORT LAYER AND MACHINE TYPE COMMUNICATIONS **9**

Mobility challenges in TCP – achieving TBPS bitrate in TCP – other challenges in TCP – machine type communications in 6G: MTC applications and devices – medium access and network architecture for 6G MTC.

UNIT IV CLOUDNET **9**

6G CloudNet:5G and beyond networks – trends towards intelligent-based optimized networks – potential technology transformation for 6G: artificial intelligence exploitation – new spectrum band exploitation – network architectures and technologies.

UNIT V APPLICATIONS OF 6G **9**

Super-smart society – extended reality – connected robotics and autonomous systems – wireless brain-computer interactions – haptic communication – smart healthcare and biomedical communication.

Total: 45 Hrs

h) Learning Resources

Text books

1. Yulei Wu, Sukhdeep Singh, Tarik Taleb, Abhishek Roy, Harpreet S. Dhillon, Madhan Raj Kanaarathinam, Aloknath De, "6G Mobile Wireless Networks", Springer, 2021.
2. Jonathan Rodriguez, Christos Verikoukis, John S. Vardakas and Nikos Passas, "Enabling 6G Mobile Networks", Springer, 2022.
3. M. Vaezi, Z. Ding, and H. V. Poor, "Multiple Access techniques for 5G Wireless Networks and Beyond", Springer Nature, Switzerland, 2019.

Reference books

1. Manish, M., Devendra, G., Pattanayak, P., Ha, N., "5G and Beyond Wireless Systems PHY Layer Perspective", Springer Series in Wireless Technology, 2021
2. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock,, "Millimeter Wave Wireless Communication", Pearson Education, 2015.

Online resources

1. 6G Introduction (YouTube)
   https://www.youtube.com/watch?v=MXNt9jbC1U&list=PLBC3G7CyizTpfoJB2qotyokOgS8X5DjdO&index=1
2. 6G Use Cases & Applications (YouTube)
   https://www.youtube.com/watch?v=ejHA-WaUI28&t=25
3. 6G Requirements (YouTube)
   https://www.youtube.com/watch?v=9bBteffPeAg&list=PLBC3G7CyizTpfoJB2qotyokOgS8X5DjdO&index=6
4. 6G Technologies (YouTube)
   https://www.youtube.com/watch?v=7OtrHXVLmvg&list=PLBC3G7CyizTpfoJB2qotyokOgS8X5DjdO&index=8

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Vel Tech
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R&D Institute of Science and Technology

Course Code	Course Title	L	T	P	C
10212EC189	SEMICONDUCTOR MATERIALS AND DEVICES	3	0	0	3

a) Course Category

Program Elective

b) Preamble

Semiconductor materials and devices form the foundation of modern electronics to develop faster and more powerful technology. This course will provide an understanding of semiconductor structures, basic devices, and their characterization.

c) Prerequisite

Nil

d) Related Courses

Semiconductor process technology

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the structure of the semiconductor materials.	K2
CO2	Interpret the significant emission of electron in semiconductor materials.	K2
CO3	Outline the basics of energy bands and dopants used in semiconductor materials.	K2
CO4	Summarize the characteristics and applications of the PN diode.	K2
CO5	Explain the primary operation, configuration, and applications of transistors.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	L	-	-	-	-	L	L	-	-	-	-
CO2	H	L	L	L	-	L	L	-	L	L	-	-	-	-
CO3	H	L	L	L	-	L	L	-	L	L	-	-	-	-
CO4	H	L	L	L	-	L	L	-	L	L	-	L	-	-
CO5	H	M	M	M	-	M	M	-	L	L	-	M	-	-

g) Course Content

UNIT I SEMICONDUCTOR STRUCTURE 9

Electronics – Atomic structure – Structure of elements –Energy of an electron – Valence electrons – Free electrons - Voltage source – Constant voltage source – Constant current source – Theorem and its equivalent circuit: Thevenin, Norton.

UNIT II ELECTRON EMISSION 9

Electron emission – Types of electron emission – Thermionic emission – Thermionic emitter – Commonly used thermionic emitters – Cathode construction – Field emission – Secondary emission – Photo electric emission.

UNIT III SEMICONDUCTOR PHYSICS 9

Semiconductor - Bonds in semiconductor - Crystals – Commonly used semiconductor – Energy band description of semiconductors – Effect of temperature on semiconductors – Hole current- Intrinsic and extrinsic semiconductor: types and properties.

UNIT IV PN JUNCTION DIODE 9

PN diode - Forward and reverse bias – I-V characteristics: diode equation, breakdown voltage, diode equivalent circuit – Applications: clipper, clamper, half wave, full wave, bride rectifier - Zener diode - Forward and reverse bias – I-V characteristics - Zener diode as voltage regulator.

UNIT V BIPOLAR JUNCTION TRANSISTOR 9

Construction of transistor – Biasing – Operation of NPN and PNP: voltage and current relations - Transistor connections: CB, CE and CC configurations, input, output characteristics, current gain and its relation – Comparison and applications - Transistor as an amplifier.

Total: 45 Hrs

h) Learning Resources

Text Books

1. V K Mehta, Rohit Mehta, "Principles of Electronics", Twelfth edition, S.Chand &Co., 2022.
2. S. Salivahanan, N. Suresh Kumar, A. Vallavaraj, "Electronic Devices & Circuits", Third edition, Tata McGraw-Hill, 2012.

Reference Books

1. Adrian Kitai, "Fundamentals of Semiconductor Materials and Devices", John Wiley & Sons Inc., New York, 2023.
2. Simon Sze, Ming-Kwei Lee, "Semiconductor Physics and Devices", Third edition, John Wiley & Sons Inc., New York, 2021.
3. Parasuraman Swaminathan, "Semiconductor materials, devices and fabrication", Wiley & Sons Inc., New York, 2017.

Online Resources

1. Semiconductor materials: https://fab.cba.mit.edu/classes/862.22/notes/semiconductor_materials_devices.pdf.
2. YouTube Semiconductor fundamentals: https://www.youtube.com/watch?v=_FMK-LqHloU&ab_channel=edX.
3. Introduction to semiconductor devices- Course (nptel.ac.in).

Course Code	Course Title	L	T	P	C
10212EC190	**SEMICONDUCTOR PROCESS TECHNOLOGY**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

Semiconductor process technology forms the bedrock of modern electronics, underpinning the production of microchips that power our digital world. It encompasses a sophisticated array of techniques and methodologies designed to fabricate semiconductor devices, such as transistors and integrated circuits, with ever-increasing precision and efficiency.

c) Prerequisite

Nil

d) Related Courses

Semiconductor materials and devices

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the flow of CMOS fabrication, characterization and evaluation.	K2
CO2	Extend the diffusion mechanisms and evaluation of diffused layers.	K2
CO3	Outline the ion implementation process and various deposition methods.	K2
CO4	Summarize different epitaxial growth techniques Silicon oxidation technologies in VLSI.	K2
CO5	Explain the various pattern transfer techniques and etching techniques.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	-	-	-	-	M	-	M	-	-
CO2	H	M	M	M	-	-	-	-	-	L	-	M	-	-
CO3	H	M	M	L	-	-	-	-	L	L	-	M	-	-
CO4	H	M	M	L	-	-	-	-	L	M	-	M	-	-
CO5	H	M	M	L	-	-	-	-	L	M	-	M	-	-

g) Course Content

UNIT I FUNDAMENTALS OF SEMICONDUCTOR FABRICATION 9

Semiconductor process technology: Semiconductor technologies and trends, Basic fabrication steps - Characterization and evaluation of crystals - wafer preparation - wafer shaping and wet chemical etching techniques.

UNIT II DIFFUSION 9

Basic Diffusion process: Diffusion equation and profiles - Evaluation of diffused layers, Extrinsic diffusion: concentration dependent diffusivity - Lateral diffusion.

UNIT III ION IMPLANTATION AND DEPOSITION 9

Ion implantation: Implantation damage and annealing - Implantation processes: multiple implantation and Masking - Deposition requirements and techniques: physical and chemical vapor deposition.

UNIT IV EPITAXIAL GROWTH AND OXIDATION 9

Epitaxial growth techniques: vapor deposition - Defects in epitaxial growth - Dielectric deposition: Silicon dioxide - Polysilicon deposition - Thermal oxidation process: Kinetics of growth - thin oxide growth.

UNIT V PHOTOLITHOGRAPHY AND ETCHING 9

Introduction to optical lithography: exposure tools – masks - photo resist - pattern transfer - Lithographic methods: e-beam lithography, dry and wet etching - Plasma etching - Reactive plasma etching techniques and equipment - applications.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", Tata McGraw- Hill Professional, Sixth edition, 2014.
2. Nandita Das Gupta and Amitava Das Gupta, “Semiconductor Devices modelling and Technology”, PHI, 2013.
3. S.K. Gandhi, “VLSI Fabrication Principles”, John Wiley Inc, Second edition, 1994.

Reference Books

1. S.M. Sze, “VLSI Technology”, Second Edition, Tata McGraw Hill, 2017
2. Marc J. Madou, “Fundamentals of Microfabrication and Nanotechnology” - Volume II, CRC Press, Third edition, 2011.
3. Yoshio Nishi and Robert Doering, “Handbook of Semiconductor Manufacturing Technology”, CRC Press, Second edition, 2007.
4. Gary. S. May and S. M. Sze, “Fundamentals of semiconductor fabrication”, John Wiley, First edition, 2003.
5. Richard Jaeger, “Introduction to Microelectronic Fabrication”, Prentice Hall, Second Edition, 2001.

Online Resources

1. Introduction to Semiconductor Process – Course (coursera.org)
2. Semiconductor Devices and circuits – Course (nptel.ac.in)

Course Code	Course Title	L	T	P	C
10212EC191	VLSI AND POST CMOS ELECTRONICS	3	0	0	3

a) Course Category

Program Elective **b)**

Preamble

This course entails on the fundamental principles of fabricating post CMOS VLSI devices and circuits. It also encompasses a diverse range of emerging technologies and material designed to overcome the limitations of conventional CMOS.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the operation and characteristics of CMOS circuits.	K2
CO2	Outline the tradeoffs in VLSI circuit.	K2
CO3	Interpret the electronic materials and devices beyond CMOS	K2
CO4	Summarize the potential and challenges of post CMOS architectures.	K2
CO5	Illustrate the mathematical models for post CMOS devices.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	L	-	-	-	-	L	L	-	L	-	-
CO2	H	L	L	L	-	-	-	-	L	L	-	L	-	-
CO3	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO4	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO5	H	M	M	L	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I CMOS VLSI CIRCUITS 9

MOS transistor theory- Long channel I-V characteristics – C-V characteristics – Non ideal I-V effects – DC characteristics: static CMOS invertor, beta ratio effects, noise margin, pass transistor – Circuit pitfalls.

UNIT II CMOS TRADEOFF 9

Delay: timing optimization, transient response – RC delay model – Logical effort on path- Power: dynamic and static – Interconnect modelling: skin effect, temperature dependence - Scaling.

UNIT III POST CMOS ELECTRONICS MATERIAL 9

Carbon nano tube field effect transistors (CNTFETs): material view, properties and limitations - Grapheme and other 2D materials, spintronics: fundamental phenomenon, materials - spintronic devices - magnetic tunnel junctions - Ferroelectric FETs (FeFETs).

UNIT IV POST CMOS ELECTRONICS- ARCHITECTURES 9

FinFETs and Gate all around FETs (GAAFETs): operation, fabrication techniques and challenges, advantages over planar transistors, Tunnel FETs (TFETs): operating principles, band-to-band tunneling mechanism - Design and fabrication challenges - Applications in low power electronics.

UNIT V MODELLING OF POST-CMOS ELECTRONICS 9

Importance of modeling in device design and optimization - Analytical models: FinFETs, GAAFETs, TFETs, negative capacitance FETs, memristors, resistive RAM - Numerical simulation techniques.

Total: 45 Hrs

h) Learning Resources

Text Books

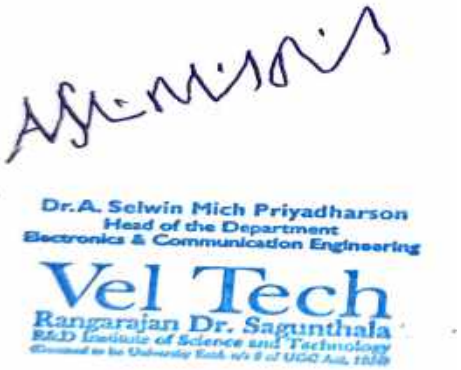
1. N.H.E.Weste and D. Harris, "CMOS VLSI Design: A Circuits and Systems Perspective", Fourth edition, Pearson, 2022.
2. Jacob Baker, "CMOS: Circuit Design, Layout, and Simulation", Fourth Edition, Wiley-IEEE Press, 2019.

Reference Books

1. 1 M. Lundstrom and J. Guo "Nanoelectronics: Device Physics, Modeling, and Simulation", Springer, 2005.
2. Dhiman, Rohit; Chandel, Rajeevan, "VLSI and Post-CMOS Electronics", Institution of Engineering and Technology, 2019.
3. Saha, Samar K., "FinFET Devices for VLSI Circuits and Systems", CRC press, 2020.

Online Resources

1. Siemens EDA Tools exploration: https://eda.sw.siemens.com/en-US/modelsim-student-edition.
2. YouTube Introduction to beyond CMOS: https://www.youtube.com/watch?v=YFQO_cZiGPY
3. Introduction to CMOS circuits: https://nptel.ac.in/courses/117101105



Course Code	Course Title	L	T	P	C
10212EC192	**SEMICONDUCTOR PACKAGING**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

This course provides the fundamental and advanced concepts in the field of electronics packaging. It also describes the testing and reliability of packaging and provides the knowledge on recent electronic packaging technologies.

c) Prerequisite

Nil

d) Related Courses

Advanced Semiconductor Devices

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic principles of electronic packaging.	K2
CO2	Outline the selection of material and issues in electrical connection.	K2
CO3	Illustrate the chip level packaging and their significance.	K2
CO4	Extend the knowledge in packaging technology and thermal design.	K2
CO5	Infer the various packaging electrical issues and testing process.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	H	-	-	-	-	-	L	M	-	M	-	-
CO2	H	M	M	M	-	-	-	-	-	L	-	M	-	-
CO3	H	M	M	-	-	-	-	-	L	L	-	M	-	-
CO4	H	M	-	H	-	-	-	-	L	M	-	M	-	-
CO5	H	M	-	L	-	-	-	-	-	M	-	M	-	-

g) Course Content

UNIT I FUNDAMENTALS OF ELECTRONIC SYSTEMS PACKAGING 9

Introduction - Functions of electronic packaging, packaging hierarchy, IC packaging: MEMS packaging, consumer electronics packaging, medical electronics packaging - Trends and challenges, driving forces on packaging technology.

UNIT II MICRO ELECTRONIC PACKAGING 9

Materials for microelectronic packaging - substrates - encapsulants – interconnects – Packaging issues- Packaging material properties: ceramics, polymers, and metals in packaging, material for high density interconnect substrates.

UNIT III CHIP LEVEL PACKAGING 9

IC assembly: purpose, requirements, technologies, flip chip - Wafer level packaging: reliability, burn – in and test - Single chip packaging: functions, materials processes – Multi-chip packaging: types, design, comparison, trends - System-In-Package (SIP) - Passives.

UNIT IV PACKAGING TECHNOLOGY AND THERMAL DESIGN 9

Printed wiring boards technology - Surface mount technology - Thermal mismatch in packages - thermal design consideration in system packaging - electrical modeling of a through silicon via - power distribution - return path discontinuities and thermal management.

UNIT V ELECTRICAL ISSUES AND TESTING 9

Enhance the reliability and performance: packaging material issues - Electrical design: Packaging roadmaps – Failures - Electrical issue: signal distribution, power distribution, electromagnetic interference and RF issues - Electrical testing: system level electrical testing, interconnection tests, active circuit testing, design for testability

Total: 45 Hrs

h) Learning Resources

Text Books

1. Rao R. Tummala, "Fundamentals of Device and Systems Packaging: Technologies and Applications", Second Edition by McGraw Hill, 2020.
2. John H.Lau, "Semiconductor Advanced Packaging", Springer, 2021.

Reference Books

1. S.A. Srinivasa Moorthy, "Introduction to Electronic Packaging-Unconventional Guide to Product Design", NotionPress, 2020.
2. Andrea Chen and Randy Hsiao-Yu Lo, "Semiconductor Packaging", CRC Press Taylor & Francis Group, 2012.
3. Ali Jamnia, "Practical Guide to the Packaging of Electronics: Thermal and Mechanical Design and Analysis", Third Edition, CRC press, 2016.

Online Resources

1. Electronic Packaging and Manufacturing - Course (nptel.ac.in)
2. An Introduction to Electronics Systems Packaging - Course (nptel.ac.in)

Course Code	Course Title	L	T	P	C
10212EC193	**VLSI TESTING AND VERIFICATION**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

The course includes design and architectures for testability techniques in digital systems with improved fault coverage. It also provides knowledge on approaches for introducing Built-In Self-Test (BIST) into logic circuits, memories and embedded cores.

c) Pre requisite

Nil

d) Related Courses

Semiconductor materials and devices

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the significance of testing to observe the faults in digital circuits.	K2
CO2	Infer the various fault modeling techniques to locate a fault in the circuit.	K2
CO3	Interpret a suitable test pattern generation to perform verification of the digital circuits.	K2
CO4	Outline the different types of design for testability approaches for testing circuits under test.	K2
CO5	Illustrate the various types of architectures utilized for BIST and Memory BIST(MBIST).	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO2	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO3	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO4	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO5	H	M	M	L	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I FUNDAMENTALS OF TEST AND DESIGN 9

Need for testing - testing during VLSI lifecycle - challenges in testing - types of simulation: compiled code and event driven - VLSI testing equipment and economics - observability and controllability - fault coverage.

UNIT II FAULT MODELLING 9

Logic fault models: stuck-at-fault, transition fault, open and short faults - single versus multiple fault model - fault detection and redundancy- fault equivalence and fault location.

UNIT III TEST GENERATION 9

Automated Test Pattern Generation (ATPG) for combinational circuits: D algorithm, Path-Oriented Decision Making (PODEM) - ATPG for sequential circuits: time frame expansion and multiple clocks.

UNIT IV DESIGN FOR TESTABILITY 9

Testability trade-offs - ad hoc design for testability - scan cell design - scan architectures - scan design flow - board level and system level DFT approaches -boundary scan standards.

UNIT V BUILT-IN SELF-TEST (BIST) 9

BIST test pattern generation - BIST architectures: LSSD On-Chip Self-Test (LOCST), Built-In Logic Block Observer (BILBO)- Memory BIST: RAM BIST compiler.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Laung-Terng Wang, Cheng-Wen Wu, and Xiaoqing Wen, "VLSI Test Principles and Architectures: Design for Testability", Morgan Kaufmann Publishers, 2021.
2. Miron Abramovici, Melvin A. Breur, Arthur D. Friedman, "Digital Systems Testing and Testable Design", Jaico Publishing House, Second Edition, 2006.

Reference Books

1. M. L. Bushnell and V.D. Agrawal, "Essentials of Electronic Testing for Digital Memory and Mixed Signal VLSI Circuits", Springer, 2013.
2. Neil H.E. Weste and David Money Harris, "A Circuits and Systems Perspective", Pearson Education, Fourth Edition, 2011.
3. Vaibbhav Taraate, "ASIC Design and Synthesis", Springer, First Edition, 2021.

Online Resources

1. VLSI Design Verification and Test: Course (nptel.ac.in)
2. Digital VLSI Testing: Course (nptel.ac.in)

Course Code	Course Title	L	T	P	C
10212EC194	QUANTUM TECHNOLOGIES FOR VLSI	3	0	0	3

a) Course Category

Program Elective

b) Preamble

This course will provide the ideas of quantum technologies into VLSI. The course also describes cutting-edge quantum algorithms and discusses the relative merits of competing quantum techniques in VLSI.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the irreversible logic design and its representation	K2
CO2	Interpret the basic quantum computing functions for logic implementation.	K2
CO3	Infer the performance metrics of quantum gates.	K2
CO4	Illustrate the performance metrics of quantum circuits	K2
CO5	Relate the concepts of quantum mechanics in to VLSI	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	M	L	-	-	-	-	L	L	-	L	-	-
CO2	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO3	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO4	H	M	L	M	-	-	-	-	L	L	-	M	-	-
CO5	H	M	M	L	-	-	-	-	L	M	-	L	-	-

g) Course Content

UNIT I IRREVERSIBLE LOGIC DESIGN 9

Overview of MOSFET- CMOS - Design of basic and universal logic gates, pass transistor, AOI gates, transmission gate, dynamic gates - Stick diagram: NAND, NOR - Static and dynamic power dissipation.

UNIT II FUNDAMENTALS OF QUANTUM COMPUTING 9

Basics of quantum computing – Principles of quantum mechanics in VLSI – need for quantum computing– Relationship between reversible and quantum logic – Qubits and operators: entanglement and superposition.

UNIT III QUANTUM GATES 9

Introduction to Quantum Gates: Single Qubit Gates, Quantum Not Gate, Reversible gates: Pauli-X, Y and Z, Hadamard, Phase Gate - Multiple Qubit Gates: controlled gate, controlled Not, swap - Ancilla inputs- Garbage outputs.

UNIT IV QUANTUM CIRCUITS 9

Quantum circuits: quantum teleportation, measurement and interference, quantum dots, quantum wells, general unitary transformations, dirac formalism, superposition of states, quantum circuit composition - Quantum cost.

UNIT V INTEGRATING QUANTUM MECHANICS INTO VLSI 9

Computational problems - Comparison with classical computing: quantum decoherence, error correction, Fault Tolerance - Classical computation - Efficiency: area, power, delay, depth, complexity.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Hafiz Md.Hasan Babu, "Quantum Computing: A Pathway to quantum logic design", IOP Publishing, 2020.
2. Chris Bernhardt, "Quantum Computing for Everyone", The MIT Press, 2019.

Reference Books

1. John Gribbin, "Computing with Quantum Cats: From Colossus to Qubits", 2021.
2. Niel H.E. Weste, David Harris, Ayan Banerjee, "CMOS VLSI Design- A Circuits and Systems Perspective", Third Edition, 2013.
3. Benenti G., Casati G. and Strini G., "Principles of Quantum Computation and Information", Vol. I: Basic Concepts, Vol II: Basic Tools and Special Topics, World Scientific, 2004.

Online Resources

1. Mermin's lecture notes http://people.ccmr.cornell.edu/~mermin/qcomp/ CS483.html
2. Michael Nielsen, "Neural Networks and Deep Learning", Determination Press, 2015. http://neuralnetworksanddeeplearning.com/
3. VLSI Physical Design: Course (nptel.ac.in).
4. Introduction to Quantum Computing: Course (nptel.ac.in).
5. Introduction to Quantum Computing: Quantum Algorithms and Qiskit - Course (nptel.ac.in).

Course Code	Course Title	L	T	P	C
10212EC195	**SEMICONDUCTOR OPTOELECTRONICS AND PHOTOVOLTAICS**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

This course provides the fundamental and advanced concepts in the field of optoelectronics and semiconductor devices. It also describes the applications of semiconductor lasers, optoelectronic sources, detectors, and photovoltaic cells.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the semiconductor materials, LED structure and characteristics.	K2
CO2	Explain the semiconductor laser dynamics, emission, population inversion, and resonators.	K2
CO3	Interpret the various optoelectronic detectors and advanced detectors.	K2
CO4	Outline the principles and characteristics of solar cells.	K2
CO5	Compare the performance of various semiconductor based solar cells.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	M	L	-	-	-	-	-	L	-	L	-	-
CO2	H	M	M	M	-	-	-	-	-	L	-	L	-	-
CO3	H	M	M	L	-	-	-	-	L	L	-	L	-	-
CO4	H	M	M	L	-	-	-	-	L	L	-	M	-	-
CO5	H	M	M	L	-	-	-	-	L	M	-	M	-	-

g) Course Content

UNIT I SEMICONDUCTOR MATERIALS AND LED MECHANISM 9

Semiconductor materials for optoelectronic devices - radiative and non-radiative recombination mechanisms - Light Emitting Diodes (LEDs): light emitting materials, device structure, spectral characteristics and applications.

UNIT II LASER DYNAMICS 9

Spontaneous and stimulated emission - absorption and amplification of light in a medium - population inversion and threshold condition for a laser - semiconductor laser: structure, materials, device characteristics.

UNIT III OPTO ELECTRONIC DETECTORS 9

Materials for optical detectors - photocurrent generation in PN diodes - photo detectors: PIN photo detector - avalanche photo detector - quantum well inter sub-band detector - chemiluminescence.

UNIT IV PHOTOVOLTAIC CELLS 9

Energy consumption and solar energy - photovoltaic effect and its application - development of solar cells - characteristics of solar cells: photocurrent and quantum efficiency - application of solar cells.

UNIT V SEMICONDUCTOR MATERIALS FOR PHOTOVOLTAIC CELLS 9

Solar cell structure - inherent limits of thin-film photovoltaics - semiconductor materials for solar cells: $Cu_2ZnSn(S,Se)$ related materials -solar cell characterization.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Pallab Bhattacharya, "Semiconductor Optoelectronic Devices", PHI, Second Edition, 2017.
2. Niloy K Dutta , Xiang Zhang, " Opto electronic detectors", World Scientific Publishing", 2018.

Reference Books

1. P. Bhattacharya, "Semiconductor Optoelectronic Devices", Prentice Hall of India, 2017.
2. S. M. Sze, "Semiconductor devices: physics and technology", Wiley, Third Edition, 2016.
3. M. Parans Paranthaman , Winnie Wong-Ng, "Semiconductor Materials for Solar Photovoltaic Cells", Springer Nature, 2015.

Online Resources

1. Semiconductor Optoelectronics: physics and technology of semiconductor optoelectronic devices- Course (nptel.ac.in)
2. Solar Photovoltaics Fundamentals, Technology and Applications- Course (nptel.ac.in)

Course Code	Course Title	L	T	P	C
10212EC235	**FPGA BASED SYSTEM DESIGN**	**1**	**0**	**4**	**3**

a) Course Category

Program Elective

b) Preamble

Recent advances in VLSI technology have led to the emergence of a new class of computer architectures that exploit application-level parallelism. These reconfigurable computers can be rapidly customized at the hardware level to execute specific computations. In this course, students will explore the latest developments in reconfigurable computing from both hardware and software perspectives.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Dave's Taxonomy)
CO1	Build an FPGA system for combinational and sequential circuits using HDL.	S1
CO2	Apply FPGA tools to synthesize and implement digital based design using HDL.	S2
CO3	Demonstrate and implement the real time interfacing using FPGAs.	S3

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	H	M	H	-	-	-	-	L	-	M	-	-
CO2	M	L	H	M	H	L	L	-	-	L	-	M	-	-
CO3	M	L	H	M	H	L	L	-	L	L	-	M	-	-

g) Course Content

Theory **15 Hrs**

Field Programmable Gate Arrays- Logic blocks, routing architecture, Design flow technology- Altera MAX 5000 and 7000 - Spartan II and Virtex II FPGAs and Cyclone FPGAs - overview of verilog HDL, basic concepts of hardware description languages: structural, dataflow and behavioral styles - Delay modeling - Control statements - FSM modeling of hardware description.

List of experiments

S. No.	CO Mapping	Practical Exercises (60 Hours)	Skill Level
1.	CO1	Introduction to lab using Xilinx FPGA - Vivado synthesis tool.	S1
2.	CO1	Demonstration of design, synthesis and implementation of digital block on FPGA.	S1
3.	CO1	Simulate a HDL code to describe the functions of a full adder using three modeling styles.	S1
4.	CO1	Simulate a verilog program for multiplexer and de-multiplexer.	S1
5.	CO1	Simulate a verilog program for encoder and decoder using any type of modeling.	S1
6.	CO1	Simulate a verilog code for 8-bit ALU using any type of modeling.	S2
7.	CO2	Simulation of counters and shift registers.	S2
8.	CO2	Simulation of finite state machine for sequence detector using Xilinx FPGA.	S2
9.	CO2	Simulation of asynchronous counter using digital logic ICs.	S2
10.	CO2	Simulation of comparator using digital logic ICs.	S2

11.	CO2	Design and implementation of digital clock using Xilinx FPGA.	S3
12.	CO3	Design and implementation of an LCD interface in FPGA.	S3
13.	CO3	Design and implementation of seven segment display interface using Xilinx FPGA.	S3

Total: 75 Hrs

h) Learning Resources

Text Books

1. Simon, "Programming FPGA's : Getting started with Verilog", McGraw – Hill Education, 2016.
2. Stephen Brown, "Fundamentals of Digital logic with Verilog Design", McGraw – Hill Education, 2017.
3. S. Palnitkar, "Verilog HDL: A Guide to Digital Design and Synthesis", Prentice Hall NJ, USA, 2003.

Reference Books

1. Nikoloas Voros Et Al. "Applied Reconfigurable Computing: Architectures, Tools and Applications", Springer, 2018.
2. Wayne Wolf, "FPGA- Based System Design", Pearson education, LPE First Indian Reprint, 2005.
3. Farzad Nekoogar and Faranak Nekoogar, "From ASICs to SOCs: A Practical Approach", Prentice Hall PTR, 2003.

Online Resources

1. Verilog notes: https://www.asic-world.com/
2. Reconfigurable computing Candidate talk: https://youtu.be/5_H_j72Ftq8http://www.verilog.com/
3. Digital Design with Verilog: Course (nptel.ac.in).

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Course Code	Course Title	L	T	P	C
10213EC101	**INTRODUCTION TO ROBOTICS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

The course provides introduction to robotics architecture and components as embedded system, sensors, actuators, kinematics of robotics also applications of robotics. It also provides an overview into control, dynamics of robots and its use in automation

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the functional elements of robotics	K2
CO2	Compare the classifications of robotics vision system	K2
CO3	Summarize the materials handling system of robots	K2
CO4	Interpret robot end effectors and selection of robotics	K2
CO5	Infer the robot applications in automation.	K2

f) **Correlation of COs with POs and PSOs**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PS O1	PS O2
CO 1	M	L	-	M	-	L	L	-	-	-	-	-	-	-
CO 2	M	M	M	-	L	-	-	-	L	-	-	-	-	-
CO 3	L	L	M	-	M	L	L	L	-	L	L	-	L	-
CO 4	L	M	M	-	-	L	L	-	-	-	-	-	-	-
CO 5	L	M	M	-	-	-	-	-	L	-	-	L	L	-

g) Course Content

UNIT I FUNDAMENTALS OF ROBOTICS 8

Brief history- Types of industrial robots-Robot classifications and specifications- Cartesian, Cylindrical, Spherical Work Envelope, Types of joints, Prismatic, Revolute, Ball and socket, Number of Axes, Degree of freedom, Joint variables.

UNIT II ROBOTIC VISION SYSTEM 8

Robotic vision systems, image representation, object recognition and categorization, depth measurement, image data compression, visual inspection, software considerations.

UNIT III MATERIAL HANDLING 8

Concepts of material handling, principles and considerations in material handling systems design, conventional material handling systems - industrial trucks, monorails, rail guided vehicles, conveyor systems, cranes and hoists, advanced material handling systems, automated guided vehicle systems, automated storage and retrieval systems(ASRS), bar code technology, radio frequency identification technology

UNIT IV END EFFECTORS 11

Gripper force analysis and gripper design, design of multiple degrees of freedom, active and passive grippers. Selection of Robot: Factors influencing the choice of a robot, robot performance testing, Impact of robot on industry and society.

UNIT V APPLICATIONS OF ROBOTICS 10

Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.

Total: 45 Hours

h) Learning Resources

Text Books

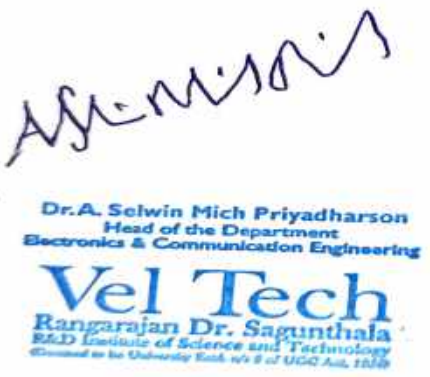
1. K.S. Fu, R.C. Gonzalez and C.S.G. Lee, "Robotics: Control, Sensing, Vision, and Intelligence",McGraw-Hill, New York, 1987.
2. H.R.Everett, "Sensors for Mobile Robots – Theory and Applications", A.K.Peteres Ltd. 1995.
3. Groover M.P et al., "Industrial Robotics – Technology, Programming & Applications", McGraw-Hill. 1986.
4. James A Rehg, "Introduction to Robotics in CIM Systems", Prentice Hall of India, 2002.

Reference Books

1. Fu,K.S. ,et al "Robotics- Control, Sensing, Vision and Intelligence ", McGraw – Hill. Inc., Singapore,1987.
2. YoremKoren, "Robotics for Engineers", McGraw-Hill Book Co., 1992.
3. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994

Online Resources

1. https://www.youtube.com/watch?v=P_PP76flZfw&list=PLyqSpQzTE6M_XM9cvjLLO_Azt1FkgPhpH&index=2
2. https://www.coursera.org/specializations/introduction-robotics-webots
3. https://ocw.mit.edu/courses/2-12-introduction-to-robotics-fall-2005/
4. https://robotacademy.net.au/masterclass/introduction-to-robotics/
5. https://see.stanford.edu/course/cs223a



Course Code	Course Title	L	T	P	C
10213EC102	**VIDEO SURVEILLANCE SYSTEM**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

This course delivers camera classification, hardware, video management system, and video networking and CCTV systems

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the types of camera used in indoor and outdoor surveillance system.	K2
CO2	Interpret the camera selection step by step process and camera hardware setup.	K2
CO3	Illustrate video management system of video analytics, trouble shooting, recording, storage and security.	K2
CO4	Explain the video networking concepts, delivery methods and trouble shooting.	K2
CO5	Summarize CCTV characteristics, components and case study of ATM and vehicle parking system.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	H	-	L	-	-	-	-	-	-	-	L	L	M	M
CO 2	M	L	L	-	L	-	L	M	-	-	-	-	-	L
CO 3	M	L	L	M	M	L	-	-	-	-	L	L	L	-
CO 4	M	L	-	-	L	L	-	-	-	-	-	M	M	-
CO 5	M	M	L	-	L	-	-	-	-	-	-	-	M	M

g) Course Content

UNIT I CAMERA CLASSIFICATION 9

Introduction, Analog camera, Digital Camera, Wired Camera, Wireless camera , HD Camera , IP/Network Cameras, Indoor/Outdoor Cameras, Pan/Tilt/Zoom Cameras and smart cameras.

UNIT II DIGITAL VIDEO HARDWARE 9

Evolution of Video Surveillance Hardware, selection of Right Cameras, PTZ Protocols and Communications, Two-Way Audio, Configuring and Commissioning Digital Video Encoders, Digital Video Cables and Connectors.

UNIT III VIDEO MANAGEMENT SYSTEMS (VMS) 9

Introduction to VMS, Dual VMS, Video Analytics, Troubleshooting .VMS Requirements, Portable Observation Device (POD), Edge Recording, storage and Security.

UNIT IV VIDEO NETWORKING 9

Introduction, Power of the Network, Networked Video Delivery Methods, Interference, Line of Sight (LOS), Wireless Mesh Networking, Wireless Security Options and Troubleshooting.

UNIT V CLOSED-CIRCUIT TELEVISION (CCTV) SYSTEMS 9

Characteristics of CCTV System Design, Components of CCTV, CCTV system design, case studies of ATM and Vehicle parking system.

Total-45 Hours

h) Learning Resources

Text Books

1. Anthony Caputo ,"Digital Video Surveillance and Security" IInd edition" , Elsevier 2014
2. Q. Huihuan, X. Wu, Y. Xu, "Intelligent Surveillance Systems", Springer Publication, 2011.

Reference Book

1. Murat A. Tekalp, “Digital Video Processing”, Prentice Hall, 1995.

Online Resources

1. https://www.businessnewsdaily.com/9067-choosing-a-surveillance-system.html
2. https://blog.koorsen.com/what-is-a-video-surveillance-system
3. https://www.youtube.com/watch?v=AQ1EPl_4O2w
4. https://www.youtube.com/watch?v=mhrRjgzRfh0

Course Code	Course Title	L	T	P	C
10213EC103	**WEARABLE DEVICES**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

This course provides the basic understanding of measurement and instrumentation systems and the insight of the resistive sensors and its applications in real life. This course also introduces the concept of classification of sensors such as reactive sensors and self-generating sensors and its applications in real life. It makes the students to get familiar with the characteristics, working principle and application of special purpose transducers. The course 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.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course, students will be able to knowledge about various types of sensors and their real time applications.

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the need for development of wearable devices and its influence on various sectors.	K2
CO2	Summarize the applications of various wearable inertial sensors for biomedical applications.	K2
CO3	Relate the various wearable bio-electrode and physiological activity monitoring devices for use in healthcare applications.	K2
CO4	Compare the use of various wearable locomotive tools for safety and security, navigation.	K2
CO5	Illustrate the usage of wearable devices as assistive devices, diagnostic devices and other modern applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO 1	M	L	-	-	-	-	M	-	-	-	L	L	M	L
CO 2	M	L	M	L	L	-	-	L	-	-	-	L	M	L
CO 3	M	L	-	M	-	-	L	-	L	L	-	-	L	L
CO 4	M	L	L	M	M	-	-	L	L	L	-	-	M	L
CO 5	M	L	M	M	M	-	-	L	-	-	-	L	M	L

g) Course Content

UNIT I INTRODUCTION TO WEARABLE DEVICES 9

Motivation for development of Wearable Devices, The emergence of wearable computing and wearable electronics, Types of wearable sensors: Invasive, Non-invasive; Intelligent clothing, Industry sectors' overview – sports, healthcare, Fashion and entertainment, military, environment monitoring, mining industry, public sector and safety

UNIT II WEARABLE INERTIAL SENSORS 9

Wearable Inertial Sensors - Accelerometers, Gyroscopic sensors and Magnetic sensors; Modality of Measurement- Wearable Sensors, Invisible Sensors, In-Shoe Force and Pressure Measurement; Applications: Fall Risk Assessment, Fall Detection , Gait Analysis, Quantitative Evaluation of Hemiplegic and Parkinson's Disease patients. Physical Activity monitoring: Human Kinetics, Cardiac Activity, Energy Expenditure measurement: Pedometers, Actigraphs.

UNIT III WEARABLE DEVICES FOR HEALTH CARE **9**

Wearable ECG devices: Basics of ECG and its design, Electrodes and the Electrode–Skin Interface; Wearable EEG devices: Principle and origin of EEG, Basic Measurement set-up, electrodes and instrumentation; Wearable EMG devices: EMG/ SEMG Signals, EMG Measurement – wearable surface electrodes, SEMG Signal Conditioning, Epidermal Electronics Systems. Wearable Blood Pressure (BP) Measurement, Body Temperature sensor.

UNIT IV OTHER WEARABLE SENSORS **9**

Wearable devices with Global Positioning System (GPS) integration for tracking and navigation. Wearable Optical Sensors -chemical sensors, optical glucose sensors, UV exposure

indicators, speech recognition using lasers; Photoplethysmography (PPG), 3D imaging and motion capture.

UNIT V SCOPE OF WEARABLE DEVICES **9**

Role of Wearable sensors, Attributes of Wearable sensors, The Meta Wearables – Textiles and clothing, Social Aspects: Interpretation of Aesthetics, Adoption of Innovation, On-Body Interaction; Case Study: Google Glass, health monitoring, Wearable: Challenges and Opportunities, Future and Research Roadmap.

Total: 45 Hrs

h) Learning Resources

Text Books

1. B. C. Nakra, K.K. Choudhury, "Instrumentation, Measurement and Analysis" -3rd Edition, Tata McGraw, 2009
2. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications" Elsevier, 2014
3. Toshiyo Tamura and Wenxi Chen, "Seamless Healthcare Monitoring", Springer 2018
4. Edward Sazonov and Michael R. Neuman, "Wearable Sensors -Fundamentals, Implementation and Applications", Elsevier Inc., 2014.

Reference Book

1. A.K. Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpatRai, Educational and Technical publications, 2021

Online Resources

1. https://www.techtarget.com/searchmobilecomputing/definition/wearable-technology
2. https://www.coursera.org/learn/wearable-technologies
3. https://www.youtube.com/watch?v=_iFIMyQJE84
4. https://www.youtube.com/watch?v=4qFW4zwXzLs
5. https://www.youtube.com/watch?v=vCvwPAZx_o0

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Course Code	Course Title	L	T	P	C
10213EC104	**WIRELESS COMMUNICATION NETWORKS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

This course addresses the fundamentals of wireless communication and provides an overview of existing and emerging wireless communications networks. It covers radio propagation and fading models, fundamentals of cellular communications, multiple access technologies, and various wireless networks, including past and future generation networks

c) Prerequisite

Nil

d) Related Courses

Network Management, Network Security

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Infer the radio signal propagation models and its impact on communication system performance.	K2
CO2	Explain the multiple access schemes based on reservation and random-access methods for Wi-Fi	K2
CO3	Relate the fundamentals of cellular communication and its related services as GSM and UMTS.	K2
CO4	Outline the concepts of packet switching cellular system.	K2
CO5	Summarize the concept of mobility management and WPAN	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	L	-	-	-	-	-	-	-	-	-	-	-
CO2	L	L	L	-	-	-	-	-	-	-	-	-	-	-
CO3	M	L	L	-	-	-	-	-	-	-	-	L	-	-
CO4	L	L	L	-	-	-	-	-	-	-	-	L	-	-
CO5	M	L	L	-	-	-	-	-	-	-	-	L	-	-

g) Course Content

UNIT I OVERVIEW AND BASIS OF WIRELESS CHANNELS AND COMMUNICATION 9

Review of Digital Communications-Cellular Systems from 1G to 3G-Wireless 4G Systems-Components of a Wireless Transmitter and Receiver–Bandwidth, Duplexing, Licensed and Unlicensed Bands-Power, Rate and SNR-Shannon's Capacity, Bandwidth and Power Limited Regimes - Radio Propagation and Propagation Path-Loss Model: Free-Space Attenuation, Multipath Channel Characteristics, Signal Fading Statistics, Path-Loss Models.

UNIT II RANDOM ACCESS SYSTEMS AND WIFI 9

Types of Multiplexing: Fixed Assignment vs. Statistical Multiplexing - Aloha, Slotted Aloha - Review of Poisson Process and Analysis of Aloha CSMA with Collision Avoidance and Collision Detection-WIFI: History and Motivation, Architecture-DCF Mode, RTS, CTS, Hidden and Exposed Terminal Problem- 802.11n Enhancements

UNIT III CIRCUIT-SWITCHED CELLULAR SYSTEMS 9

Cellular Concept and Spatial Reuse – Interference Limited and Coverage Limited Systems – Frequency Reuse - Cellular vs. WIFI - GSM: Architecture, Voice Support – UMTS: Basics of CDMA, Architecture and Key Channels.

UNIT IV PACKET-SWITCHED CELLULAR SYSTEMS 9

Packet Switched vs. Circuit-Switched Communication - HSDPA (High Speed Downlink Packet Access) -HSUPA (High Speed Uplink Packet Access) - Introduction to LTE: History, Architecture - OFDM- Uplink and Downlink Communication in LTE

UNIT V MOBILITY AND WPANS 9

Principles of Handovers: Switching Conditions, Hysteresis, Detection - Mobility in Cellular Systems: The Gateway Concept, Measurement Reports, Mobility Procedures- Mobile IP: Basic Components, Tunneling, Enhancements for Mobile Ipv6-Wireless Personal Area Networks (PANS): Bluetooth80215.1, Zigbee802.15.4.

Total : 45 Hrs

h) Learning Resources

Text Books

1. V.K.Garg,Wireless Communications and Networking, Morgan Kaufmann, ISBN: 9780123735805, 2007
2. D.P.Agrawal and Q.-A.Zeng, Introduction to Wireless and Mobile Systems, ThirdEdition, Cengage Learning, ISBN:1439062056, 2010

Reference Books

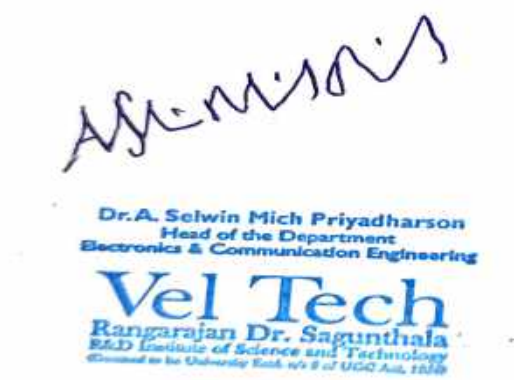
1. W.Stallings, Wireless Communications & Networks, Second Edition, Prentice Hall,ISBN:0131918354, 2004
2. T.S.Rappaport, Wireless Communications, Second Edition, Prentice Hall, ISBN:0130422320, 2002.
3. J.Schiller, Mobile Communications, Second Edition, Addison Wesley, ISBN: 0321123816, 2003.

Online Resources

1. www.nptelvideos.in/2012/12/wireless-communication.html
2. nptel.ac.in/courses/117105076/pdf/2.2%20Lesson%203%20.pdf
3. https://www.coursera.org/learn/wireless-communication.../5g-mobile-communications
4. https://www.mooc-list.com/.../wireless-communication-emerging-technologies-courser.
5. https://www.digimat.in/nptel/courses/video/117102062/L03.html

Practical Aspects

1. NS3 simulator Tool



Course Code	Course Title	L	T	P	C
10213EC105	**BASICS OF SIGNAL PROCESSING**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

Basics of Signal Processing provides an introduction to the basic concepts of signal processing methods essential for application in various fields of engineering. It provides knowledge in analysis of systems using various transformation techniques, and its application to various fields.

c) Prerequisite

Nil

d) Related Courses

Image Processing and its Applications

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify the CT and DT signals and systems and describe its characteristics	K2
CO2	Compute the frequency components present in continuous time signal using fourier series and fourier transforms	K3
CO3	Apply the characteristics of LTI systems in time domain and frequency domain	K3
CO4	Determine the fourier transform and Z transform of DT signals and use it for analysis of DT systems	K3
CO5	Summarize various real time applications of CT and DT systems.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	L	L	M	-	-	-	L	L	-	L	-	-
CO2	H	M	L	L	M	-	-	-	L	L	-	L	-	-
CO3	H	M	L	L	M	L	-	-	L	L	-	L	-	-
CO4	H	M	L	L	M	-	-	-	L	L	-	L	-	-
CO5	H	M	L	M	M	L	-	-	L	L	-	L	-	-

g) Course Content

UNIT I CLASSIFICATION OF SIGNALS AND SYSTEMS 9

Standard signals: Step, Ramp, Pulse, Impulse, Real and complex exponentials, Sinusoids - Classification of signals: Continuous time (CT) and Discrete Time (DT) signals, Periodic and Aperiodic signals, Deterministic and Random signals, Energy and Power signals - Classification of systems: CT systems and DT systems, Linear and Nonlinear, Time-variant and Time-invariant, Causal and Non-causal, Stable and Unstable.

UNIT II CONTINUOUS TIME SIGNAL ANALYSIS 9

Fourier series for periodic signals: Trigonometric Fourier series, Exponential Fourier Series - Fourier Transform, Inverse Fourier Transform, Properties of Fourier Transform.

UNIT III LINEAR TIME INVARIANT CONTINUOUS TIME SYSTEMS 9

Impulse response - Convolution integral - Differential Equation - Fourier transforms in analysis of CT systems - Systems connected in series/parallel.

UNIT IV DISCRETE TIME SIGNALS AND SYSTEMS 9

Base band signal sampling – Fourier Transform of discrete time signals (DTFT) and Properties - Z-Transform and Properties - Analysis of DT systems using Z-Transform.

UNIT V APPLICATIONS OF SIGNAL PROCESSING 9

Signal Processing Applications: Speech and Audio processing, Multimedia (image and video) processing, Underwater acoustic signal processing, Biological signal analysis.

Total : 45 Hrs

h) Learning Resources

Text Books

1. Allan V. Oppenheim, S. Wilsky and S. H. Nawab, "Signals and Systems", Pearson, 2015.(Unit I-IV)

Reference Books

1. B. P. Lathi, "Principles of Linear Systems and Signals", Second Edition, Oxford, 2009.
2. Saeed V Vaseghi, "Multimedia signal processing: Theory and Applications in Speech, Music and Communications", Wiley, 2007. (UNIT –V)
3. John Alan Stuller, "An Introduction to Signals and Systems", Thomson, 2007.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc20_ee41/preview (UNIT-V: Biological signal analysis)
2. https://apps.dtic.mil/sti/citations/ADA460793 (UNIT–V: Underwater acoustic signal processing)

Course Code	Course Title	L	T	P	C
10213EC106	**IMAGE PROCESSING AND ITS APPLICATIONS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

The purpose of this course is to provide the basic concepts and methodologies for Image Processing. It provides students adequate knowledge on image transform, image enhancement, image restoration, image segmentation and image compression and apply it in real world applications.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom'sTaxonomy)
CO1	Illustrate the components of digital image, image acquisition and the various color models	K2
CO2	Identify the various 2D image transforms	K2
CO3	Discuss the various spatial and frequency domain filtering techniques in image enhancement	K2
CO4	Explain the various image segmentation techniques and its applications	K2
CO5	Describe the various image compression methods and standards	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	L	L	L	-	-	-	L	L	-	L	-	-
CO2	M	M	L	L	L	-	-	-	L	L	-	L	-	-
CO3	M	M	L	L	L	-	-	-	L	L	-	L	-	-
CO4	M	M	L	L	L	-	-	-	L	L	-	L	-	-
CO5	M	M	L	L	L	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I FUNDAMENTALS OF DIGITAL IMAGE 9

Introduction –Steps in Digital Image Processing – Components – Elements ofVisual Perception – Image Sensing and Acquisition – Image Sampling and Quantization – Relationships between pixels – color models.

UNIT II IMAGE TRANSFORMS 9

2 – D Discrete Fourier Transform, Discrete Cosine Transform (DCT), KL Transform, Walsh Transform, Walsh Transform, Hadamard Transform, Discrete Wavelet transform, Singular Value Decomposition

UNIT III IMAGE ENHANCEMENT 9

Spatial Domain: Basic relationship between pixels- Basic Gray level Transformations – Histogram Processing – Smoothing spatial filters- Sharpening spatial filters. Frequency Domain: Smoothing frequency domain filters- sharpening frequency domain filters Homomorphic filtering, applications of image enhancement.

UNIT IV IMAGE SEGMENTATION 9

Introduction to image segmentation, Point, Line and Edge Detection, thresholding, Region based segmentation, clustering techniques, Edge based segmentation, Edge detection and linking, applications of image segmentation

UNIT V IMAGE COMPRESSION 9

Need for image compression, Redundancy in images, Classification of redundancy in images, Classification of image compression schemes, Run length coding, Shannon – Fano coding, Huffman coding, Arithmetic coding, compression standards, applications of image compression

Total: 45 Hrs

h) Learning Resources

Text Books

1. Rafael C.Gonzalez, Richard E.Woods, "Digital Image Processing", Pearson Prentice Hall, Second Edition, 2004.
2. S.Jayaraman, S.Esakkirajan and T.Veera Kumar, "Digital Image processing," TataMc Graw Hill publishers, 2009

Reference Books

1. Scotte E Umbaugh, "Digital Image Processing and Analysis-Human and Computer Vision Application with CVIP Tools", 2nd Ed, CRC Press, 2011.

Online Resources

1.https://www.coursera.org/learn/digital

2.https://onlinecourses.nptel.ac.in/noc22_ee116

3.https://www.udemy.com/topic/image-processing

Course Code	Course Title	L	T	P	C
10213EC107	**INDUSTRIAL AUTOMATION**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

The purpose of this course is provide the knowledge of automation components, tools, machine to machine communication, internet of things involved in industrial automation

c) Prerequisite

Nil

d) Related Courses

Building Automation.

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the basic elements of industrial automation system and its architecture.	K2
CO2	Relate the concepts of PLC used in industrial automation.	K2
CO3	Summarize the concept of SCADA used in industrial automation	K2
CO4	Outline the concept of distributed control system	K2
CO5	Interpret the concepts of industry 4.0.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	M	L	L	-	-	-	M	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	L	M	-
CO3	M	-	-	-	-	-	-	-	L	L	-	-	-	-
CO4	M	L	L	-	-	-	M	-	L	L	-	L	-	-
CO5	M	L	-	-	-	-	-	-	L	L	-	L	M	-

g) Course Content

UNIT I FUNDAMENTALS OF AUTOMATION 9

Basic elements, Requirement, Evaluation of automation from technology perspectives, Benefits and Impact of Automation on Manufacturing and Process Industries; Architecture of Industrial Automation Systems. Introduction to Industrial bus systems: MODBUS & PROFIBUS

UNIT II PROGRAMMABLE LOGIC CONTROLLER (PLC): 9

History of PLC, Architecture of PLC, CPU IO Modules Power Supply and Communications, Input and Output Devices, Need of PLC for Industrial Automation, Types of PLC Models.
Introduction to PLC Programming: Types of Programming Languages, Ladder logic diagram, Examine On/OFF, timer, counter

UNIT III SCADA SYSTEMS 9

History of SCADA, typical SCADA System Architecture, Communication requirements, Desirable properties of SCADA system, Features, advantages, disadvantages and applications of SCADA.

UNIT IV DISTRIBUTED CONTROL SYSTEMS 9

Introduction - Local Control Unit (LCU) architecture, LCU Process Interfacing Issues, Block diagram and Overview of different LCU security design approaches, Networking of DCS, Information gathering, Real-time analysis of data stream from DCS

UNIT V TECHNOLOGIES ENABLING INDUSTRY 4.0 9

Overview of Internet of Things, cloud computing, cyber-physical systems, automated flow lines and transfer mechanisms: Analysis of transfer lines without storage, automated flow lines with

storage buffers Introduction to Smart Manufacturing: smart devices and products, smart logistics, smart cities, predictive analytics.

Total: 45 Hrs

h) Learning Resources

Text Books

1. S.K. Singh, "Industrial Instrumentation and control"–The Mc Graw Hill companies 3rd edition — 2009.
2. F. G Shinskey Process Control Systems, McGrahill Publications,1996.
3. Curtis D. Johnson "Prentice Process control Instrumentation Technology"–Hall India,8thedition, 2006
4. Thomas Hughes, "Programmable Logic Controller",ISA Publication
5. StuartA. Boyer, "SCADA supervisory control and data acquisition", ISA Publication.
6. McMillan.G.K, "Process/ Industrial instrument and handbook", McGraw-Hill,NewYork,1999
7. Vojislab B. Misic, Jelenamisic, 'Machine- to-machine communications', edited CRC Press Taylor & Francis group–2015.
8. ArshdeepBahga,Vijaymadisetti, 'Internet of Things: A hands on approach', Publisher-2014

Reference Books

1. Samuel M. Herb, "Understanding Distributed Processor Systems for Control", ISA Publication, 1998.
2. Thomas Hughes,"Programmable Logic Controller",ISA Publication,2000.
3. StuartA.Boyer,"SCADA supervisory control and data acquisition", ISA Publication,2000.

Online Resources

1. https://www.automation.com/en-us/automation-control-resources
2. https://www.youtube.com/playlist?list=PLln3BHg93SQ9SEN8jXvhycxAeFcmkjTNs
3. https://www.classcentral.com/course/swayam-industrial-automation-and-control-5222
4. https://library.automationdirect.com/industry-resources/

Course Code	Course Title	L	T	P	C
10213EC108	**BUILDING AUTOMATION**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

Security of the building and safety of personal are becoming important aspects nowadays and in near future, it will be in a great demand. Complex infrastructure requires a variety of building automation and control systems. Building Management System (BMS) is computer-based control system installed in building that controls and monitors the total MEP (Mechanical – Electrical – Plumbing) and security structure.

c) Prerequisite

Nil

d) Related Courses

Industrial Automation

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the building management system and automation.	K2
CO2	Compare the various sensors and transducers and automation components in BMS	K2
CO3	Illustrate the fire alarm system and access control system	K2
CO4	Summarize security systems and its components used in building automation.	K2
CO5	Relate the HVAC and energy management systems.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	M	L	L	-	-	-	M	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	L	-	-
CO3	M	-	-	-	-	-	-	-	L	L	-	-	-	-
CO4	M	L	L	-	-	-	M	-	L	L	-	L	-	-
CO5	M	L	-	-	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I BUILDING MANAGEMENT SYSTEM AND AUTOMATION 9

Concepts, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS

UNIT II AUTOMATION COMPONENTS 9

Temperature Sensors: RTD, Thermistor, Thermocouple, Bimetallic strip - Pressure Sensors: Diaphragm type, piezoelectric sensors – Air flow sensor: Anemometer, velocity pressure sensors – Flow sensors: Turbine flow meter, ultrasonic flow meter–Different types of mounting for air & water flow meters

UNIT III FAS AND ACCESS CONTROL SYSTEMS 9

Fire Alarm Systems components, Field components, panel components–FAS Architectures Access Components, Access control system Design-CCTV camera types and operation– camera selection criteria– CCTV Applications.

UNIT IV SECURITY SYSTEMS 9

Fundamentals: Introduction to Security Systems Security Design: Security system design for verticals. Concept of automation in access control system for safety, Physical security system with components, RFID enabled access control with components, Computer system access control – DAC, MAC, and RBAC.

UNIT V HVAC SYSTEM AND ENERGY MANAGEMENT 9

HVAC Fundamentals, Control Panel: HVAC Control Panel, MCC Basics, Panel Components Communication: Communication Basics, Networks, BACNet, Modbus , LON, Energy Savings concept & methods, lightning control, Bureau of Energy Efficiency (BEE) standards, Green Building(LEED) Concept Examples.

Total : 45 Hours

h)Learning Resources

Text Books

1. Reinhold A, Carlson and Robert A, Di Giando Menico, 'Understanding Building automation Systems (Direct Digital Control, Energy Management, Life safety, Security, Access control, Lightning, Building management Programs), 1991.
2. Roger W. Haines, 'HVAC systems Design Hand book', Fifth edition, 2009.

Reference Books

1. Bela G. Liptak, 'Process Control –Instrument Engineers Hand book', Chilton book Co, 2006.

Online Resources

1. https://www.ncvttraining.com/building-automation.html
2. https://www.youtube.com/watch?v=YkDbOd26dFI
3. https://www.youtube.com/watch?v=OeVt4_5GLxQ
4. https://www.coursera.org/projects/building-test-automation-framework-using-selenium-and-testng

COURSE CODE	COURSE TITLE	L	T	P	C
10213EC109	EMBEDDED SYSTEMS	3	0	0	3

a) Course Category:
Open Elective

b) Preamble:
The objective of this course is to impart the concepts, design life cycles, compilation and debugging process in embedded systems which connect to the real time applications.

c) Prerequisite Courses:
Nil

d) Related Courses:
Nil

e) Course Outcomes:
Upon the successful completion of the course, students will be able to:

CO Nos	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the role of individual components involved in a typical embedded system	K2
CO2	Relate the embedded systems life cycle and selection process	K2
CO3	Compare the different communication protocols and interfaces	K2
CO4	Outline the different compilation and debugging techniques	K2
CO5	Infer the various applications using embedded system design	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	M	L	M	L	-	-	-	-	L	L	-	L	L	M
CO2	M	M	H	L	-	-	-	-	M	L	-	L	-	L
CO3	M	L	L	M	-	-	-	-	-	L	-	-	-	L
CO4	M	L	L	L	-	-	-	-	-	L	-	-	M	L
CO5	M	L	M	L	-	-	-	-	-	L	-	M	M	L

g) Course Content:

UNIT I INTRODUCTION TO EMBEDDED SYSTEM 9

Embedded Systems-Processor Embedded into a System-Embedded Hardware Units and Devices in a System-Embedded Software in a System-Examples of Embedded Systems-Design Process in Embedded System-Classification of Embedded System.

UNIT II EMBEDDED SYSTEM LIFE CYCLE & SELECTION PROCESS 9

Introduction - Product Specification-Hardware Partitioning, Software Partitioning -Iteration and Implementation-Product Testing and Release-Maintaining and Upgrading Existing Products,

UNIT III DEVICES AND COMMUNICATION BUSES FOR DESIGN NETWORK 9

Input output Types and Examples-Serial Communication Devices-Parallel Device Ports-Wireless Devices-Timer and Counting Devices-Watchdog Timer-Real Time Clock-Network Embedded Systems

UNIT IV COMPILATION AND DEBUGGING TECHNIQUES 9

Compiling code- The pre-processor- Compilation- assembler- Linking and loading- linker/loader- Writing a library- Downloading. Debugging techniques- High level language simulation- Low level simulation- Task level debugging.

UNIT V EMBEDDED SYSTEMS APPLICATIONS 9

Embedded Systems in Healthcare Industry (smart watch) –Agricultural (drug delivery system) Automobile Sector (ECU) --Smart City (energy consumption and optimization)

Total : 45 Hours

h) Learning Resources:

Text Books:

1. Raj Kamal, Embedded Systems: Architecture, Programming and Design (3rd Edition), New Delhi: McGraw Hill Education (India),2015.
2. Steve Heath "Embedded Systems Design" Second Edition, Elsevier, 2009.
3. Arnold S. Berger, Embedded Systems Design: An Introduction to Processes, Tools, and Techniques, CMP Books, 2002.

Reference Books:

1.Frank Vahid & Tony Givargis, "Embedded System Design-A Unified Hardware/Software Introduction", Third Edition, John Wiley & Sons Inc., Reprint 2010.

Online Resources:

1.https://www.youtube.com/watch?v=4CPIjYGIYqc
2.https://www.youtube.com/watch?v=y70V0qHAFNQ
3.https://www.youtube.com/watch?v=yAOfqK1kQso

Course Code	Course Title	L	T	P	C
10213EC110	**FPGA ARCHITECTURES AND APPLICATIONS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

This course discusses the features, programming and applications of Programmable Logic Devices. The students shall emphasize the VLSI architectures such as Xilinx, Actel, Altera, Plessy, plus logic, AMD, quick logic, algotronic Concurrent logic, technology mapping and design flow. This course introduce the Verilog HDL using data flow, behavioral and structural modeling. It also provides VLSI system design experience using FSM.

c) Prerequisite

Nil

d) Related Courses

Reconfigurable Computing With FPGA

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the features of programmable logic devices and CPLD	K2
CO2	Summarize the various FPGA architectures, technology mapping, design flow and one hot encoding.	K2
CO3	Demonstrate the combinational and sequential circuits using hardware description language	K2
CO4	Interpret the state assignments for FPGAs and FSM.	K2
CO5	Explain the VLSI system design using combinational and sequential circuit	K2

f) Correlation of COs with POs and PSOs

	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	M	M	M	L	L	-	-	-	-	-	-	M	M	L
CO2	M	L	M	M	M	-	-	-	-	-	-	L	M	L
CO3	M	L	H	M	H	M	-	-	-	-	-	L	L	-
CO4	H	H	M	H	H	M	-	-	-	-	-	M	M	L
CO5	M	M	H	H	M	M	-	-	-	-	-	M	L	L

g) Course Content

UNIT I INTRODUCTION TO CPLDS **9**

Introduction to PLDs- PLA, PAL, PROM, CPLD-Architectures, Basic concepts - Macrocell Architecture, Logic array, programmable flip-flops, programmable clock, I/O control block, MAX product family and FLEX Architecture

UNIT II INTRODUCTION TO FPGAS **9**

Commercial FPGAs- programming technologies, Xilinx, Actel, Altera, plessy, plus logic, AMD, quick logic, algotronix, Concurrent logic, Crosspoint Solutions, Design flow

UNIT III INTRODUCTION TO HARDWARE DESCRIPTION LANGUAGE **9**

Introduction to Verilog - Structural, Dataflow and Behavioral modeling, modeling of combinational logic circuits (Basic Gates, Buffer, Adder, Subtractor, Encoder, and Decoder), modeling of sequential logic circuits (D and T Flip Flops).

UNIT IV FINITE STATE MACHINES **9**

Top down Approach to Design, State diagram, State Transition Table, State assignments for FPGAs, Case study Mealy & Moore Machines, Pipelining, FSM issues-Starring state, Power on Reset, State diagram optimization, fault Tolerance

UNIT V SYSTEM LEVEL DESIGN **9**

Controller, data path and functional partitions, Parallel adder, Multiplexer's, sequential circuits-counters, Shift Register, FPGA Applications

Total: 45 Hours

h) Learning Resources

Text Books

1. P.K.Chan & S. Mourad, Digital Design Using Field Programmable Gate Array, Prentice Hall (Pte), 1994.
2. S.Brown, R.Francis, J.Rose, Z.Vransic, "Field Programmable Gate Array", Kluwer Publications, 1992.
3. J Bhasker, A Verilog HDL Primer, 3th Edition, Star Galaxy Publishing, 2018
4. M. J. S. Smith, "Application Specific Integrated Circuits," Addition – Wesley Longman Inc., 1997.

Reference Books

1. Old Field, R.Dorf, "Field Programmable Gate Arrays", John Wiley & Sons, New York, 1995.
2. S.Trimberger, Edr. "Field Programmable Gate Array Technology", Kluwer Academic Publications, 1994. 3. Bob Zeidman, "Designing with FPGAs & CPLDs", CMP Books, 2002. Jon F Wakerly, Digital Design: Principles and Practices, Prentice Hall.
3. M. Morris Mano, Michael D Ciletti, Digital Design, 5th Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.

Online Resources

1. https://www.elprocus.com/fpga-architecture-and-applications/
2. https://www.logic-fruit.com/blog/fpga/fpga-design-architecture-and-applications/
3. https://towardsdatascience.com/introduction-to-fpga-and-its-architecture-20a62c14421c
4. https://www.geeksforgeeks.org/xilinx-fpga-architecture/

Course Code	Course Title	L	T	P	C
10213EC111	**INTELLIGENT TRANSPORT SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

Fundamental concepts of Intelligent Transportation Systems (ITS) for the students with interest in engineering, transportation systems, communication systems, vehicle technologies, transportation planning, transportation policy, and urban planning

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the historical background and evolution of intelligent transportation systems and its types	K2
CO2	Discuss the hardware requirements and data necessities of ITS.	K2
CO3	Describe the user requirements and amenities of ITS	K2
CO4	Outline the planning requirements of ITS in various transportation modes to improve their safety and efficiency	K2
CO5	Demonstrate the cutting-edge of ITS applications and visualize the evolution of transportation in the near future.	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	L	L	-	-	-	-	-	-	M	L	-	L	-	-
CO2	L	L	L	L	L	-	-	-	M	L	-	M	-	-
CO3	L	L	M	M	M	-	-	-	M	L	-	M	-	-
CO4	L	L	M	M	M	-	-	-	M	L	-	H	-	-
CO5	L	L	L	H	H	-	-	-	M	L	-	M	-	-

g) Course Content

UNIT I FUNDAMENTALS OF INTELLIGENT TRANSPORTATION SYSTEMS 9

Introduction to ITS, Historical Context of ITS - Roles and Responsibilities - Types of ITS - Functionality and Business Models - Benefits of ITS - Importance of Telecommunications in the ITS - Information Management, Traffic Management Schemes

UNIT II HARDWARE AND DATA NECESSITIES OF ITS 9

Application of Sensors in Traffic management – Traffic Prediction Systems; Transponders and Communication systems - Data Management Centres - Elements of Vehicle Location and Route Navigation - ITS Data Collection Techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), GIS, Video Data Collection.

UNIT III I T S USER REQUIREMENTS AND AMENITIES 9

Advanced Traffic Management Systems (ATMS), Advanced Traveller Information Systems (ATIS), Commercial Vehicle Operations (CVO), Advanced Vehicle Control Systems (AVCS), Advanced Public Transportation Systems (APTS), Advanced Rural Transportation Systems (ARTS)

UNIT IV ITS PLANNING AND DEPLOYMENT 9

ITS Models and Evaluation Methods - Planning and Human Factor issues for ITS - Case Studies on Deployment Planning - System Design and Operation of ITS – ITS Safety and Security, Current Researches in ITS, Development and Business models of ITS

UNIT V APPLICATIONS 9

Traffic and Incident Management Systems - Travel Demand Management - Electronic Toll Collection - ITS and Road Pricing - Transportation Network Operations - Commercial Vehicle Operations and Intermodal Carriage - Public Transportation Applications - ITS

regional Architectures – ITS Programs in the World – Overview of ITS implementations in developed countries - ITS in developing countries.

Total 45 Hrs

h) Learning Resources

Text Books

1. Chowdhury, Mashrur A., and Adel Wadid Sadek, "Fundamentals of Intelligent Transportation Systems Planning". Artech House, 2003.
2. Klein, Lawrence A., "Sensor Technologies and Data Requirements for ITS". 2001.
3. Chen, Kan, and John Collingwood Miles, "ITS Handbook 2004: Recommendations from the world road association (PIARC)." (2004).

Reference Books

1. Sussman, Joseph S, "Perspectives on intelligent transportation systems (ITS)" Springer Science & Business Media, 2008.
2. "National ITS Architecture Documentation", US Department of Transportation, 2007

Online Resources

1. https://www.pcb.its.dot.gov/eprimer/default.aspx

Course Code	Course Title	L	T	P	C
10213EC112	**WIRELESS COMMUNICATION TECHNOLOGIES**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices. This course focuses on the fundamental concepts of mobile communication, various propagation models, signaling schemes and recent trends in wireless communication.

c) Prerequisite

Nil

d) Related Courses

Wireless Networks

e) Course Outcomes

Upon the successful completion of the course, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe the evolution of wireless communication systems.	K2
CO2	Discuss a cellular system based on resource availability and traffic demands.	K2
CO3	Characterize a wireless channel and distinguish various signalling schemes.	K2
CO4	Interpret the 5G cellular concepts and the techniques used to increase the data rate and capacity.	K2
CO5	Explain the recent trends in wireless communication and resource management	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	-	-	-	-	-	-	-	-	-	-
CO2	H	M	M	-	-	-	-	L	L	-	-	-	-	L
CO3	H	M	M	-	L	-	-	L	L	-	-	-	-	-
CO4	H	M	L	-	L	-	-	L	L	-	-	L	-	M
CO5	H	M	L	-	L	-	-	L	L	-	-	L	-	M

g) Course Content

UNIT I INTRODUCTION TO WIRELESS COMMUNICATION SYSTEM 9

Evolution of mobile communications - Types of wireless communication systems - Comparison of common mobile radio systems- Trends in cellular radio and personal communication – An overview on generations of wireless technology: 1G, 2G, 3G, 4G/ LTE

UNIT II CELLULAR SYSTEM DESIGN FUNDAMENTALS 9

Cellular system- hexagonal geometry cell and concept of frequency reuse- Channel assignment strategies - Handoff Strategies: Types of Handoffs, Prioritizing Handoff- Interference and system capacity: Co- channel and adjacent interference, Umbrella cell concept, Trunking and Grade of service - Improving coverage & capacity in cellular system: Cell splitting, Cell sectoring, Repeaters, Micro cell zone concept.

UNIT III MOBILE RADIO PROPAGATION AND SIGNAL TRANSMISSION 9

Signal Propagation: Basic propagation mechanisms, path loss, multipath propagation, fading effects –Modulation Techniques: Offset-QPSK, MSK, GMSK - Multicarrier modulation – Spread spectrum: DSSS, FHSS- Multiple Access techniques: FDMA, TDMA, CDMA

UNIT IV 5G SYSTEM CONCEPTS 9

5G concept overview –Millimeter wave communication- Extreme mobile broadband: Multiple antenna systems (MIMO), Beamforming, Spatial diversity - 5G architecture: Basics about 5G RAN, High level requirement, physical architecture and 5G deployment -5G waveform :OFDM- NOMA

UNIT V RECENT TRENDS IN WIRELESS COMMUNICATION 9

Machine type communication: Fundamental techniques, massive MTC, V2X communication - D2D communication :4G to 5G Research challenges, Radio resource management for mobile broadband D2D, RRM and system design for D2D, Power control and Mode selection.

Total: 45 Hours

h) Learning Resources

Text Books

1. Theodore, S. Rappaport, "Wireless Communications, Principles, Practice", Second Edition, PHI, 2002.
2. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005

Reference Books

1. William Stallings, "Wireless Communications and Networks", Second Edition, Pearson Education, 2004.
2. Andreas F Molisch, "Wireless Communications, Wiley, 2011.
3. Afif Osseiran, Jose F. Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology, Cambridge University Press, 2016.
4. David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005, South Asian Edition, 2006.

Online Resources

1. https://www.digimat.in/nptel/courses/video/106106167/L01.html
2. https://onlinecourses.nptel.ac.in/noc21_ee66/preview
3. https://youtu.be/SljXFf0vgvw
4. https://onlinecourses.nptel.ac.in/noc22_ee65/preview
5. https://archive.nptel.ac.in/courses/108/105/108105134/

Course Code	Course Title	L	T	P	C
10213EC113	FPGA TECHNOLOGY AND APPLICATIONS	3	0	0	3

a) Course Category

Open Elective

b) Preamble

This course discusses the features, programming and applications of Programmable Logic Devices. The students shall emphasize the VLSI architectures such as Xilinx, Actel, Altera, plessy, plus logic, AMD, quick logic, algotronic Concurrent logic, technology mapping and design flow. This course introduce the Verilog HDL using data flow, behavioral and structural modeling. It also provides VLSI system design experience using FSM.

c) Prerequisite

Nil

d) Related Courses

Reconfigurable Computing with FPGA

e) Course Outcomes

Upon the successful completion of the course, students will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the features of programmable logic devices and CPLD	K2
CO2	Summarize the various FPGA architectures, technology mapping, design flow and one hot encoding.	K2
CO3	Develop the combinational and sequential circuits using hardware description language	K3
CO4	Interpret the state assignments for FPGAs and FSM.	K2
CO5	Relate the VLSI system design using FPGA	K2

f) Correlation of COs with POs and PSOs

	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	M	M	M	L	L	-	-	-	-	-	-	M	M	L
CO2	M	L	M	M	M	-	-	-	-	-	-	L	M	L
CO3	M	L	H	M	H	M	-	-	-	-	-	L	L	L
CO4	H	H	M	H	H	M	-	-	-	-	-	M	M	L
CO5	M	M	H	H	M	M	-	-	-	-	-	M	L	L

g) Course Content

UNIT I COMPLEX PROGRAMMABLE LOGIC DEVICES 9

Introduction to PLDs - PLA, PAL, PROM, CPLD-Architectures, Basic concepts - Macrocell Architecture, Logic array, programmable flip-flops, programmable clock, I/O control block, MAX product family and FLEX Architecture

UNIT II FIELD PROGRAMMABLE GATE ARRAY 9

Commercial FPGAs- programming technologies, Xilinx, Actel, Altera, plessy, plus logic, AMD, quick logic, algotronix, Concurrent logic, Cross point Solutions, Design flow

UNIT III HARDWARE DESCRIPTION LANGUAGE 9

Introduction to Verilog- Structural, Dataflow and Behavioral modeling, modeling of combinational logic circuits - Basic Gates, Buffer, Adder, Subtractor, Encoder, and Decoder, modeling of sequential logic circuits - D and T Flip Flops.

UNIT IV FINITE STATE MACHINES 9

Top down Approach to Design, State diagram, State Transition Table, State assignments for FPGAs, Mealy and Moore Machines, Pipelining, FSM issues-Starring state, State diagram optimization

UNIT V SYSTEM LEVEL DESIGN 9

Controller, data path and functional partitions, Parallel adder, Multiplexer's, Sequential circuits-Counters, Shift Register, FPGA Applications

Total: 45 Hours

h) Learning Resources

Text Books

1. Juan Jose Rodriguez Andina, Eduardo de la Torre Arnanz, Maria Dolores Valdes Pena, "FPGAs: Fundamentals, Advanced Features, and Applications in Industrial Electronics", CRC Press, 2020.
2. J Bhasker, "A Verilog HDL Primer", 3rd Edition, Star Galaxy Publishing, 2018

3. M. J. S. Smith, "Application Specific Integrated Circuits", Pearson Education, 2009.
4. P.K.Chan and S. Mourad, Digital Design using Field Programmable Gate Array, Prentice Hall (Pte), 1994.

Reference Books

1. Old Field, R.Dorf, "Field Programmable Gate Arrays", John Wiley & Sons, New York, 1995.
2. S.Brown, R.Francis, J.Rose, Z.Vransic, "Field Programmable Gate Array", Kluwer Publications, 1992.
3. S.Trimberger, Edr. "Field Programmable Gate Array Technology", Kluwer Academic Publications, 1994.
4. Bob Zeidman, "Designing with FPGAs and CPLDs", Elsevier CMP Books, 2002.
5. Jon F Wakerly, "Digital Design: Principles and Practices", 4th Edition, Prentice Hall of India, 2008
6. M. Morris Mano, Michael D Ciletti, "Digital Design", 5th Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.

List of Learning Websites

1. https://www.elprocus.com/fpga-architecture-and-applications/
2. https://www.logic-fruit.com/blog/fpga/fpga-design-architecture-and-applications/
3. https://towardsdatascience.com/introduction-to-fpga-and-its-architecture-20a62c14421c
4. https://www.geeksforgeeks.org/xilinx-fpga-architecture/

Online resources

1. Jayaraj U Kidav, Workshop on FPGA Architecture and Programming using Verilog HDL [MOOC]
   NPTEL. https://elearn.nptel.ac.in/shop/nptel/workshop-on-fpga-architecture-and-programming-using-verilog-hdl/

Course Code	Course Title	L	T	P	C
10213EC114	**BASICS OF EMBEDDED SYSTEM**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

The purpose of this course is to acquire knowledge on complete design of an embedded system with functional requirements for hardware and software components including processor, sensors, and subsystem interfaces to connect real world applications systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Classify Embedded Systems based on their characteristics, including single-purpose systems, real-time systems, networked systems, and mobile systems.	K2
CO2	Summarize of 8051 Microcontroller: Architecture, Memory, Addressing, Instruction Set, Interrupts, I/O Ports, Assembly Language.	K2
CO3	Explain the peripheral interfacing required to design an embedded system.	K2
CO4	Relate various types of serial communication protocol.	K2
CO5	Outline the various aspects of complete embedded system design through applications.	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CO2	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CO3	M	-	-	-	-	-	-	H	-	-	-	-	M	M
CO4	M	-	L	-	-	-	-	-	-	-	-	M	L	-
CO5	M	-	-	-	-	-	-	-	L	L	-	-	M	M

g) Course Content

UNIT I FUNDAMENTALS OF EMBEDDED SYSTEMS 8

Embedded system definition, classification of embedded system, embedded system design process, reset circuits.

UNIT II MICROCONTROLLER 10

Difference between microprocessor and microcontroller, Overview of the architecture of 8051 microcontroller, Memory organization, and special function registers, Addressing Modes, Instruction formats, Instruction set, Interrupt and Interrupt routines, I/O Ports, Assembly Language programming.

UNIT III INTERFACING PERIPHERALS USING EMBEDDED C 10

Embedded C Programming structure, logical operations, IO programming, delay programming, timer and counter programming, serial port programming, LCD interfacing, and keypad interfacing.

UNIT IV COMMUNICATION PROTOCOL 8

Communication Basics, Serial communication protocols: UART, RS232, RS485, SPI, USB, Introduction to I2C and CAN.

UNIT V APPLICATIONS 9

Smart Agriculture System, Intelligent Transportation Systems Autonomous Drone Navigation System.

Total: 45 Hours

h) Learning Resources

Textbooks

1. RajKamal, “Embedded Systems: Architecture, Programming and Design”, Second Edition, Tata Mc Graw-Hill Education, 2011.
2. Mohamed Ali Mazidi, Janice Mazidi, Rolin Mc Kinlay, “The 8051 Microcontroller

and Embedded Systems: Using Assembly and C", Second Edition, Pearson education, 2011.

Reference Books:

1. M.Natale, A.Ghosal, "Understanding the CAN Communication Protocol", Springer, 2012.
2. Don Anderson, "Universal Serial Bus System Architecture", Addison Wesley, 2007.

Online Resources

1 https://www.scribd.com/document/332179045/101535193-embedded-systems-by-rajkamal-pdf-pdf#

Course Code	Course Title	L	T	P	C
10213EC115	**BASICS OF SENSORS AND TRANSDUCERS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

The purpose of this course is to acquire knowledge on complete design of an embedded system with functional requirements for hardware and software components including processor, sensors, and subsystem interfaces to connect real world applications systems.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the concepts of measurement technology.	K2
CO2	Illustrate the working principle and characteristics of motion ,proximity and ranging sensors	K2
CO3	Infer the working principle and characteristics of force, magnetic and heading sensors	K2
CO4	Compare the working principle and characteristics of optical, pressure and temperature sensors	K2
CO5	Interpret the operation and applications of modern industrial transducers	K2

f) Correlation of COs with POs and PSOs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO12	PSO1	PSO2
CO1	M	L	-	-	-	-	-	-	-	-	-	L	M	L
CO2	M	L	M	L	L	-		L	-	-	-	L	M	L
CO3	M	L	-	M	-	-	L	-	L	L	-	-	L	L
CO4	M	L	L	M	M	-		L	L	L	-	-	M	L
CO5	M	L	M	M	M	-	-	L	-	-	-	L	M	L

g) Course Content

UNIT I FUNDAMENTALS OF MEASUREMENT SYSTEMS 9

Basics of Measurement – Classification of errors – Error analysis – Static and dynamic characteristics of transducers – Performance measures of sensors – Classification of sensors – Sensor calibration techniques – Sensor Output Signal Types.

UNIT II MOTION, PROXIMITY AND RANGING SENSORS 9

Motion Sensors – Potentiometers, Resolver, Encoders – Optical, Magnetic, Inductive, Capacitive, LVDT – RVDT – Synchro – Microsyn, Accelerometer, Range Sensors – RF beacons, Ultrasonic Ranging, Reflective beacons, Laser Range Sensor (LIDAR).

UNIT III FORCE, MAGNETIC AND HEADING SENSORS 9

Strain Gage, Load Cell, Magnetic Sensors –types, principle, requirement and advantages: Magneto resistive – Hall Effect – Current sensor Heading Sensors – Compass, Gyroscope, Inclinometers.

UNIT IV OPTICAL, PRESSURE AND TEMPERATURE SENSORS 9

Photo conductive cell, photo voltaic, Photo resistive, Fiber optic sensors – Pressure – Diaphragm, Bellows, Piezoelectric – Tactile sensors, Temperature – IC, Thermistor, RTD, Thermocouple. Acoustic Sensors – flow and level measurement, Radiation Sensors – Smart Sensors – Film sensor, MEMS & Nano Sensors, LASER sensors.

UNIT V ADVANCED TRANSDUCERS 9

Energy harvesting transducers– Hall Effect transducer – Magneto resistor -Digital displacement transducer– Fiber optic sensor - Introduction to SQUID sensor, Hyper spectral sensor, Touch screen sensor, Smart Transducer.

Total : 45 Hours

h) Learning Resources

Textbooks

1) Ernest O. Doebelin,- Measurement system, 7th Edition, Tata McGraw Hill Education Private Ltd, New Delhi, 2019.
2) A.K. Sawhney, A course in Electrical & Electronic Measurement and Instrumentation, DhanpatRai and Company Private Limited, 2015.

Reference Books

1) D. Patranabis, Sensors and Transducers, 2nd Edition, Prentice Hall of India, 2010.
2) John P.Bentley, Principles of Measurement Systems, 4th Edition, Pearson Education, 2004.
3) Neubert H.K.P., ―Instrument Transducers – An Introduction to their Performance and Design, Oxford University Press, Cambridge, 2003.
4) Murthy D.V.S., ―Transducers and Instrumentation‖, 2nd Edition, Prentice Hall of India Private Limited, New Delhi, 2010.
5) S.Renganathan, ―Transducer Engineering, Allied Publishers, 2005.

Online Resources

1. Electro Schematics - Sensor Circuits Section:
   Website: https://www.electroschematics.com/category/sensors/
2. All about Circuits - Sensors Section:
   Website: https://www.allaboutcircuits.com/technical-articles/category/sensors/

Course Code	Course Title	L	T	P	C
10213EC201	**VEHICLE ELECTRONICS & NETWORKS**	**2**	**0**	**2**	**3**

a) Course Category

Open Elective

b) Preamble

In this course, the students will learn about basic electronic modules used in modern vehicles and the networking architecture used to interconnect these modules. Concretely, they will learn (1) The sensors and actuators used in modern vehicles (2) The design of electronic subsystems in vehicles (3) The interconnection of all the electronic subsystems using vehicle networking.

c) Prerequisite

Nil

d) Related Courses

Nil

e) Course Outcomes

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Summarize the key benefits of passive elements and active elements	K2
CO2	Interpret the terminology of instrumentation and analyze various sensors.	K2
CO3	Illustrate the various switching and control devices.	K2
CO4	Explain the automotive electronic system for monitoring engine performance, infotainment and telematics.	K2
CO5	Relate the appropriate protocols used in vehicle networking	K2

f) Correlation of COs with POs and PSOs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	-	-	-	-	-	-	-	-	L	L	-
CO2	M	M	M	-	-	-	-	-	-	-	-	L	L	-
CO3	M	-	M	-	M	-	-	-	-	-	-	-	L	-
CO4	M	M	L	L	L	L	L	L	-	-	-	L	L	-
CO5	M	-	-	-	L	-	-	-	L	L	L	-	L	-

g) Course Content

UNIT I INTRODUCTION 6

Introduction to Basic Electronics: Passive elements, Op-Amp, LED and LCD, logic gates, Mux,De-mux, driver circuits, ADC, DAC.

UNIT II SENSORS AND ACTUATORS 6

Sensors – Specifications and applications of ABS Sensor, wheel speed sensor, tyre pressure sensor, fluid level sensor, Accelerometer, Light sensor, Infra-Red, temperature sensor, limit switch. Actuators – Specifications and applications of tyre inflator, AC unit compressor, windshield wiper, heating coil, lighting systems, airbag system, motors and electronic-valves.

UNIT III SWITCHING AND CONTROL DEVICES 6

Specifications and applications of relays and switches – dip switch, push buttons, touch switch, toggle switch-Microcontrollers (Arduino)-microprocessor (Raspberry Pi)-ECU.

UNIT IV AUTOMOTIVE ELECTRONIC SYSTEMS 6

Ignition Control and Start-Stop System, Heating and AC System, Seat belt indication system, Parking Assistance System, Vehicle telematics system

UNIT V NETWORKING 6

Automotive Bus: LIN, CAN, MOST, FlexRay, Automotive-Ethernet- Bus- Architecture Design& Simulation Tool: MATLAB, Vector CANoe Simulation Tool

h) List of Projects/Tasks

S. No	Theme	CO Mapping	Projects/Tasks (30 Hours)
1.	Body Electronics	CO2	Task1: Door Lock/Unlock System
2.	Infotainment System	CO2	Task2: Bluetooth based infotainment system
3.		CO2	Task3: Design a Digital Dashboard showing Fuel, Oil Pressure values.
4.	Comfort Electronics	CO2	Task4: Automatic climate control system
5.		CO2	Task5: Reverse Parking assistance system
6.	Performance Monitoring System	CO2	Task6: Engine Ignition ON/OFF System
7.		CO2	Task7: Coolant and Brake Fluid Level
8.	Vehicle Telematics	CO3	Task8: Vehicle Tracking System
9.		CO3	Task9: Vehicle to Vehicle and Vehicle to Infrastructure Communication System
10.		CO3	Task10: Vehicle telematics system
11.	Automotive Networks	CO3	Task11: Simulation of CAN communication using MATLAB
12.		CO3	Task12: Simulation of CAN/LIN communication using Vector CANoe

Total: 60 Hrs

i) Learning Resources

Text Books

1. Bosch Automotive Electrics and Automotive Electronics: Systems, Components and Hybrid Drive, Robert Bosch GmbH, Springer Vieweg, 2007.
2. Marc Emmelmann, Bernd Bochow, Christopher Kellum, "Vehicular Networking: Automotive Applications and Beyond", Wiley, 2010

.

Reference Book

1.Timo Kosch, Christoph Schroth, Markus Strassberger, Marc Bechler, "Automotive Internetworking", Wiley, 2012

Online Resources

1. https://resources.pcb.cadence.com/blog/2022-automotive-circuit-design-essentials
2. https://nptel.ac.in/courses/108103009
3. https://ed.iitm.ac.in/~shankarram/Course_Files/ED5160/ED5160.html

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Course Code	Course Title	L	T	P	C
10214EC501	**COMMUNITY SERVICE PROJECT**	**0**	**0**	**2**	**1**

a. Course Category:

Independent Learning

b. Preamble:

The Community Service Project which carries one credit, helps students to find solutions to real life societal problems. They need to identify the problem, conduct literature survey and provide the feasible solution. Maximum of three in a group will carry out the project.

c. Prerequisite Courses:

- Basic Engineering / Science courses relevant to the student's discipline
- Environmental Studies / Environmental Science
- Engineering Ethics and Human Values (or Professional Ethics)
- Basic Communication Skills
- Fundamental problem-solving skills

d. Related Courses:

Minor Project-I, Minor Project-II, Major Project

e. Course Outcomes:

On successful completion of this course the student will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Infer contemporary real time problems in society and its challenges.	K2
CO2	Apply appropriate knowledge and skills to respond effectively to social and practical needs in real-world situations.	K3
CO3	Solve the societal problems by selecting and applying appropriate solutions based on their feasibility, impact, and effectiveness.	K3

f. Correlation of COs with POs and PSOs:

COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	H	M	M	L	L	L	L	L	M	-	M	-	-
CO2	H	H	H	-	H	M	M	M	M	M	-	M	-	-
CO3	H	H	H	H	H	H	H	H	H	H	H	H	H	H

g. Course Content:

The course objective shall be:

1. The students will gain practical understanding of real time problems in society and its challenges.
2. Apply their knowledge & skill, and technology available to solve the issue.
3. Students will learn to respond to social and practical needs.

Methodology:

1. Student(s) as a team or individual will be carrying out survey at their location with the local community groups based on the domain knowledge.
2. Students are recommended to carry out the CSP in the University UBA adopted villages near our campus. (Morai, Pandeeswaram, Kanniamman Nagar, Veerapuram and Vellanur). The service of UBA coordinator of the University may be used to approach the adopted villages.
3. Students may interact with local government authorities/communities to identify the problems.
4. Suggest a technology driven best solution in term of prototype model development or develop a new solution for solving the societal problems with the support of a faculty guide in the institution.

Evaluations:

1. The community service project will be evaluated for the 100 marks.
2. The Internal & External evaluations will be done as per clause 8.2.10 & 8.3.6 under the Regulations VTR UGE 2021.
3. The following components may be given due weightage in the evaluation of community service project.
    a. Survey/ Society relevant problem identification.
    b. Regular interaction & updates with the local panchayat/community president.
    c. Novel idea generation.
    d. Prototype/Development of new solution.
    e. Documentation via photo, video with authenticated signatures.
    f. Final Report.

Total: 30 Hrs

h. Learning Resources:

1. Research Journals and Digital Libraries
2. Online Learning Platforms
3. Industry Reports and Technical Standards

COURSE CODE	COURSE TITLE	L	T	P	C
10214EC601	MINOR PROJECT I	0	0	4	2

a. Course Category:

Independent Learning

b. Preamble:

The Minor Project provides students with an opportunity to apply fundamental concepts acquired during their coursework to address a focused engineering problem. It emphasizes problem understanding, basic design, implementation, and documentation within a limited scope. The course aims to develop analytical thinking, creativity, and practical skills while introducing students to systematic problem-solving approaches. It also fosters individual initiative, effective communication, and the ability to present technical outcomes clearly.

c. Prerequisite Courses:

- Basic Engineering Mathematics
- Core courses relevant to the chosen project domain (e.g., Programming, Electronics, etc.)
- Fundamental Laboratory Courses
- Problem Solving and Programming (if applicable)
- Engineering Graphics / Design Fundamentals (if applicable)

d. Related Courses:

Community service project, Minor Project-II, Major Project

e. Course Outcomes:

On successful completion of this course the student will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Identification of thrust area, novelty and understanding of the project topic.	K2
CO2	Formulate and demonstrate the problem, time flow, Project work flow and methodology/design of project.	K3
CO3	Demonstrate the project with CDIO skill, team work, proper interpretation, conclusion and prepare the project report.	K3

f. Correlation of COs with POs:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	M	L	L	L	L	L	L	-	L	-	-
CO2	H	H	H	-	H	M	M	M	M	M	-	M	-	-
CO3	H	H	H	H	H	H	H	H	H	H	H	H	H	H

g. Course Content:

The Minor Project course provides students with an opportunity to apply foundational knowledge gained during their program to solve a well-defined engineering problem within a limited scope. Students identify a suitable problem area, perform a basic literature survey, and propose a simple and feasible solution using appropriate tools and techniques.

Projects may be selected from domains such as signal processing, communication systems, embedded systems, VLSI design, or networking at an introductory level. The work may involve basic algorithm development, simulation, design, or small-scale hardware/software implementation depending on the chosen domain.

Students follow essential stages of project development including problem identification, requirement analysis, methodology/design, implementation or simulation, and preliminary testing. Emphasis is given to understanding the project workflow, time planning, and systematic execution.

The course also includes documentation of the project work, presentation of results, and demonstration of outcomes. Periodic reviews are conducted to monitor progress and provide guidance.

This course helps students develop problem-solving ability, technical skills, teamwork, and communication skills, while preparing them for more advanced project work in the Major Project.

Total: 60 Hrs

h. Learning Resources:

1. Research Journals and Digital Libraries
2. Online Learning Platforms
3. Industry Reports and Technical Standards

COURSE CODE	COURSE TITLE	L	T	P	C
10214EC602	MINOR PROJECT II	0	0	4	2

a. Course Category:

Independent Learning

b. Preamble:

The Minor Project provides students with an opportunity to apply fundamental concepts acquired during their coursework to address a focused engineering problem. It emphasizes problem understanding, basic design, implementation, and documentation within a limited scope. The course aims to develop analytical thinking, creativity, and practical skills while introducing students to systematic problem-solving approaches. It also fosters individual initiative, effective communication, and the ability to present technical outcomes clearly.

c. Prerequisite Courses:

- Basic Engineering Mathematics
- Core courses relevant to the chosen project domain (e.g., Programming, Electronics, etc.)
- Fundamental Laboratory Courses
- Problem Solving and Programming (if applicable)
- Engineering Graphics / Design Fundamentals (if applicable)

d. Related Courses:

Community service project, Minor Project-1, Major Project

e. Course Outcomes:

On successful completion of this course the student will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Identification of thrust area, novelty and understanding of the project topic.	K2
CO2	Formulate and demonstrate the problem, time flow, Project work flow and methodology/design of project.	K3
CO3	Demonstrate the project with CDIO skill, team work, proper interpretation, conclusion and prepare the project report.	K3

f. Correlation of COs with POs:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO12	PSO 1	PSO 2
CO1	H	H	M	M	L	L	L	L	L	L	-	L	-	-
CO2	H	H	H	-	H	M	M	M	M	M	-	M	-	-
CO3	H	H	H	H	H	H	H	H	H	H	H	H	H	H

g. Course Content:

The Minor Project course provides students with an opportunity to apply foundational knowledge gained during their program to solve a well-defined engineering problem within a limited scope. Students identify a suitable problem area, perform a basic literature survey, and propose a simple and feasible solution using appropriate tools and techniques.

Projects may be selected from domains such as signal processing, communication systems, embedded systems, VLSI design, or networking at an introductory level. The work may involve basic algorithm development, simulation, design, or small-scale hardware/software implementation depending on the chosen domain.

Students follow essential stages of project development including problem identification, requirement analysis, methodology/design, implementation or simulation, and preliminary testing. Emphasis is given to understanding the project workflow, time planning, and systematic execution.

The course also includes documentation of the project work, presentation of results, and demonstration of outcomes. Periodic reviews are conducted to monitor progress and provide guidance.

This course helps students develop problem-solving ability, technical skills, teamwork, and communication skills, while preparing them for more advanced project work in the Major Project.

Total: 60 Hrs

h. Learning Resources:

1. Research Journals and Digital Libraries
2. Online Learning Platforms
3. Industry Reports and Technical Standards

Course Code	Course Title	L	T	P	C
10214EC701	**MAJOR PROJECT**	**0**	**0**	**18**	**9**

a. Course Category:

Independent Learning

b. Preamble:

The Major Project enables students to integrate and apply the knowledge gained throughout their program to solve real-world engineering problems. It emphasizes problem identification, design, implementation, analysis, and documentation. The course also develops teamwork, project management, and communication skills while encouraging innovation, critical thinking, and practical application of engineering principles.

c. Prerequisite Courses:

All Core Courses

d. Related Courses:

Minor Project I, Minor Project II, Community Service Project

e. Course Outcomes:

On successful completion of this course the student will be able to:

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Identify and formulate a relevant engineering problem with well-defined objectives and relevance to societal and environmental impact	K3
CO2	Apply appropriate engineering tools and techniques to develop a systematic methodology/algorithm, work effectively as a team, and recognize the need for lifelong learning	K3
CO3	Utilize smart technology-based CDIO skills to analyze simulation/experimental results and demonstrate project management and cost estimation	K3

f. Correlation of COs with POs:

COs	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	H	M	M	M	M	M	M	H	M	-	M	-	-
CO2	H	H	H	H	M	M	M	M	H	M	H	M	-	H
CO3	H	H	H	M	H	H	H	H	H	M	H	H	H	H

g. Course Content:

The Major Project course provides students with an opportunity to integrate and apply the knowledge gained throughout the program to solve real-world engineering problems across diverse domains such as signal processing, communication systems, embedded systems, VLSI design, and computer networking. In this course, students identify a relevant problem, conduct a comprehensive literature review, and design an appropriate solution using modern engineering tools and technologies. Projects in the signal processing domain may involve algorithms for filtering, image or speech processing, and data analysis. Communication-based projects may focus on wireless communication systems, antenna design, modulation techniques, or IoT-based communication frameworks. Embedded system projects emphasize microcontroller or FPGA-based hardware development for automation, monitoring, and control applications. In the VLSI domain, students may design and simulate digital or analog circuits, ASIC blocks, or low-power architectures using industry-standard tools. Networking projects may involve the design and analysis of network protocols, resource sharing systems, or security frameworks. Throughout the course, students follow systematic stages including problem formulation, system design, simulation or hardware implementation, testing, and performance evaluation. Regular progress reviews, technical documentation, and final project demonstrations are integral components of the course. This capstone experience enhances students' technical competence, innovation, teamwork, and project management skills while preparing them for professional engineering practice, research, and advanced studies.

Total: 270 Hrs

h. Learning Resources:

1. Research Journals and Digital Libraries
2. Online Learning Platforms
3. Industry Reports and Technical Standards