



**SCHOOL OF ELECTRICAL AND COMMUNICATION**

**DEPARTMENT OF ELECTRONICS AND COMMUNICATION  
ENGINEERING**

**VTR UGE 2021 CURRICULUM**



## **Department of Electronics and Communication Engineering**

### **Vision of the Department**

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 of the Department**

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 (POs)**

Engineering graduates will be able to:

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.

**Program Specific Outcomes (PSOs)**

On Successful Completion of the program, the graduates will be able to

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 cybersecurity technologies.

## **VTR UGE 2021 CURRICULUM**

<b>PROGRAM CORE COURSES</b>						
<b>S.No</b>	<b>Course Code</b>	<b>Program Core</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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 Lab	0	0	4	2
19	10211EC302	Digital Electronics Lab	0	0	2	1
20	10211EC303	Signal Processing Lab	0	0	2	1
21	10211EC304	Microprocessor and Microcontroller Lab	0	0	2	1
22	10211EC305	Communication Lab	0	0	2	1
23	10211EC306	Optical and Microwave Engineering Lab	0	0	2	1
		<b>Total Credits</b>				<b>58</b>

PROGRAM ELECTIVE COURSES						
S.No	Course Code	Program Elective	L	T	P	C
<b>Communication System Domain</b>						
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
<b>Embedded System Domain</b>						
12	10212EC109	Embedded System Design	3	0	0	3
13	10212EC110	Robotics and its Applications	3	0	0	3
14	10212EC111	Embedded Communication Protocols	3	0	0	3
15	10212EC112	Video Analytics	3	0	0	3
16	10212EC113	Wearable Devices	3	0	0	3
17	10212EC114	Process Control	3	0	0	3
18	10212EC204	Embedded C Programming	2	0	2	3
19	10212EC205	Embedded Linux and Device Drivers	1	0	4	3
20	10212EC206	Embedded Systems and Robotics	1	0	4	3
21	10212EC207	System on Chip	1	0	4	3
22	10212EC208	Virtual Instrumentation Programming	1	0	4	3
<b>Networks Domain</b>						
23	10212EC115	High Performance Communication Networks	3	0	0	3

24	10212EC116	Network Security	3	0	0	3
25	10212EC117	Network Management	3	0	0	3
26	10212EC118	Next Generation Mobile Networks	3	0	0	3
27	10212EC119	Wireless Body Area Networks	3	0	0	3
28	10212EC209	Software Defined Networking	2	0	2	3
29	10212EC210	Cognitive Radio Networks	2	0	2	3
30	10212EC211	Wireless Sensor Networks and its Application	2	0	2	3
31	10212EC212	Flying IoT	2	0	2	3
<b>Signal Processing Domain</b>						
32	10212EC120	Advanced Digital Signal Processing	3	0	0	3
33	10212EC121	Estimation Theory	3	0	0	3
34	10212EC122	DSP Algorithms and Architecture	3	0	0	3
35	10212EC123	Signal Processing Techniques for Speech Recognition	3	0	0	3
36	10212EC124	ANN and Deep Learning	3	0	0	3
37	10212EC125	Fuzzy-Neural Systems	3	0	0	3
38	10212EC126	Biomedical Instrumentation and Imaging	3	0	0	3
39	10212EC175	Fundamentals of Quantum Computing	3	0	0	3
40	10212EC213	Digital Image and Video Processing	2	0	2	3
41	10212EC214	Fundamentals of Machine Learning	2	0	2	3
42	10212EC215	Professional Python Programming	2	0	2	3
<b>VLSI Domain</b>						
43	10212EC127	Low Power VLSI Design	3	0	0	3
44	10212EC128	VLSI Design Techniques	3	0	0	3
45	10212EC129	VLSI for Wireless Communication	3	0	0	3
46	10212EC130	Solid State Devices	3	0	0	3
47	10212EC131	Architectural Design of Digital Integrated Circuits	3	0	0	3
48	10212EC132	Nano Scale Transistors	3	0	0	3
49	10212EC133	Opto Electronic Devices	3	0	0	3
50	10212EC134	Electronic Instrumentation	3	0	0	3
51	10212EC135	Nano Photonics	3	0	0	3

52	10212EC136	Fiber Lasers and Applications	3	0	0	3
53	10212EC137	Sensors and Transducers	3	0	0	3
54	10212EC216	FGPA Architecture Technologies and Tools	2	0	2	3
55	10212EC217	Electronic Circuit Simulation and PCB Design	1	0	4	3
56	10212EC232	Reconfigurable System Design	1	0	4	3
57	10212EC233	VLSI Chip Design	1	0	4	3
<b>Minimum no. of credits to be Completed</b>						<b>18</b>

<b>SPECIALIZATION DEGREE – ELECTIVE COURSES</b>						
<b>S.No</b>	<b>Course Code</b>	<b>Specialization Electives</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>Cyber Security</b>						
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	xxxxxxxxxx	NPTEL Course – Mandatory	0	0	0	3
<b>Minimum no. of credits to be Completed</b>						<b>18</b>
<b>Artificial Intelligence and Data Science</b>						
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	xxxxxxxxxxx	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
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	xxxxxxxxxxx	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	xxxxxxxxxxx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				18

## HONORS DEGREE - ELECTIVE COURSES

S.No	Course Code	Honors Electives	L	T	P	C
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
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	xxxxxxxxxx	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	xxxxxxxxxx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				18

## MINOR DEGREE – ELECTIVE COURSES

S.No	Course Code	Minor Electives	L	T	P	C
<b>Smart Communication Technologies</b>						
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	xxxxxxxxxx	NPTEL Course – Mandatory	0	0	0	3
<b>Minimum no. of credits to be Completed</b>						<b>18</b>
<b>Smart Automation</b>						
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	xxxxxxxxxx	NPTEL Course – Mandatory	0	0	0	3
<b>Minimum no. of credits to be Completed</b>						<b>18</b>
<b>5G and Beyond</b>						
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	xxxxxxxxxxx	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	xxxxxxxxxxx	NPTEL Course – Mandatory	0	0	0	3
		Minimum no. of credits to be Completed				18

<b>OPEN ELECTIVE COURSES</b>						
<b>S.No</b>	<b>Course Code</b>	<b>Open Electives</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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
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
		<b>Minimum no. of credits to be Completed</b>				<b>18</b>

<b>MOOC COURSES – NPTEL</b>					
<b>S.No</b>	<b>Course Code</b>	<b>Course Title</b>	<b>Weeks</b>	<b>Degree</b>	<b>C</b>
<b>PROGRAM ELECTIVE</b>					
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	10212EC419	5G Wireless Standard Design	12	5G and Beyond (Minor)	3
7	10212EC406	Millimeter Wave Technology	8	Program Elective	2
8	10212EC407	Optical Wireless Communications for Beyond 5G Networks and IoT	12		3
9	10212EC408	Embedded Sensing, Actuation and Interfacing Systems	12		3
10	10212EC409	Sensors and Actuators	12		3
11	10212EC410	Information Security - 5 - Secure Systems Engineering	8		2
12	10212EC411	Natural Language Processing	12		3
13	10212EC412	Reinforcement Learning	12		3
14	10212EC413	Design and Analysis of VLSI Subsystems	12		3
15	10212EC414	Cyber Security and Privacy	12		3
16	10212EC415	Modern Digital Communication Techniques	12		3
17	10212EC416	Operating System Fundamentals	12		3
18	10212EC417	Responsible & Safe AI systems	12		3
19	10212EC418	VLSI Design Flow: RTL to GDS	12	3	
OPEN ELECTIVE – MOOC COURSES					
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
6	10213EC406	Introduction to Semiconductor Devices	12		3
7	10213EC407	Optimization Theory and Algorithms	12		3
8	10213EC408	Microelectronics: Devices to Circuits	12		3

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

<b>PROFESSIONAL PROFICIENCY COURSES</b>						
<b>S.No</b>	<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
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
		<b>Minimum no. of credits to be Completed</b>				<b>4</b>

<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10211EC101</b>	<b>CIRCUIT THEORY</b>	<b>2</b>	<b>1</b>	<b>0</b>	<b>3</b>

**a) Course Category :**

Program 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:

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on revised Bloom's Taxonomy)</b>
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 8<sup>th</sup> 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, Shyammoan 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. Chandrashekharaiiah, “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>.

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Deemed to be University) Rank. A of UGC Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	H	M	L	-	L	-	-	-	-	-	-	L	L	-
<b>CO2</b>	M	M	L	-	L	-	-	-	L	-	-	-	-	-
<b>CO3</b>	M	H	L	M	L	-	-	-	-	-	-	-	L	-
<b>CO4</b>	M	M	L	-	M	L	-	L	M	L	L	-	L	-
<b>CO5</b>	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 II 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, 11<sup>th</sup> edition, 2010.
2. S.Salivahanan, N.Suresh Kumar and A.Vallavaraj, “Electronic Devices and Circuits”, McGraw-Hill, 5<sup>th</sup> edition, 2022.
3. David .A. Bell, “Electric Circuits And Electronic Devices Oxford University Press”, 5<sup>th</sup> 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, 3<sup>rd</sup> Edition, 2003.
6. Dr. R. S. Sedha, “A Textbook of Electronic Circuits” , S. Chand, 2014.

### **Online Resources**

1. Analog Electronics Course (nptel.com)

*Asst. Prof. M. V. V.*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Inst. by UAC Act 1986

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

**a) Course Category**

Program 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 (Based on 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
<b>CO1</b>	H	M	L	M	M	-	-	-	-	-	L	-	M	
<b>CO2</b>	H	M	H	L	H	-	-	-	-	-		M	L	
<b>CO3</b>	H	M	H	L	H	-	-	-	-	-	-	M	L	L
<b>CO4</b>	H	M	M	M	-	-	-	-	-	-	M	L	M	L
<b>CO5</b>	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, 5<sup>th</sup> Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.
2. Donald. P. Leach, Digital principles and applications, 7<sup>th</sup> Edition, McGraw-Hill, 2012.
3. S.Salivahanan, S. Arivazhagan, Digital Circuits and Design, 5<sup>th</sup> Edition, Oxford University Press, 2018
4. W.H. Hayt and I.E.Kemmerley, "Engineering Circuits Analysis", McGraw Hill Education 8<sup>th</sup> 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](https://onlinecourses.nptel.ac.in/noc22_ee55/preview)
3. <https://courses.cs.washington.edu/courses/csep567/10wi/lectures/Lecture2.pdf>

*Asim 18/12/17*

Dr. A. Selwin Muthu Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
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Course Code	Course Title	L	T	P	C
10211EC104	Linear Integrated Circuits	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	M	L	L	L	-	-	-	-	-	L	-	L	-	-
<b>CO2</b>	H	M	L	L	L	-	L	-	-	-	-	L	-	-
<b>CO3</b>	H	M	M	-	L	L	-	-	M	-	-	-	L	-
<b>CO4</b>	H	M	M	-	L	L	L	-	-	L	L	M	-	-
<b>CO5</b>	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", 2<sup>nd</sup> 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](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](https://onlinecourses.nptel.ac.in/noc20_ee13/preview)

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Road, on 8 of AUGUST 1982)

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

**a) Course Category**

Program 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 II order systems for various test signals and examine the system stability using time domain approach.	K3
CO3	Sketch the Frequency response of I order and II order systems and examine the system stability using frequency response plots.	K3
CO4	Develop controllers and compensators for Control System analysis using Frequency domain approach.	K3
CO5	Apply the concept of State-Space for Control System 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, 8<sup>th</sup> 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.

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the Vel Tech Inst. of Eng. & Tech. in 1996

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

**a) Course Category**

Program 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 for the analysis of continuous time signals.	K3
CO3	Use Fourier and Laplace transforms to examine the continuous time systems and realize it.	K3
CO4	Construct the discrete time signals using DTFT, Z transform and their properties.	K3
CO5	Make use of DTFT and Z transform to examine the discrete time systems 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
<b>CO1</b>	H	H	L	L	M	-	-	-	L	L	-	L	L	M
<b>CO2</b>	H	H	L	L	M	-	-	-	L	L	-	L	L	M
<b>CO3</b>	H	H	L	L	M	-	-	-	L	L	-	L	L	M
<b>CO4</b>	H	H	L	L	M	-	-	-	L	L	-	L	L	M
<b>CO5</b>	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](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)

*Asin M 18/12/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the Veltech Inst. of Eng. & Tech. in 1988)

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

**a) Course Category**

Program 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
<b>CO1</b>	H	M	L	L	-	-	-	-	L	L	-	M	-	-
<b>CO2</b>	H	H	L	L	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	M	L	-	-	-	L	L	L	-	M	L	-
<b>CO4</b>	H	H	M	L	L	L	L	L	L	L	-	M	L	-
<b>CO5</b>	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, 6<sup>th</sup> 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, 2<sup>nd</sup> Ed, 1978
4. E C Jordan and K G Balmain, “Electromagnetic Waves and Radiating Systems”, PHI, 2<sup>nd</sup> Ed, 2015

### **Reference Books**

1. J.F.D Kraus, Keith. R.Carver “Electromagnetics”, 5<sup>th</sup> 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, 6<sup>th</sup> Ed, 2006

### **Online Resources**

1. [https://onlinecourses.nptel.ac.in/noc20\\_ee59/preview](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

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. in 1984 of UGC Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	M	H	L	H	L	-	-	L	L	-	-	-	-	-
<b>CO2</b>	M	H	L	H	L	-	-	L	L	-	-	-	-	-
<b>CO3</b>	M	L	L	L	-	M	-	L	L	-	L	M	M	-
<b>CO4</b>	H	H	H	H	H	-	-	L	L	L	L	H	H	-
<b>CO5</b>	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-Gaussian 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, 4<sup>th</sup> Edition, 2000.
2. Herbert Taub, Donald L Schilling, and Goutam soha "Principles of Communication Systems", 4<sup>th</sup> 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", 28<sup>th</sup> reprint, Tata McGraw-Hill, 2003
2. R. P Singh and S.D. Sapre "Communication Systems-Analog and Digital", 2<sup>nd</sup> Edition, Tata McGraw Hill, 2007.
3. John G. Proakis, Masoud Salehi "Fundamentals of Communication Systems" Pearson Education, 2006.
4. Bruce Carlson, "Communication Systems" 5<sup>th</sup> Edition, Tata Mc Graw Hill. 2010
5. Sam K. Shanmugam, "Analog & Digital Communication" John Wiley, 2006
6. Wayne Tomasi "Electronic Communication Systems", 5<sup>th</sup> 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](http://www.csun.edu/~skatz/katzpage/sdr_project/sdr/FM_and_PM.pdf)

*Asim 18/11/17*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the Vel Tech Institute of Engineering & Technology in 1988)

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

**a) Course Category**

Program core

**b) Preamble**

The Purpose of the course is to provide students with the Knowledge of Microprocessors and Microcontroller. To solve real world problems in an efficient manner, this course also emphasis on architecture, Programming and system design used in various day to day gadgets.

**c) Prerequisite**

Digital Electronics

**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 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 an 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
<b>CO1</b>	H	M	M	L	H	-	-	L	L	L	-	-	M	M
<b>CO2</b>	H	M	M	L	H	-	-	L	L	L	-	-	M	M
<b>CO3</b>	H	M	M	L	H	-	-	L	L	L	-	-	M	H
<b>CO4</b>	M	L	-	-	-	-	-	-	L	L	-	-	M	-
<b>CO5</b>	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, instruction set; ARM: Features and Classifications. **Case Studies PIC /ARM:** Temperature Control System, Motor Speed Control System, Traffic light System, Elevator System, Data Acquisitions System.

**Total Hours: 45Hrs**

## **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", Pearson Education, 2008.
5. Muhammad Ali Mazidi, Sarmad Naimi, and Sepehr Naimi "AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2014.

### **Reference Book**

1. Kenneth J Ayala, The 8051 Microcontroller Architecture Programming and Application, Third Edition, Penram International Publishers, 2005.

### **Online Resources**

1. <https://www.youtube.com/watch?v=liRPtvj7bFU&list=PL0E131A78ABFBFDD0>
2. <https://www.youtube.com/watch?v=95uGOJ1Ud2c&list=PLJGA4olwzpA-rvcdWULcRuMn2495g0n8j>
3. <http://irist.iust.ac.ir/files/ee/pages/az/mazidi.pdf>

*Asim 18/11/17*

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

a) **Course Category**

Program Elective

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 and routing protocols	K2
CO4	Outline the concepts of end to end process and application protocols	K2
CO5	Infer the Queuing model and advance switching concepts.	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
<b>CO1</b>	H	M	-	-	L	-	-	L	L	L	-	L	-	-
<b>CO2</b>	H	M	-	-	L	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	-	-	L	-	-	L	L	L	-	L	-	-
<b>CO5</b>	H	M	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”, 5th Edition, 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.

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
RAJ Institute of Science and Technology  
(Established as per Government Order No. 3 of 1980 Act, 1980)

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

**a) Course Category**

Program 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”, 5<sup>th</sup> 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”, 2<sup>nd</sup> 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”, 3<sup>rd</sup> 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](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](https://www.tutorialspoint.com/digital_signal_processing/dsp_discrete_fourier_transform_introduction.htm)

*A. Selwin Muthu Priyadharson*  
Dr. A. Selwin Muthu Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established on the University Rank. No. 2 of UGC Act, 1956)



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

**a) Course Category**

Program 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
<b>CO1</b>	M	M	M	L	-	-	-	-	-	L	-	M	-	-
<b>CO2</b>	H	M	M	M	L	-	-	-	-	L	L	L	M	-
<b>CO3</b>	L	L	L	M	L	-	-	-	-	L	L	M	M	-
<b>CO4</b>	M	L	L	M	L	-	-	-	-	L	L	M	M	-
<b>CO5</b>	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, 2<sup>nd</sup> 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](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](https://onlinecourses.nptel.ac.in/noc23_ee75/preview)
4. <https://nptel.ac.in/courses/117104099>
5. <https://nptel.ac.in/courses/108105134>

*A. Selwin Mith Priyadharson*  
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Established as the University Rank with 8 of UGC Act, 1956

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

**a) Course Category**

Program 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, 2<sup>nd</sup> Edition, 2015.
2. Warren L Stutzman and Gary A Thiele, “Antenna Theory and Design”, John Wiley and Sons, 2<sup>nd</sup> Edition, 2009.

### **Reference Books**

1. A. Balanis, “Antenna Theory: Analysis and Design”, Wiley Publications. 3<sup>rd</sup> 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, 2<sup>nd</sup>, Edition, 2005.
6. Constantine A.Balanis, P .Loannides, “Introduction to Smart Antennas”, Morgan & Claypool Publisher’s series, 1<sup>st</sup> Edition, 2007.

### **Online Resources**

1. <http://www.cdeep.iitb.ac.in/nptel/Electrical%20&%20Comm%20Engg/Transmissiones%20and%20EM%20Waves/TOC.html>.
2. <http://nptel.ac.in/courses/117101056>.
3. [www.antenna-theory.com](http://www.antenna-theory.com).
4. <http://www.dxzone.com/catalog/Antennas>
5. [http://www.engr.sjsu.edu/rkwok/EE172/Antenna\\_Fundamental.pdf](http://www.engr.sjsu.edu/rkwok/EE172/Antenna_Fundamental.pdf).

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Saguntiala  
Vellore Institute of Science and Technology  
Established as the University Institute of VIT in 1982

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

**a) Course Category**

Program 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
<b>CO1</b>	M	L	L	-	-	-	-	-	-	-	-	H	-	-
<b>CO2</b>	H	M	L	L	L	-	L	-	-	-	-	L	-	-
<b>CO3</b>	H	L	L	L	L	L	-	-	L	-	-	L	-	-
<b>CO4</b>	H	H	H	M	M	L	-	-	-	-	-	L	L	L
<b>CO5</b>	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<sub>2</sub>: 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", 4<sup>th</sup> Edition, Pearson Education, 2015.
2. Douglas A. Pucknell and Kamran Eshraghian, "Basic VLSI Design", 3<sup>rd</sup> 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", 2<sup>nd</sup> Edition, Pearson, 2016.

### **Online Resources**

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

*Asim 18/12/17*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. on 8 of OCTOBER 1999

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

**a) Course Category**

Program 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 and detectors 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
<b>CO1</b>	H	M	M	-	-	-	L	-	-	L	L	L	L	-
<b>CO2</b>	H	M	M	-	-	-	-	-	-	-	M	L	L	-
<b>CO3</b>	H	M	M	L	M	L	L	-	L	L	-	L	M	-
<b>CO4</b>	H	M	M	-	-	-	-	-	-	-	-	L	L	-
<b>CO5</b>	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](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)

*Asim 18/11/17*

**Dr. A. Selwin Mich Priyadharson**  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Estd. in 1988

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

**a) Course Category**

Program Core

**b) Preamble**

This course teaches 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

**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 operating system and RTOS objects.	K2
CO2	Summarize the concept of board support package.	K2
CO3	Illustrate the concept of embedded storage architecture.	K2
CO4	Compare the various embedded file systems and storage space optimization techniques.	K2
CO5	Infer the linux device driver development process for communication interfaces and basic peripherals.	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
<b>CO1</b>	M	L	M	M	M	-	-	L	M	M	H	H	-	L
<b>CO2</b>	L	-	L	-	H	-	-	-	-	-	-	-	L	L
<b>CO3</b>	L	-	L	-	H	-	-	-	-	-	-	-	L	L
<b>CO4</b>	M	-	-	M	H	-	-	L	M	M	H	L	M	M
<b>CO5</b>	L	-	M	M	H	-	-	L	M	M	H	H	M	M

**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 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: RAMDisk – 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<sup>2</sup>C Subsystem on Linux - USB Gadgets.

**Total: 30 Hours**

## Practical Exercises

	CO
1 Exploring the features of Keil and RTX51	CO1
2 Introductory Embedded C Programming	CO1
3 Task Creation and Deletion using RTX51 in Keil	CO1
4 Task scheduling using RTX51 in Keil	CO1
5 Processing Critical Section using RTX51 in Keil	CO1
6 Task Synchronization using RTX51 semaphores in Keil	CO1
7 Task Communication using shared memory in Keil	CO1
8 Linux Installation	CO4
9 Basic Linux Programming	CO4
10 Creating Linux Loadable kernel Modules	CO5
11 Linux Serial Driver	CO5

**Total : 60 Hrs**

## 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, 3rd edition, 2005.

### Online Resources

1. <https://www.youtube.com/watch?v=PEzpOembKNc>
2. <https://www.youtube.com/watch?v=mCs21yByQqk>

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

**a) Course Category**

Program core

**b) Preamble**

This introductory course is designed to provide information about the technologies that make up the Internet of Things (IoT) and intends 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
<b>CO1</b>	H	-	L	-	-	-	-	L	L	-	-	-	-	-
<b>CO2</b>	H	-	L	-	L	-	-	L	L	L	-	L	L	-
<b>CO3</b>	H	M	M	-	L	-	-	L	L	L	-	L	L	L
<b>CO4</b>	H	M	M	L	-	-	-	L	L	L	-	L	L	L
<b>CO5</b>	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) Lab****Total : 30 Hrs****List of experiments**

<b>S. No</b>	<b>Practical Exercises</b>	<b>Course Outcome</b>
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 Madiseti,-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 Höller, 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](https://onlinecourses.nptel.ac.in/noc17_cs22/preview).

*Agil M. 18/12/17*

Dr. A. Selwin Mich. Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute on 8 of 1980 Act, 1980

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

**a) Course Category**

Program 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”, 5<sup>th</sup> Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.
2. Donald. P. Leach, “Digital principles and applications”, 7<sup>th</sup> Edition, McGraw-Hill, 2012
3. S.Salivahanan, S. Arivazhagan, “ Digital Circuits and Design”, 5<sup>th</sup> Edition, Oxford University Press, 2018
4. W.H. Hayt and I.E.Kemmerley, “Engineering Circuits Analysis”, McGraw Hill Education 8<sup>th</sup> 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/LN08CombinationalLogicModules.pdf>
2. <http://www.learnabout-electronics.org>

*Dr. A. Selwin Mich Priyadharsan*  
Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Road, 4th of 1982 Act, 1982

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

**a) Course Category**

Program 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**

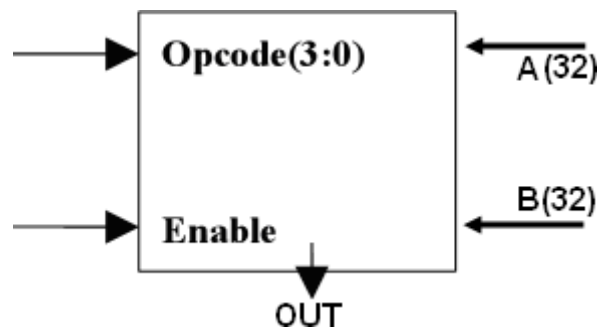
	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO2
CO1	H	M	H	L	H	-	-	-	M	-	-	M	H	L
CO2	H	H	H	M	H	-	-	-	M	-	-	M	H	-
CO3	H	H	H	H	H	L	M	-	M	-	-	M	H	L

## 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 is 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](https://onlinecourses.nptel.ac.in/noc22_ee55/preview)
2. <http://asic-world.com/>
3. <http://www.learnabout-electronics.org>

*Asim 18/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established on the University Rank on 8 of UGC Act, 1956)

Course Code	Course Title	L	T	P	C
10211EC303	SIGNAL PROCESSING LAB	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
<b>MATLAB based experiments</b>		
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
<b>Processor Based experiments</b>		
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, 3<sup>rd</sup> 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>

*Asst. Prof. Dr. A. Selwin Muthu Priyadharson*  
 Head of the Department  
 Electronics & Communication Engineering  
**Vel Tech**  
 Rangarajan Dr. Sagunthala  
 R&D Institute of Science and Technology  
 Chennai-600 062

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

**a) Course Category**

Program 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**

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 (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 basic ALU manipulation and 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 8051 and 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
<b>CO1</b>	M	M	-	L	M	-	-	-	-	-	-	-	-	-
<b>CO2</b>	M	M	L	L	M	-	-	-	-	-	-	-	-	-
<b>CO3</b>	H	M	L	L	H	-	-	-	-	-	-	-	M	-
<b>CO4</b>	H	M	L	L	L	-	-	-	-	-	-	-	M	-

**g) Course Content**

<b>EXP NO</b>	<b>EXPERIMENT NAME</b>	<b>CO</b>
1	8-bit ALU Operations in 8085 Microprocessor	CO1
2	16-bit ALU Operations in 8086 Microprocessor	CO2
3	Programming 8255 Peripheral Devices in 8086	CO2
4	Programming 8279 Peripheral Devices in 8086	CO2
5	Bit Manipulation and Masking Program for 8051	CO3
6	Timer Programming with Keil C for 8051	CO3
7	Serial Port Programming with Keil C	CO3
8	Interrupt Programming with Keil C	CO3
9	ADC and DAC Interfacing with 8051 Microcontroller	CO4
10	DC Motor and Stepper Motor Interfacing with 8051	CO4
11	Musical Tone and Elevator Control with 8051	CO4
12	Sensor Interfacing using PIC (MP Lab IDE and Proteus/Hardware)	CO4
13	Actuator Interfacing using PIC (MP Lab IDE and Proteus/Hardware)	CO4

**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",

- Pearson Education, 2008.
5. Muhammad Ali Mazidi, Sarmad Naimi, and Sepehr Naimi "AVR Microcontroller and Embedded Systems: Using Assembly and C", Pearson Education, 2014.

### Reference Book

1. Kenneth J Ayala, The 8051 Microcontroller Architecture Programming and Application, Third Edition, Penram International Publishers, 2005.

### Online Resources

1. <https://www.youtube.com/watch?v=liRPtvj7bFU&list=PL0E131A78ABFBFDD0>
2. <https://www.youtube.com/watch?v=95uGOJ1Ud2c&list=PLJGA4olwzpA-rvcdWULcRuMn2495g0n8j>
3. <http://irist.iust.ac.ir/files/ee/pages/az/mazidi.pdf>

*Asim 18/12/17*

Dr. A. Selwin Mithi Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank, No. 1 of UGC, Aug. 1999

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

**a. Course Category:**

Program 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

*Asst. M. 18/12/17*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank no. 8 of UGC Act, 1956

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

**a) Course Category**

Program core

**b) Preamble**

Optical and Microwave laboratory provides an opportunity to explore the concepts in optical devices and microwave systems in a laboratory setting with an emphasis on 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 Engineering.

**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

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 062, Tamil Nadu

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

**a) Course Category**

Program 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
<b>CO1</b>	H	M	-	M	H	-	-	-	-	-	-	-	-	-
<b>CO2</b>	H	M	M	M	H	M	L	-	L	L	L	M	L	-
<b>CO3</b>	L	M	M	M	-	L	-	-	M	M	L	H	H	-
<b>CO4</b>	H	M	-	M	L	-	L	-	L	-	L	-	L	-
<b>CO5</b>	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**

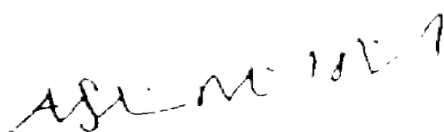
1. S.Raghavan, "Microwave Integrated Circuit Components Design Through MATLAB", Taylor and Francis, 2020.
2. Reinhold Ludwig, Gene Bogdanov, "RF Circuit Design Theory and Applications" Prentice Hall Inc. 2009.
3. Habil. MBA Frank Ellinger, "Radio frequency integrated circuits and technologies", Springer- Verlag 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](https://onlinecourses.nptel.ac.in/noc23_ee18/preview)
2. <http://home.sandiego.edu/~ekim/e194rfs01/>
3. <https://parts.jpl.nasa.gov/mmhc/3-IX.PDF>

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank on 8 of 1987 Act 1986

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

**a) Course Category**

Program 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
<b>CO1</b>	<b>M</b>	<b>L</b>	<b>L</b>	<b>L</b>	<b>-</b>	<b>-</b>	<b>L</b>	<b>L</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>CO2</b>	<b>M</b>	<b>M</b>	<b>M</b>	<b>L</b>	<b>L</b>	<b>-</b>	<b>-</b>	<b>L</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>
<b>CO3</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>-</b>	<b>M</b>	<b>M</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>-</b>	<b>L</b>	<b>-</b>	<b>L</b>	<b>-</b>
<b>CO4</b>	<b>H</b>	<b>M</b>	<b>H</b>	<b>L</b>	<b>-</b>	<b>L</b>	<b>M</b>	<b>L</b>	<b>L</b>	<b>L</b>	<b>L</b>	<b>L</b>	<b>L</b>	<b>-</b>
<b>CO5</b>	<b>H</b>	<b>M</b>	<b>H</b>	<b>M</b>	<b>M</b>	<b>L</b>	<b>M</b>	<b>M</b>	<b>L</b>	<b>L</b>	<b>-</b>	<b>L</b>	<b>L</b>	<b>-</b>

**g) Course Content**

**UNIT I 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.

**UNIT II 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.

**UNIT III 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.

**UNIT IV 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.

**UNIT V 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”, 3<sup>rd</sup> Ed., John Wiley & Sons, Inc., 2014.
2. Gottapu S. Rao, “Mobile Cellular Communication”, 2<sup>nd</sup> Ed., Dorling Kindersley (India) Pvt. Ltd., 2013.

### **Reference Books**

1. A. Goldsmith, “Wireless Communications,” 2<sup>nd</sup> Ed., Cambridge University Press, 2005.
2. William C. Y. Lee, “Wireless and Cellular Communications,” 3<sup>rd</sup> 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](https://www.tutorialspoint.com/wireless_communication/wireless_communication_cellular_networks.htm)

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sakunthala  
R&D Institute of Science and Technology  
Established on the University Rank No. 1 of UGC Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	H	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	L	M	L	L	-	-	-	L	L	-	-	L	-
<b>CO3</b>	H	L	M	L	-	L	-	L	L	L	L	-	L	-
<b>CO4</b>	H	L	M	L	L	-	L	-	L	L	L	L	L	-
<b>CO5</b>	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”, 3<sup>rd</sup> 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”, 2<sup>nd</sup> 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>

*A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Rank with 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC104	<b>RADAR AND ELECTRONIC NAVIGATION SYSTEMS</b>	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	M	M	M	L	L	-	L	-	L	-	-	-	L	-
<b>CO2</b>	M	M	L	M	-	L	-	L	-	L	-	L	-	-
<b>CO3</b>	M	M	L	L	L	-	L	-	-	-	L	-	-	L
<b>CO4</b>	M	M	M	L	L	L	-	L	H	M	L	-	-	-
<b>CO5</b>	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", 3<sup>rd</sup> Edition, Tata McGraw-Hill, 2001.
2. GSN Raju, "Radar Engineering and Fundamentals of Navigational Aids" 2<sup>nd</sup> Edition, IK International Publishers, 2008.
3. N. S. Nagaraju, "Elements of Electronic Navigation Systems", 2<sup>nd</sup> Edition, Tata McGraw-Hill, 2000.

### **Reference Books**

1. Peyton Z. Peebles, "Radar Principles", John Wiley, 2004.
2. J.C Toomay, "Principles of Radar", 2<sup>nd</sup> 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, New York, 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](http://www.radartutorial.eu/index.en.html)
4. <https://pe.gatech.edu/courses/basic-radar-concepts>

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Inst. with U of UGC Act, 1956



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

**a) Course Category**

Program 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

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](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>

*Agim m. 7*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the University East, on 8 of March, 1980

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

**a) Course Category**

Program 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
<b>CO1</b>	L	L	-	-	-	L	L	-	L	-	-	-	-	-
<b>CO2</b>	H	M	M	-	-	-	-	L	L	-	L	-	-	-
<b>CO3</b>	M	H	-	-	-	-	-	-	L	-	-	-	-	-
<b>CO4</b>	H	H	L	L	M	-	-	-	L	-	-	L	-	-
<b>CO5</b>	L	H	-	-	-	-	-	-	L	-	-	M	-	-

**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.

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**

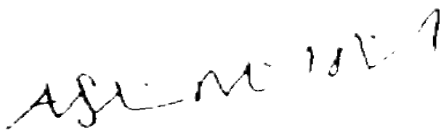
1. G.P Aggrawal, “Fiber-Optic Communication Systems”, Wiley-inter science, 5th Edition, June 2021.
2. G. Keiser, “Optical Fiber Communication”, Tata –McGraw Hill, 3<sup>rd</sup> edition, 2000.
3. John Gowar , “Optical communication system”, PHI, 2nd edition, 1993.

#### **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>

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. on 8 of DEC 2002

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

**a) CourseCategory**

Program 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
<b>CO1</b>	M	M	-	M	M	-	L	L	L	-	L	L	L	-
<b>CO2</b>	M	-		L	-	L	L		L	-	-	L	L	-
<b>CO3</b>	M	M	L	L	-	-	L	-	L	L	L	L		-
<b>CO4</b>	H	L	-	M	L	-	L	L	L	-	M	-	-	-
<b>CO5</b>	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, 4<sup>th</sup> revised edition, 2002
2. R.R. Gulati, “Monochrome And Colour Television”, New Age International Publication, 3<sup>rd</sup> 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>

*Agarwal*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the Understanding that, on 8 of March, 1980

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

**a) Course Category**

Program 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	PO1 0	PO 11	PO 12	PSO 1	PSO 2
<b>CO1</b>	L	L	L	-	-	-	-	-	-	L	-	-	-	-
<b>CO2</b>	L	L	L	-	-	-	-	-	-	L	-	-	-	-
<b>CO3</b>	L	L	L	L	M	L	-	-	L	L	-	-	L	-
<b>CO4</b>	L	H	L	L	M	L	-	-	L	L	-	-	L	-
<b>CO5</b>	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-rsquo-software-defined-radio.html>

*A. Selwin Mith Priyadharsan*  
Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank. No. 2 of UGC Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	H	H	M	L	L	L	-	L	-	-	-	-	-	-
<b>CO2</b>	H	M	M	M	L	L	-	M	-	-	-	-	-	-
<b>CO3</b>	M	M	L	M	L	-	L	L	-	L	L	-	L	-
<b>CO4</b>	M	H	M	M	L	-	L	M	L	-	L	L	L	-
<b>CO5</b>	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, 2<sup>nd</sup> Ed., IEEE Press, 1996.
2. Henry W Ott, Noise Reduction Techniques in Electronic Systems, 2<sup>nd</sup> Ed., Wiley Inter Science, 1998.

#### **Reference Books**

1. Bemhard Keiser, principles of Electromagnetic Compatibility, 2<sup>nd</sup> Ed., Artech House, 1996.
2. C R Paul, Introduction to Electromagnetic Compatibility, 2<sup>nd</sup> 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/>

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

**a) Course Category**

Program 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
<b>CO1</b>	M	M	L	L	M	L	L	L	M	L	-	L	L	-
<b>CO2</b>	M	M	L	L	M	-	L	L	M	M	-	M	-	-
<b>CO3</b>	M	M	L	L	H	-	-	L	M	L	-	M	-	-
<b>CO4</b>	M	M	M	L	H	-	-	L	H	L	-	M	-	-
<b>CO5</b>	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 Beamforming for a MIMO OFDM system.	CO5
12	Simulation of Massive MIMO system for 5G applications	CO5

**Total: 60 Hrs**

#### **h) Learning Resources**

##### **Text Books**

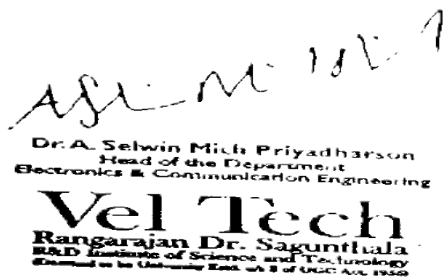
1. Tolga M.Duman and Ali Ghrayeb, "Coding for MIMO Communication Systems", John Wiley & Sons Ltd.,2007.
2. EzioBiglieri, Robert Calderbank and Anthony Constantinides. "MIMO Wireless Communications" Cambridge University Press,2007.
3. R. S. Kshetrimayum, "Fundamentals of MIMO Wireless Communications", 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. Marzetta, 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**

Program 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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO 10</b>	<b>PO 11</b>	<b>PO 12</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	L	H	H	H	H	-	-	M	M	L	L	M	L	-
<b>CO2</b>	M	L	H	L	L	-	-	-	L	-	-	L	-	-
<b>CO3</b>	L	M	H	L	L	-	L	L	M	L	L	L	M	-
<b>CO4</b>	L	M	H	H	H	-	L	L	M	L	-	M	M	-
<b>CO5</b>	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", 4<sup>th</sup> Ed., Wiley, 2016.
2. Collin, Robert E. "Antennas and radio wave propagation", 1<sup>st</sup> Ed., McGraw-Hill, 1985.
3. Thomas A. Milligan, "Modern Antenna Design", 2<sup>nd</sup> 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", 1<sup>st</sup> 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>

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
<b>CO1</b>	M	L	M	L	H	-	-	-	L	L	L	M	L	M
<b>CO2</b>	L	M	H	L	M	-	-	-	M	L	-	M	-	-
<b>CO3</b>	-	L	-	M	-	H	-	-	-	L	-	-	M	L
<b>CO4</b>	L	M	H	-	-	-	-	-	-	L	-	-	M	-
<b>CO5</b>	-	-	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>

*Aswini*

Dr. A. Selwin Muthu Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Road, at II of 1987, Aug 1988

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

	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	-

## UNIT I FUNDAMENTALS OF ROBOTICS 9

UNIT II      SENSORS AND ACTUATORS      10

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.

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

<b>UNIT IV</b>	<b>ROBOT PROGRAMMING &amp; ROBOT CONTROLLERS</b>	<b>9</b>
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Robot Programming &amp; 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\\_PP76fIZfw&list=PLyqSpQzTE6M\\_XM9cvjLLO\\_Azt1Fk\\_gPhpH&index=2](https://www.youtube.com/watch?v=P_PP76fIZfw&list=PLyqSpQzTE6M_XM9cvjLLO_Azt1Fk_gPhpH&index=2)
2. <https://www.coursera.org/learn/robotics-flight>
3. <https://robotacademy.net.au/masterclass/introduction-to-robotics/>

*Agarwal*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the Vel Tech Inst. of Eng. & Tech. in 1988

Course Code	Course Title	L	T	P	C
10212EC111	<b>EMBEDDED COMMUNICATION PROTOCOLS</b>	3	0	0	3

**a) Course Category**

Program 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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO1 0</b>	<b>PO1 1</b>	<b>PO1 2</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	L	L	L	-	-	-	-	-	-	-	-	M	-	L
<b>CO2</b>	L	L	L	-	-	-	-	-	-	-	-	H	-	L
<b>CO3</b>	L	L	L	-	-	-	-	-	-	-	-	H	-	L
<b>CO4</b>	L	L	L	-	-	-	-	-	-	-	-	H	-	L
<b>CO5</b>	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](http://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/>

*Aswini M. 18/11/19*

Dr. A. Selwin Mith. Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 062, Tamil Nadu, India

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

**a) Course Category**

Program 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
<b>CO 1</b>	H	-	L	-	-	-	-	-	-	-	L	L	M	M
<b>CO 2</b>	M	L	L	-	L	-	L	M	-	-	-	-	-	L
<b>CO 3</b>	M	L	L	M	M	L	-	-	-	-	L	L	L	-
<b>CO 4</b>	M	L	-	-	L	L	-	-	-	-	-	M	M	-
<b>CO 5</b>	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 II<sup>nd</sup> 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=AQ1EPI\\_4O2w](https://www.youtube.com/watch?v=AQ1EPI_4O2w)
4. <https://www.youtube.com/watch?v=mhrRigzRfh0>

*Asim*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sakunthala  
R&D Institute of Science and Technology  
Established as the University Rank, No. 1 of UGC, Aug. 1999

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
<b>CO1</b>	M	L	-	-	-	-	M	-	-	-	L	L	M	L
<b>CO2</b>	M	L	M	L	L	-	-	L	-	-	-	L	M	L
<b>CO3</b>	M	L	-	M	-	-	L	-	L	L	-	-	L	L
<b>CO4</b>	M	L	L	M	M	-	-	L	L	L	-	-	M	L
<b>CO5</b>	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, 1<sup>st</sup> 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=7zRPZJE1pat272ANlrAVzGV7mTg#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=scholar](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=scholar)

- 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=scholar](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=scholar)
- 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-4XbnV9y7wEzK8E#v=onepage&q=Wearable%20and%20Implantable%20Medical%20Devices%3A%20Applications%20and%20Challenges&f=false>
- 8 <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](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>

*Ag. M. 10/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Rank, vol. II of UGC Act, 1956

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	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
<b>CO 1</b>	M	L	L	-	-	M	H	-	-	-	-	L	-	-
<b>CO 2</b>	M	L	-	-	-	L	L	-	-	-	L	L	-	-
<b>CO 3</b>	M	M	L	L	L	L	M	L	L	L	-	M	L	-
<b>CO 4</b>	M	L	-	-	-	M	M	L	-	L	-	L	-	-
<b>CO 5</b>	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** **9**  
**IN PLANT DESIGN**

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, 8<sup>th</sup> 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., 2<sup>nd</sup> 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>

*Agim 10/11/17*  
Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Chennai - 600 062

<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC204</b>	<b>EMBEDDED C PROGRAMMING</b>	<b>2</b>	<b>0</b>	<b>2</b>	<b>3</b>

**a) Course Category:**

Program 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:

<b>CO Nos.</b>	<b>Course Outcome</b>	<b>Knowledge Level (Based on revised Bloom's Taxonomy)</b>
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 Peripheral interface (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 Edition 2014. 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**

*Agil M. 18/12/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established as the University Rank, on 8 of OCTOBER, 1989

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

**a) Course Category**

Program 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**

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

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Demonstrate an embedded linux system.	S3
CO2	Simulate an embedded linux device driver application.	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.	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, makefiles, character device driver.

**h) List of experiments**

<b>S. No</b>	<b>CO Mapping</b>	<b>Practical Exercises (60 Hours)</b>
1.	CO2	Develop a host system.
2.	CO2	Understand basic Linux Commands.
3.	CO2	Build native toolchain.
4.	CO2	Native Compile Linux Kernel and its C programming.
5.	CO2	Makefile creation.
6.	CO2	Build cross toolchain.
7.	CO2	Cross Compile Linux Kernel.
8.	CO2	Configure target system bootloader.
9.	CO2	Cross Linux C programming.
10.	CO2	Emulate and deploy target Linux system.
11.	CO3	Loadable Kernel module programming with makefile and argument passing.
12.	CO3	GPIO device driver development.
13.	CO3	LCD device driver development.
14.	CO3	Serial port device driver development.
15.	CO4	Project.

**Total    75    Hrs**

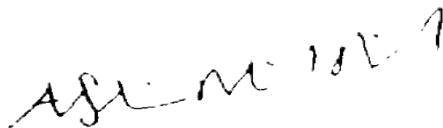
## i) Learning Resources

### Text Books

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.

### List of Major Equipment/ Instrument/Software with Broad Specifications

1. Personal Computer (Windows or Linux) with internet connection.
2. Raspberry Pi Board.
3. Ubuntu Linux 16.04.
4. Oracle VM Virtualbox.
5. Consumable components.

  
Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 092

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

**a) Course Category**

Program 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 Display Driving motors. Manual Robots and Autonomous Robots - fundamentals and its applications Gear 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](http://www.avr-asm-download.de/beginner_en)

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the University Rank of UGC AICTE 1982

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

a) **Course Category**

Program 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 – Multiple Configurations – Project Running. APSoC Architecture – IP Creation – IP Integration – Implementation. Embedded System on SoC – Application – Automation.

## **i) List of experiments**

<b>S. No</b>	<b>CO Mapping</b>	<b>Practical Exercises (60 Hours)</b>
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 and ZedBoard 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>

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Road, 11 of UGC Act, 1956

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
<b>CO1</b>	L	L	-	-	H	-	-	-	M	L	-	M	-	-
<b>CO2</b>	M	L	L	-	H	L	-	-	M	L	-	M	L	-
<b>CO3</b>	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**

<b>List of Experiments</b>	<b>CO Mapping</b>
<p><b>Introduction to Graphical Programming (6 Hours)</b></p> <ol style="list-style-type: none"> <li>1. Build a VI using Numeric controls and indicators to perform various arithmetic operations.</li> <li>2. Build a VI using Boolean controls and indicators to perform various Boolean operations.</li> <li>3. Build a VI using String controls and indicators to perform various String operations.</li> </ol>	CO1



<p style="text-align: center;"><b>Operations using Data Types (6 Hours)</b></p> <p>4. Create a Sub VI to compute area and volume of planes and solids.</p> <p>5. Develop a Sub VI using to solve a quadratic equation <math>ax^2 + bx + c = 0</math> and display whether the roots are real or imaginary.</p> <p>6. Build a VI to implement and verify adder circuits using logic gates.</p>	CO2
<p style="text-align: center;"><b>Loops (6 Hours)</b></p> <p>7. Build a VI to monitor the level of tank using loop functions.</p> <p>8. Simulate a VI to indicate charging of a battery level. Use appropriate functions and display notification messages.</p>	CO2
<p style="text-align: center;"><b>Arrays (6 Hours)</b></p> <p>9. Build a VI using to create a 1-D array. Perform the operations such as indexing, insertion, deletion and search of an element.</p> <p>10. Build a VI to generate Fibonacci series using loop and array functions.</p> <p>11. Build a VI to perform sorting of given numbers in ascending order using loop and array functions.</p>	CO2
<p style="text-align: center;"><b>Case Structure (6 Hours)</b></p> <p>12. Build a VI for temperature monitoring system using Case structures. Display the safe and emergency alarms using LEDs of varying colours.</p> <p>13. Design a VI to display a 7-segment LED using case structures.</p>	CO2
<p style="text-align: center;"><b>Charts and Graphs (6 Hours)</b></p> <p>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.</p> <p>15. Develop a VI program to demonstrate Frequency modulation and amplitude modulation using Formula node.</p>	CO2
<p style="text-align: center;"><b>Sequence Structures (6 Hours)</b></p> <p>16. Build a VI for traffic light control for varying time delays using sequence structures.</p> <p>17. Design a Ticket vending machine system using the concept of state machine in LabVIEW.</p> <p>18. Perform READ/WRITE operations on a file using sequence structures and loops.</p>	CO2
<p style="text-align: center;"><b>Clusters (6 Hours)</b></p> <p>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.</p> <p>20. Create a VI to calculate Body Mass Index (BMI) using Clusters and display the BMI status using LED and pop-up message.</p>	CO2
<p style="text-align: center;"><b>Data Acquisition (12 Hours)</b></p> <p>21. Develop a VI to export data from DAQ assistant device and to spreadsheet.</p>	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.	
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**Total 75 Hours**

## **h) Learning Resources**

### **Text Books**

1. Jovitha Jerome, “Virtual Instrumentation Using LabVIEW”, PHI Learning Pvt. Ltd., 2<sup>nd</sup> 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, 1<sup>st</sup> edition, 2014.
2. LabVIEW Graphical Programming by Johnson, 4th Edition, McGraw Hill, 2011.
3. Robert H. Bishop, “Learning with Lab VIEW”, Prentice Hall, 1<sup>st</sup> 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/>

*Aseem 18V1*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank. No. 1 of UGC Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	H	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	-	-	-	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	H	-	-	-	-	-	-	-	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 Aparcar, “MPLS and VPN architecture”, Cisco Press, Volume 1 and 2, 2003

#### Online Resources

1. [www.networks.com/categories](http://www.networks.com/categories)
2. [www.nptel/lectures/networking](http://www.nptel/lectures/networking)

*Asim 18/11/17*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Institute of UGC Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	H	H	L	-	L	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	M	L	-	L	-	-	-	L	L	-	-	L	L
<b>CO3</b>	H	M	-	-	L	-	-	-	L	L	-	L	L	L
<b>CO4</b>	H	-	-	-	L	-	-	-	L	L	-	L	L	L
<b>CO5</b>	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 – El Gamal – Schnorr – Authentication applications – Kerberos– X.509 Authentication services and Network Access control.

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



Course Code	Course Title	L	T	P	C
10212EC117	NETWORK MANAGEMENT	3	0	0	3

**a) Course Category**

Program 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 and networks 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	-	-	-	-
CO3	M	M	L	L	L	-	-	-	L	L	-	-	-	-
CO4	M	M	L	L	L	-	-	-	L	L	-	L	-	-
CO5	M	-	-	-	-	-	-	-	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.

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”, 3<sup>rd</sup>edition, Elsevier, 2003.

**Online Resources**

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

*Agarwal*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as per University Estt. act II of 1946 Act, 1956

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

**a) Course Category**

Program 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
<b>CO1</b>	M	L	L	L	L	-	-	-	L	L	-	L	L	-
<b>CO2</b>	M	L	L	L	-	-	-	-	L	L	-	L	L	-
<b>CO3</b>	M	L	M	M	-	-	-	-	L	L	-	L	L	-
<b>CO4</b>	M	L	L	-	-	-	-	-	L	L	-	L	L	-
<b>CO5</b>	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 to 4G – 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 Rodriguez, “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](https://onlinecourses.nptel.ac.in/noc23_ee46/preview)

*Agarwal*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the University Rank, 28 of 1990 Act, 1990

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC119</b>	<b>WIRELESS BODY AREA NETWORKS</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Program 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

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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
<b>CO1</b>	H	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	M	L	L	L	-	-	-	L	L	-	-	-	-
<b>CO3</b>	H	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO4</b>	H	L	H	L	H	-	-		L	L	-	L	-	-
<b>CO5</b>	H	L	H	L	L	M	-	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](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>

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

**a) Course Category**

Program 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 data and 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
<b>CO1</b>	M	-	-	-	-	L	-	-	L	L	-	-	-	-
<b>CO2</b>	M	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO3</b>	M	L	-	-	M	-	-	-	L	L	-	-	-	-
<b>CO4</b>	M	L	-	-	M	-	-	-	L	L	-	L	-	-
<b>CO5</b>	M	L	-	-	M	-	-	-	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) Lab

**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](https://onlinecourses.nptel.ac.in/noc23_ee121/preview)

*Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Instt. on 8 of AUG. 1988

Course Code	Course Title	L	T	P	C
10212EC210	COGNITIVE RADIO NETWORKS	2	0	2	3

**a) Course Category**

Program 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
<b>CO1</b>	H	-	-	-	-	-	-	-	M	M	-	-	-	-
<b>CO2</b>	H	L	L	L	M	-	-	L	M	M	L	L	L	L
<b>CO3</b>	H	-	-	L	M	-	-	L	M	M	L	L	L	L
<b>CO4</b>	H	L	L	L	M	-	-	L	M	M	L	L	L	L
<b>CO5</b>	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 andMAC 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) Lab****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 from Theory 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](http://www.nptel/Cognitive Radio and Wireless Communications)
2. <https://www.iitk.ac.in/eeold/archive/courses/2013/wireless/topics.html>

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established in the Year 1984



Course Code	Course Title	L	T	P	C
10212EC211	WIRELESS SENSOR NETWORKS AND ITS APPLICATION	2	0	2	3

**a) Course Category**

Program 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
<b>CO1</b>	H	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	L	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	L	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	L	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO5</b>	H	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, Routing 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/>

*Agarwal*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Rank with B of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC212	FLYING IOT	2	0	2	3

**a) Course Category**

Program Elective

**b) Preamble**

The purpose of this course is to provide the hands on experience on design, fabrication and flying of Unmanned Aerial Vehicle category aircraft. Students will get in-depth skill set on design and fabrication techniques of Unmanned Aerial 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
<b>CO1</b>	M	L	L	L	-	-	-	L	L	L	-	-	-	-
<b>CO2</b>	M	L	L	L	-	-	-	-	L	L	-	-	-	-
<b>CO3</b>	M	L	L	L	L	-	-	L	L	L	-	L	-	-
<b>CO4</b>	M	L	L	L	L	-	-	L	L	L	-	L	-	-
<b>CO5</b>	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

**Lab**

**Total : 30 Hrs**

### **List of Experiments**

<b>S. No</b>	<b>Practical Exercises (30 Hrs)</b>
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 and Implementation” February 2021.

## Online resources

1. <https://ardupilot.org/>
2. <https://dojofordrones.com/drone-programming/>
3. <https://pythonprogramming.net/building-quadcopter-tutorial-intro/>

*Asim 18/12/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sakunthala  
RAD Institute of Science and Technology  
(Established as an Autonomous Institute by U of Madras Act, 1956)

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.

*Asin M 18V 1*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Inst. with 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC121	ESTIMATION THEORY	3	0	0	3

**a) Course Category**

Program 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 Wiener 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", 3<sup>rd</sup> 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>

*Asim*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank. No. 1 of UGC AICTE 1950

Course Code	Course Title	L	T	P	C
10212EC122	DSP ALGORITHMS AND ARCHITECTURE	3	0	0	3

**a) Course Category:**

Program 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
<b>CO1</b>	M	-	-	-	-	-	-	-	L	L	-	M	-	-
<b>CO2</b>	M	-	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	L	L	L	-	-	-	-	L	L	-	L	M	-
<b>CO4</b>	L	M	L	L	M	L	-	-	L	L	-	L	L	-
<b>CO5</b>	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

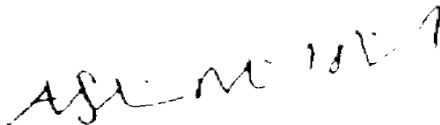
1. AvtarSingh and S.Srinivasan, “Digital Signal Processing”, 4<sup>th</sup> edition, Thomson Publications, 2004
2. SenM.Kuo, Woon-SengS.Gan, “Digital Signal Processor-Architectures, Implementation and Applications”, Pearson Prentice Hall, 2005.

#### 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, TMS320C6713 databooks

#### Online Resources

1. <http://www.ti.com/product/TMS320C6713/technicaldocuments>
2. <http://www.ti.com/tool/tmdsdsk6713>

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University, Vellore, India



Course Code	Course Title	L	T	P	C
10212EC123	SIGNAL PROCESSING TECHNIQUES FOR SPEECH RECOGNITION	3	0	0	3

**a) Course Category**

Program 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 Revised Bloom'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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO 10</b>	<b>PO 11</b>	<b>PO 12</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	M	M	L	L	-	-	-	-	-	-	-	L	L	-
<b>CO2</b>	H	M	L	L	L	-	-	-	L	L	-	L	M	L
<b>CO3</b>	H	M	L	L	L	-	-	-	L	L	-	L	M	L
<b>CO4</b>	H	H	M	M	L	-	-	-	L	L	-	L	M	L
<b>CO5</b>	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”, 1<sup>st</sup> 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)

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Road, on 8 of AUGUST, 1982)

Course Code	Course Title	L	T	P	C
10212EC124	ANN AND DEEP LEARNING	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	H	-	-	L	-	-	-	-	-	-	M	-	M
<b>CO2</b>	H	H	M	M	L	-	-	-	-	-	-	M	L	M
<b>CO3</b>	H	H	M	M	L	-	-	-	-	-	-	M	L	M
<b>CO4</b>	H	H	M	M	L	-	-	-	M	M	-	M	L	M
<b>CO5</b>	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, Medialine 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 – Kohonen Self Organizing Maps – Learning Vector Quantization – 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.

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Centre, on 8 of AUGUST 1988

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
<b>CO1</b>	M	L	L	L	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	M	M	M	L	L	-	-	-	L	L	-	-	-	-
<b>CO3</b>	M	M	M	L	L	-	-	-	L	L	-	-	L	M
<b>CO4</b>	M	M	M	M	L	-	-	-	L	L	-	L	L	M
<b>CO5</b>	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/-](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://wwjmr.com/upload/fuzzy-logic-as-a-tool-for-rainfall-prediction-a-case-study\_1511780408.pdf

*Asin*

Dr.A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
RAJ Institute of Science and Technology  
(Chartered as an Educational Inst. on 8 of March, 1999)

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
<b>CO1</b>	M	L	L	-	-	-	L	-	L	L	-	L	L	L
<b>CO2</b>	M	M	L	-	-	-	L	-	L	L	-	L	M	L
<b>CO3</b>	M	M	L	-	-	-	L	-	L	L	-	L	M	L
<b>CO4</b>	M	M	L	-	-	-	L	-	L	L	-	L	M	L
<b>CO5</b>	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 wave, 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 publishing Co., 1990 (Unit III, IV, V)

#### Reference Books

1. Arumugam, “Biomedical Instrumentation” ,Anuradha Agencies Publishers, Vidyal 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](http://www.globalspec.com)
2. [https://www.youtube.com/playlist?list=PLm\\_MSClsnwm-kjSqlfwaEhKwfnfLUUBM](https://www.youtube.com/playlist?list=PLm_MSClsnwm-kjSqlfwaEhKwfnfLUUBM)  
(Biomedical Instrumentation)

*Agarwal*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Rank, vol. II of UGC Act, 1956)

Course Code	Course Title	L	T	P	C
10212EC175	FUNDAMENTALS OF QUANTUM COMPUTING	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	L	-	-	-	-	-	-	L	L	-	-	-	M
<b>CO2</b>	H	M	M	L	-	-	-	-	L	L	-	-	-	M
<b>CO3</b>	H	M	M	L	L	-	-	-	L	L	-	-	L	M
<b>CO4</b>	H	M	M	M	L	-	-	-	L	L	-	-	M	M
<b>CO5</b>	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](https://nptel.ac.in))

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
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Course Code	Course Title	L	T	P	C
10212EC213	DIGITAL IMAGE AND VIDEO PROCESSING	2	0	2	3

**a) Course Category**

Program 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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO 10</b>	<b>PO 11</b>	<b>PO 12</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	H	L	L	M	H	-	-	L	H	-	-	L	L	L
<b>CO2</b>	H	H	L	M	H	-	-	L	L	-	-	L	L	L
<b>CO3</b>	M	M	L	M	H	-	-	L	L	-	-	L	L	L
<b>CO4</b>	M	M	L	M	H	-	-	L	L	-	-	L	L	L
<b>CO5</b>	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 images- 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”, 2<sup>nd</sup> 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, 2<sup>nd</sup> Edition, 2015.
4. John Woods, “Multidimensional Signal, Image and Video Processing and Coding”, Elsevier, 2<sup>nd</sup> Edition, 2011.
5. Keith Jack, “Video Demystified – A Hand Book for the Digital Engineer”, Elsevier, 5<sup>th</sup> Edition., 2007.

**Online Resources**

1. <https://archive.nptel.ac.in/courses/117/104/117104020/>
2. <https://nptel.ac.in/courses/117105079>

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

<b>S. No.</b>	<b>Name of the Experiment</b>	<b>CO</b>
	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

## **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”, 3rd Edition, MIT Press 2014.(Unit 5)

### **Reference Books**

1. Richert & Coelho, “Building Machine Learning Systems with Python”, 3<sup>rd</sup> 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)

*Agarwal*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
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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 to solve 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, 4<sup>th</sup> 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/>

*Agarwal*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the University Rank No. 1 of 1990 Act, 1956

Course Code	Course Title	L	T	P	C
10212EC127	LOW POWER VLSI DESIGN	3	0	0	3

**a) Course Category**

Program 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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO1 0</b>	<b>PO1 1</b>	<b>PO1 2</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	H	H	M	L	-	-	-	-	-	-	-	H	M	-
<b>CO2</b>	M	L	L	-	-	M	-	-	-	-	-	L	L	-
<b>CO3</b>	H	M	M	M	M	-	-	-	-	-	-	L	H	-
<b>CO4</b>	H	M	M	M	M	-	-	-	-	-	-	M	M	-
<b>CO5</b>	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.Brodersen, “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**

Program 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
<b>CO1</b>	M	M	M	L	M	L	-	-	-	-	-	M	M	-
<b>CO2</b>	H	M	M	M	M	L	L	-	-	-	-	L	M	-
<b>CO3</b>	M	L	M	M	M	L	L	-	-	-	-	L	L	-
<b>CO4</b>	H	H	M	H	M	L	L	L	L	L	L	M	M	-
<b>CO5</b>	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 Dijkstra’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. Sabih H. Gerez, "Algorithms for VLSI Design Automation," Wiley India Pvt Ltd, 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," McGraw Hill, 1996.

#### Online Resources

1. [http://people.ece.umn.edu/~kia/Courses/EE5323/tutorial/Cadence\\_tutorial.html](http://people.ece.umn.edu/~kia/Courses/EE5323/tutorial/Cadence_tutorial.html)
2. <https://www.eit.lth.se/cadsys/chapter1.pdf>
3. [https://www.mics.ece.vt.edu/ICDesign/Tutorials/Cadence/index\\_old.html](https://www.mics.ece.vt.edu/ICDesign/Tutorials/Cadence/index_old.html)

*Asst. Prof. Dr. A. Selwin Mitha Priyadharson*  
Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Centre for ECE in 1983

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC129</b>	<b>VLSI FOR WIRELESS COMMUNICATION</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Program 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:

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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
<b>CO1</b>	H	H	M	M	M	L	-	-	L	L	-	L	-	-
<b>CO2</b>	M	M	L	L	M	L	L	-	L	L	-	L	-	-
<b>CO3</b>	M	L	L	L	M	-	-	-	-	-	-	-	-	-
<b>CO4</b>	M	L	L	L	M	-	-	-	-	-	-	L	-	-
<b>CO5</b>	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](http://www.nptelvideos.in/2012/12/wireless-communication.html)
2. [www.springer.com/us/book/9781461409854/](http://www.springer.com/us/book/9781461409854/).

*Asim 18/12/17*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Institute of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC130	SOLID STATE DEVICES	3	0	0	3

**a) Course Category**

Program 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**

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

*ASU-M-18V-1*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute with U of Madras Affiliation, 1982

Course Code	Course Title	L	T	P	C
10212EC131	ARCHITECTURAL DESIGN OF DIGITAL INTEGRATED CIRCUITS	3	0	0	3

**a) Course Category**

Program 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	P O 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 decrements, ones' complement, two's complement, Single bit addition, sum of N –natural numbers, Resource sharing , prioritization, greatest common divisor (GCD).

#### UNIT II ADDER AND MULTIPLIER ARCHITECTURE 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](https://onlinecourses.nptel.ac.in/noc22_ee58).

*Agarwal*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
(Established as the Veltech Institute of Engineering & Technology in 1988)



Course Code	Course Title	L	T	P	C
10212EC132	NANO SCALE TRANSISTORS	3	0	0	3

**a) Course Category**

Program 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 MOLECULAR 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 on integrated circuits and systems, 2008
2. Mark Lundstrom Jing Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation, Springer, 2006

#### Reference Books

1. M S Lundstrom, Fundamentals of Carrier Transport, 2nd Ed., Cambridge University Press, Cambridge UK, 2000
2. Yuan Taur and Tak H. Ning, Fundamentals of Modern VLSI Devices, 2<sup>nd</sup> Edition , Cambridge Univ. Press, Cambridge UK, 2021
3. R.F. Pierret, Advanced Semiconductor Fundamentals, 2<sup>nd</sup> Edition Prentice Hall, 2003

#### Online Resources

1. [https://onlinecourses.nptel.ac.in/noc22\\_ee47/preview](https://onlinecourses.nptel.ac.in/noc22_ee47/preview)
2. [https://onlinecourses.nptel.ac.in/noc22\\_ee47/preview](https://onlinecourses.nptel.ac.in/noc22_ee47/preview)

*Asim*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute on 8 of OCTOBER 1988

Course Code	Course Title	L	T	P	C
10212EC133	OPTO ELECTRONIC DEVICES	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	L	L	L	L	-	-	-	-	-	-	-	L	-	-
<b>CO2</b>	L	M	M	L	M	L	-	-	L	L	-	M	L	-
<b>CO3</b>	M	M	L	M	L	L	-	-	M	L	L	M	-	L
<b>CO4</b>	L	L	M	M	L	L	-	L	L	L	L	M	L	-
<b>CO5</b>	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 and FAX printing-Emission and Absorption of Radiation, Population Inversion, Laser losses, Laser Modes: 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.

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 of India 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/>

*Asim*

Dr. A. Selwin Muthu Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
VIT Institute of Science and Technology  
Established on the 1st January 2002, at 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC134	ELECTRONIC INSTRUMENTATION	3	0	0	3

**a) Course Category**

Program 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 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
<b>CO1</b>	M	M	M	M	M	-	-	-	-	-	-	L	L	-
<b>CO2</b>	M	M	M	M	L	-	-	-	-	-	-	M	L	-
<b>CO3</b>	M	M	M	M	L	-	-	-	L	L	L	L	L	-
<b>CO4</b>	M	L	M	L	-	-	-	-	-	-	-	L	L	-
<b>CO5</b>	H	M	M	M	L	L	L	-	L	L	L	L	-	-

**g) Course Content**

**UNIT I 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.



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, A Course in “Electrical & Electronic Measurements and Instrumentation”, Nineteenth revised edition, Dhanpat Rai and Co, New Delhi, 2011.
2. David A Bell, “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 Hall India, 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>

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Road, on 8 of AUG. A.Y. 1982)

Course Code	Course Title	L	T	P	C
10212EC135	NANO PHOTONICS	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	L	-	M	L	-	-	L	M	-	-	L	-	-
<b>CO2</b>	H	M	M	L	M	-	-	L	-	-	-	M	L	-
<b>CO3</b>	M	M	L	H	-	L	-	-	M	L	L	-	-	-
<b>CO4</b>	L	L	M	M	M	-	-	L	-	-	-	M	-	-
<b>CO5</b>	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.

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 Wiley 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](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](https://onlinecourses.nptel.ac.in/noc23_ee139/preview)

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Coll. of Engg. & Tech. in 1982

Course Code	Course Title	L	T	P	C
10212EC136	FIBER LASERS AND APPLICATIONS	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	L	-	M	L	-	-	L	M	-	-	L	-	-
<b>CO2</b>	H	M	M	L	M	-	-	L	-	-	-	M	L	-
<b>CO3</b>	M	M	L	H	-	L	-	-	M	L	L	-	-	-
<b>CO4</b>	L	L	M	M	M	-	-	L	-	-	-	M	-	-
<b>CO5</b>	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/>

*Agarwal*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Road, VA 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC137	SENSORS AND TRANSDUCERS	3	0	0	3

**a) Course Category**

Program 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, characteristics and 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
<b>CO1</b>	M	L	L	H	-	-	-	-	-	-	-	L	L	-
<b>CO2</b>	L	L	M	M	-	H	-	L	-	-	-	L	M	-
<b>CO3</b>	L	M	L	M	-	-	L	-	L	L	-	L	L	-
<b>CO4</b>	L	M	H	M	M	L	-	L	L	L	L	M	M	L
<b>CO5</b>	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, tachogenerators –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 Resources

#### Text Books

1. Ernest O.Doebelin,- Measurement systems, 6th Edition, Tata McGraw Hill Education Private 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 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. [https://onlinecourses.nptel.ac.in/noc21\\_ee32/preview](https://onlinecourses.nptel.ac.in/noc21_ee32/preview)

*Asim 18/11/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank 11 of 1000 AEC 1998

Course Code	Course Title	L	T	P	C
10212EC216	FPGA ARCHITECTURE TECHNOLOGIES AND TOOLS	2	0	2	3

**a) Course Category**

Program 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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO 10</b>	<b>PO 11</b>	<b>PO 12</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	H	H	-	L	-	-	-	-	-	-	-	M	M	-
<b>CO2</b>	H	L	-	H	-	-	-	-	-	-	-	M	M	-
<b>CO3</b>	M	L	-	M	-	-	-	-	-	-	-	M	M	-
<b>CO4</b>	H	H	H	H	H	M	M	-	H	L	M	H	H	-
<b>CO5</b>	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 - Cypress 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, Fourth 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/>

*Agarwal*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
RAED Institute of Science and Technology  
Established as the University Rank, on 8 of 1990, Act, 1992

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC217	ELECTRONICS CIRCUIT SIMULATION AND PCB DESIGN	1	0	4	3

**a) Course Category**

Program 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/](http://www.techdocs.altium.com/)
9. [www.ni.com](http://www.ni.com) (Multisim and Ultiboard - Academic version)
10. [www.cadence.com](http://www.cadence.com) (Orcade - Student version)
11. [www.youtube.com](http://www.youtube.com) (PCB Manufacturing Videos)

*Agum 10/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Rank with B of UGC Act, 1956



Course Code	Course Title	L	T	P	C
10212EC232	Reconfigurable System Design	1	0	4	3

**a) Course Category**

Program 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, 1<sup>st</sup> 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, 2<sup>nd</sup> Edition, 2003.
5. John Michael Williams, “Digital VLSI Design with Verilog”, 2<sup>nd</sup> 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>

*Asim*

Dr.A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the Autonomous Inst. with U of USC Act, 1986

Course Code	Course Title	L	T	P	C
10212EC233	VLSI CHIP DESIGN	1	0	4	3

**a) Course Category**

Program 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
<b>CO1</b>	M	M	H	M	H	-	-	-	-	L	-	M	M	-
<b>CO2</b>	M	L	H	M	H	L	L	-	-	L	-	M	M	L
<b>CO3</b>	M	L	H	M	H	L	L	-	L	L	-	M	M	M
<b>CO4</b>	M	L	H	M	H	L	L	-	L	L	-	M	M	M
<b>CO5</b>	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**

<b>S. No</b>	<b>Practical Exercises (60 Hours)</b>	<b>CO Mapping</b>
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](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](https://onlinecourses.nptel.ac.in/noc21_cs12/preview)

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the 14th January 2002, as a part of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC150	DIGITAL FORENSICS	3	0	0	3

**a) Course Category**

Program 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**

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



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, 3<sup>rd</sup> Edition, 2022.
3. Gerard Johansen, “Digital Forensics and Incident Response: Incident response tools and techniques for effective cyber threat response” Packt Publishing, 3<sup>rd</sup> 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/](https://onlinecourses.swayam2.ac.in/cec20_lb06/)

*Agarwal*  
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Head of the Department  
Electronics & Communication Engineering  
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Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the University Rank No. 1 of 1990 Act, 1956

Course Code	Course Title	L	T	P	C
10212EC151	CRYPTOGRAPHY FOR CYBER AND NETWORK SECURITY	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	M	M	L	L	-	-	-	L	L	L	-	-	-	-
<b>CO2</b>	M	M	L	L	-	-	-	L	L	L	-	-	-	-
<b>CO3</b>	M	M	L	-	-	-	-	L	L	L	-	L	-	-
<b>CO4</b>	M	-	-	-	L	L	-	L	L	L	-	L	-	-
<b>CO5</b>	M	-	-	-	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”, 2<sup>nd</sup> 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-eb13H50FiEPr4erSJiJHURM9BX>
3. [https://www.youtube.com/watch?v=-j80aA8q\\_IQ](https://www.youtube.com/watch?v=-j80aA8q_IQ)
4. <https://www.youtube.com/watch?v=NQ1cvwEvh44>

*Asim 18/11/21*

**Dr. A. Selwin Mich Priyadharson**  
Head of the Department  
Electronics & Communication Engineering

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Course Code	Course Title	L	T	P	C
10212EC152	BLOCKCHAIN TECHNOLOGY	3	0	0	3

**a) Course Category**

Program 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**

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

**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.

Introduction to Blockchain platforms: Hyperledger-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-Trippl 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 Goldfeder, '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>

Course Code	Course Title	L	T	P	C
10212EC153	AUTOMOTIVE CYBER SECURITY	3	0	0	3

**a) Course Category**

Program 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**

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

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Estd. on 8 of AUGUST 1988

Course Code	Course Title	L	T	P	C
10212EC154	CYBER SECURITY FOR SMART WEARABLES	3	0	0	3

**a) Course Category**

Program Core

**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
<b>CO1</b>	M	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	M	-	-	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	-	-	-	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	M	L	L	L	-	L	-	-	L	L	-	L	-	-
<b>CO5</b>	M	L	L	L	-	L	-	-	L	L	-	L	-	-

**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>

*Asim 18/12/19*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai - 600 062

Course Code	Course Title	L	T	P	C
10212EC222	PRINCIPLES OF NETWORKING AND CYBER SECURITY	2	0	2	3

**a) Course Category**

Program 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
<b>CO1</b>	M	M	L	L	L	-	-	-	L	L	-	-	-	-
<b>CO2</b>	M	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	L	L	-	L	-	-	-	L	L	-	L	-	-
<b>CO4</b>	M	L	L	-	L	-	-	-	L	L	-	L	-	-
<b>CO5</b>	M	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- DHCP-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) Lab****Total: 30 Hrs****List of experiments**

<b>Exp.No</b>	<b>Experiment Name</b>	<b>CO Level</b>	<b>Skill Level</b>
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) <ul style="list-style-type: none"><li>• Ipconfig</li><li>• Ping</li><li>• Tracert</li><li>• Nslookup</li></ul>	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", Pearson, 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>

*Asim*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the Unswear Inst. in 1982

Course Code	Course Title	L	T	P	C
10212EC223	ETHICAL HACKING	2	0	2	3

**a) Course Category**

Program 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
<b>CO1</b>	L	L	L	-	L	-	-	L	L	L	-	-	-	-
<b>CO2</b>	M	L	L	-	L	-	-	L	L	L	-	L	-	-
<b>CO3</b>	M	L	L	-	L	-	-	L	L	L	-	L	-	-
<b>CO4</b>	M	L	L	-	L	-	-	L	L	L	-	L	-	-
<b>CO5</b>	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**

### Lab 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-promiscuous 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 gather information 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 Lab 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 Starch Press, First Edition 2014. ISBN-13: 978-1593275648 ISBN-10: 1593275641.
3. Dr. Patrick Engebretson, "The Basics of Hacking and Penetration Testing", Syngress Publications Elsevier, 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>

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank, vol. 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC224	ARTIFICIAL INTELLIGENCE FOR CYBER SECURITY	2	0	2	3

**a) Course Category**

Program 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
<b>CO1</b>	L	L		-	-	-	-	-	-	--	-	-	-	-
<b>CO2</b>	M	L	L	-	-	-	-	-	-	-	-	-	L	-
<b>CO3</b>	M	L	L	-	L	-	-	L	L	L	-	L	L	-
<b>CO4</b>	M	L	L	-	L	-	-	L	L	L	-	L	L	-
<b>CO5</b>	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 Lab : 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)



Course Code	Course Title	L	T	P	C
10212EC155	FUNDAMENTALS OF DATA SCIENCE	3	0	0	3

**a) Course Category**

Specialization 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  $F_\beta$  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”, 3<sup>rd</sup> 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, 1<sup>st</sup> 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, 1<sup>st</sup> 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-ee6024fdb08>
7. <https://www.youtube.com/watch?v=njKP3FqW3Sk>
8. <https://www.analyticsvidhya.com/blog/2020/03/6-data-visualization-python-libraries/>

*Ag. M. 18.11.17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established on the University Rank, on 8 of June, 1988

Course Code	Course Title	L	T	P	C
10212EC156	DATA ANALYSIS AND VISUALIZATION	3	0	0	3

a) **Course Category**  
Specialization 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
<b>CO1</b>	L	L	L	L	L	-	-	-	L	-	-	L	L	M
<b>CO2</b>	M	M	M	M	L	-	-	-	L	-	-	L	L	M
<b>CO3</b>	M	M	M	M	L	-	-	-	L	-	-	L	L	M
<b>CO4</b>	L	L	L	L	L	-	-	-	L	-	-	L	L	M
<b>CO5</b>	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, Reducing 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>

*Agarwal*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the Government Engg. Coll. in 1984)

Course Code	Course Title	L	T	P	C
10212EC157	SOFT COMPUTING	3	0	0	3

**a) Course Category**

Specialization 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,  $\epsilon$  -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

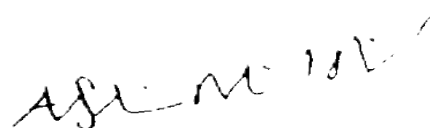
1. S.N. Sivanandam, S.N. Deepa, “Principles of Soft Computing”, Wiley India Pvt. Ltd., 2nd Edition, 2011.(Unit II)
2. S. Rajasekaran, G.A. Vijayalakshmi Pai, “Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications”, PHI Learning Pvt. Ltd., 2017.(Unit I, III, IV)

#### 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](http://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

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Extension II of OGC, Aug. 1988

Course Code	Course Title	L	T	P	C
10212EC158	STATISTICAL INFERENCE TECHNIQUES	3	0	0	3

**a) Course Category**

Specialization 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
<b>CO1</b>	M	L	L	L	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	M	L	L	L	L	-	-	-	L	L	-	-	L	-
<b>CO3</b>	M	L	L	L	L	-	-	-	L	L	-	-	L	L
<b>CO4</b>	M	L	L	L	L	-	-	-	L	L	-	-	L	L
<b>CO5</b>	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/UCQKwruq0LY3cjbvSx7>
2. Inferential Statistics- <https://www.youtube.com/watch?v=FtIH4svqx4&list>

Course Code	Course Title	L	T	P	C
10212EC159	MACHINE VISION	3	0	0	3

**a) Course Category**

Specialization 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
<b>CO1</b>	M	L	M	-	M	-	-	L	H	L	-	L	L	-
<b>CO2</b>	M	L	-	L	M	-	-	L	H	-	-	M	M	M
<b>CO3</b>	M	L	-	L	M	-	-	L	H	-	-	H	M	M
<b>CO4</b>	L	L	M	L	-	-	L	-	M	L	-	L	L	L
<b>CO5</b>	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: 26<sup>th</sup> 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>

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as an Autonomous Inst. on 11 of Dec. 1998)

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC174</b>	<b>PRINCIPLES OF DATA SCIENCE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Program 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:

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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-world problems.	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
<b>CO1</b>	H	L	L	-	-	-	-	-	-	-	-	L	L	L
<b>CO2</b>	H	M	M	L	H	-	-	-	L	L	-	L	L	L
<b>CO3</b>	H	M	M	M	H	-	-	-	L	L	L	L	L	L
<b>CO4</b>	H	H	M	M	H	-	-	-	L	L	-	L	L	L
<b>CO5</b>	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, 1<sup>st</sup> 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, 1<sup>st</sup> 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](#)

*Asim 18/12/21*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Deemed to be University) Rank no. 8 of 1000 AEC, 1996

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC225	TOOLS FOR DATA SCIENCE	1	0	4	3

a) **Course Category:**

Specialization 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	PO1 0	PO1 1	PO1 2	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**

<b>LIST OF EXPERIMENTS</b>		
<b>Sl. No.</b>	<b>Name of the Experiment</b>	<b>CO</b>
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", O'Reilly, 2<sup>nd</sup> 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/UCBAAdmissions.html>  
- PIMA Indian Diabetes dataset for case study.
3. <https://stat.ethz.ch/R-manual/R-patched/library/datasets/html/UCBAAdmissions.html>  
- The UCBS admissions dataset for case study.

Course Code	Course Title	L	T	P	C
10212EC226	MACHINE LEARNING	2	0	2	3

**a) Course Category**

Specialization 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, 3<sup>rd</sup> 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 \(tutorialspoint.com\)](https://www.tutorialspoint.com/machine-learning/)
5. Machine Learning Mastery, [Best Machine Learning Resources for Getting Started \(machinelearningmastery.com\)](https://machinelearningmastery.com/)

*ASU M 10/1/17*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Road, on 8 of AUGUST, 1989

Course Code	Course Title	L	T	P	C
10212EC227	DEEP LEARNING	2	0	2	3

**a) Course Category**

Specialization 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**

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

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**

<b>S. No</b>	<b>Name of the experiment</b>	<b>CO</b>
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](https://onlinecourses.nptel.ac.in/noc20_cs62/preview) (Deep Learning)
4. <https://nptel.ac.in/courses/106/106/106106224/> (Deep Learning for Computer Vision)

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as an Autonomous Instt. on 8 of March, 2008)

Course Code	Course Title	L	T	P	C
10212EC160	OPTIMIZATION TECHNIQUES	3	0	0	3

**a) Course Category**

Specialization 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
<b>CO1</b>	H	L	L	H	L	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	H	L	M	L	-	-	-	L	L	-	L	-	L
<b>CO3</b>	H	H	M	L	L	-	-	-	L	L	-	L	-	L
<b>CO4</b>	H	M	L	L	L	-	-	-	L	L	-	L	-	L
<b>CO5</b>	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.

*Asim*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the Vel Tech Inst. of Engg. & Tech. in 1988



Course Code	Course Title	L	T	P	C
10212EC228	DATA SCIENCE AND VISUALIZATION	2	0	2	3

**a) Course Category**

Specialization 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
<b>CO1</b>	M	M	M	L	H	-	-	L	M	L	-	L	-	L
<b>CO2</b>	M	M	M	L	H	-	-	L	M	L	-	L	-	L
<b>CO3</b>	M	M	M	L	H	-	-	L	M	L	-	L	L	M
<b>CO4</b>	M	M	M	L	H	-	-	L	M	L	-	L	L	M
<b>CO5</b>	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 <ul style="list-style-type: none"><li>• Bar chart</li><li>• Geographic map</li><li>• Crosstab report</li><li>• Scatter plot</li><li>• Line chart</li></ul>	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](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>

*Agil M. 10/10/21*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Chartered as an Autonomous Instt. by UGC Act. 1956)

Code	Course Title	L	T	P	C
10212EC229	AI IN NATURAL LANGUAGE PROCESSING	2	0	2	3

**a) Course Category**

Specialization 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
<b>CO1</b>	H	M	L	L	L	-	L	-	L	L	-	M	-	L
<b>CO2</b>	H	M	L	L	L	-	L	-	L	L	-	M	-	L
<b>CO3</b>	H	M	M	M	L	-	L	-	L	L	-	M	-	M
<b>CO4</b>	H	M	M	M	L	-	L	-	L	L	-	M	-	M
<b>CO5</b>	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	<b>CO1</b>
2	Demonstrate a bigram language model & trigram language model	<b>CO1</b>
3	N-Grams Smoothing, POS Tagging: Hidden Markov Model	<b>CO2</b>
4	Identify parts-of Speech using Penn Treebank tag set.	<b>CO2</b>
5	Implement HMM for POS tagging	<b>CO2</b>
6	Implementation of Antonyms from WordNet	<b>CO3</b>

	<b>CYCLE-2</b>	
7	Implementation of stemming non-English words	<b>C03</b>
8	Word sense disambiguation by LSTM/GRU	<b>C04</b>
9	Case study-based program (IBM) or Sentiment analysis	<b>C04</b>
10	Implement POS Tagging or Word Embedding's.	<b>C05</b>
11	Create a chatbot for VTU	<b>C05</b>
12	Develop a Movie review system	<b>C05</b>

**Total: 60 Hours**

## **h) Learning Resources**

### **Text Book:**

1. Daniel Jurafsky, 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 Javal, 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 Indurkha 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-natural-language-processing-part-i-processing-understanding-text-9f4abfd13e72>
5. <https://www.edx.org/course/natural-language-processing>
6. NLTK – Natural Language Tool Kit - <http://www.nltk.org/>
7. [https://www.cs.vassar.edu/~cs366/docs/Manning\\_Schuetze\\_StatisticalNLP.pdf](https://www.cs.vassar.edu/~cs366/docs/Manning_Schuetze_StatisticalNLP.pdf)

Course Code	Course Title	L	T	P	C
10212EC230	AI IN SPEECH PROCESSING	2	0	2	3

**a) Course Category**

Specialization 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 Programming

**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**

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

Course Code	Course Title	L	T	P	C
10212EC176	INDUSTRY 4.0 AND IIOT	3	0	0	3

**a) Course Category**

Specialization 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
<b>CO1</b>	H	L	L	-	-	-	-	-	—	L	-	L	M	L
<b>CO2</b>	H	L	L	-	-	-	-	-	L	L	-	L	M	L
<b>CO3</b>	H	M	M	L	L	-	-	-	L	L	-	L	M	L
<b>CO4</b>	H	M	M	M	-	-	L	L	L	L	-	L	M	L
<b>CO5</b>	H	M	M	L	-	-	-	-	L	L	M	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](https://onlinecourses.nptel.ac.in/noc20_cs69/preview)
2. Introduction to internet of things: [https://onlinecourses.nptel.ac.in/noc21\\_cs63/preview](https://onlinecourses.nptel.ac.in/noc21_cs63/preview)

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute on 11 of March, 2008

Course Code	Course Title	L	T	P	C
10212EC177	IOT SECURITY	3	0	0	3

a) **Course Category**

Specialization 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
<b>CO1</b>	H	L	L	-	-	L	-	-	L	L	-	L	-	L
<b>CO2</b>	H	L	L	-	-	L	-	-	L	L	-	L	-	L
<b>CO3</b>	H	H	L	-	M	L	-	-	L	L	-	M	-	L
<b>CO4</b>	H	L	L	L	M	L	-	-	L	L	-	M	-	L
<b>CO5</b>	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](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**

Specialization 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
<b>CO1</b>	H	L	L	L	L	-	-	-	L	L	-	-	L	M
<b>CO2</b>	H	M	M	L	L	-	-	-	L	L	-	-	L	M
<b>CO3</b>	H	M	M	L	L	-	-	-	L	L	-	-	L	M
<b>CO4</b>	H	M	M	M	L	-	-	-	L	L	-	-	L	M
<b>CO5</b>	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", Bentham 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](https://onlinecourses.nptel.ac.in/noc22_cs56/preview)
2. Machine Learning-(NPTEL):  
[https://onlinecourses.nptel.ac.in/noc22\\_cs24/preview](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](https://www.youtube.com/watch?v=kmeaG_BQZ7M&list=PLrjkTql3jnm_yol-ZK1QqPSn5YSg0NF9r)

*Asi m 10/11/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Engg. Coll. of Vel Tech, 1982)

Course Code	Course Title	L	T	P	C
10212EC179	FLEXIBLE AND WEARABLE SENSORS	3	0	0	3

**a) Course Category**

Specialization 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
<b>CO1</b>	H	L	L	-	-	-	-	-	-	L	-	L	-	-
<b>CO2</b>	H	-	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	M	L	L	-	-	-	L	-	-	L	L	M
<b>CO4</b>	H	M	M	M	-	-	L	L	L	-	-	L	L	M
<b>CO5</b>	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](https://www.youtube.com/watch?v=a_rhr4jtZtY)

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established as the University Institute of VIT in 1988

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC180</b>	<b>AUTOMOTIVE SENSORS AND IN-VEHICLE NETWORKING</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Specialization 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

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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
<b>CO1</b>	H	L	L	L	L	-	-	-	L	L	-	-	L	L
<b>CO2</b>	H	M	M	L	L	-	-	-	L	L	-	-	L	M
<b>CO3</b>	H	M	M	L	L	-	-	-	L	L	-	-	L	M
<b>CO4</b>	H	M	M	M	L	-	-	-	L	L	-	-	L	M
<b>CO5</b>	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 ( $\lambda$ ), 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<sub>2</sub>), 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=PyxjIWnb6BA>
2. CAN Bus- Serial Communication:  
<https://www.youtube.com/watch?v=JZSCzRT9TTo>

*Asim 18/11/17*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the Anniversary Year, viz 11 of 1980 A.M. 1980

Course Code	Course Title	L	T	P	C
10212EC234	IOT SYSTEM DESIGN AND DEVELOPMENT	2	0	2	3

a) **Course Category**

Specialisation 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**

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

## Lab Experiments

S. No.	Practical Exercises	Course Outcome
1	Simulate the program to blink LEDs and read digital inputs.	C01
2	Simulate the program to read sensor data and display it on a serial monitor or LCD.	C01
3	Develop a web interface or mobile application to manage a LED or relay.	C02
4	Design and implement a smart lighting system using motion sensors.	C02
5	Develop a system to manage multiple appliances using a smartphone app.	C03
6	Develop a system to monitor air quality parameters like CO2 and PM2.5.	C03
7	Simulate the program for reading RFID tags and controlling access to a virtual system.	C04
8	Simulate the program for measuring power consumption and visualizing data on a virtual platform.	C04
9	Design and implement an irrigation facility based on soil moisture levels.	C05
10	Simulate the program to interface temperature and humidity sensors.	C05

**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/](https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-Embedded%20Systems%20-%20Introduction%20to%20Embedded%20Systems%20Design/)
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>

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute on 11 of Dec 2002

<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC138</b>	<b>INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Honors 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:

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on revised Bloom's Taxonomy)</b>
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, 4<sup>th</sup> 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, 1<sup>st</sup> edition. 2011.
3. Ric, E., Knight, K and Shankar, B, “Artificial Intelligence”, Tata McGraw Hill. 3<sup>rd</sup> edition, 2009
4. Luger, G.F, “Artificial Intelligence -Structures and Strategies for Complex Problem Solving”, Pearson, 6<sup>th</sup> edition, 2008
5. Alpaydin, E, “ Introduction to Machine Learning” MIT, 2<sup>nd</sup> 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>

*Asim*

Dr. A. Selwin Muthu Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Inst. on 8 of DEC 1988



Course Code	Course Title	L	T	P	C
10212EC139	WIRELESS COMMUNICATIONS AND NETWORKING	3	0	0	3

**a) Course Category**

Honor 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	PO10	PO11	PO12	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](https://onlinecourses.nptel.ac.in/noc21_ee66/preview)
3. <https://youtu.be/SljXFf0vgvw>
4. [https://onlinecourses.nptel.ac.in/noc22\\_ee65/preview](https://onlinecourses.nptel.ac.in/noc22_ee65/preview)
5. <https://archive.nptel.ac.in/courses/108/105/108105134/>

*Asif M. 18/11/21*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Centre on 8 of UGC Act, 1956

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC140	MACHINE LEARNING FOR WIRELESS COMMUNICATIONS	3	0	0	3

**a. Course Category:**

Honor 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, 1<sup>st</sup> Ed., Wiley IEEE Press, 2020.
2. Ruisi He and Zhiguo Ding, Applications of Machine Learning in Wireless Communications (Telecommunications), 2<sup>nd</sup> Ed., Institution of Engineering and Technology, 2019.

### **Reference Books:**

1. Ioan-Sorin Comşa and Ramona Trestian, Next-Generation Wireless Networks Meet Advanced Machine Learning Applications, 2<sup>nd</sup> 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, 1<sup>st</sup> 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>

*A. Selwin M. Priyadharson*  
Dr. A. Selwin M. Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. on 8 of Dec. 1988

Course Code	Course Title	L	T	P	C
10212EC141	ARTIFICIAL INTELLIGENCE BASED WIRELESS NETWORK DESIGN	3	0	0	3

**a) Course Category**

Honor 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
<b>CO1</b>	H	M	L	M	L	-	-	M	-	-	M	L	-	-
<b>CO2</b>	H	H	M	-	-	-	L	-	-	-	-	-	L	-
<b>CO3</b>	M	L	L	-	-	-	-	-	-	M	-	-	-	-
<b>CO4</b>	M	M	-	-	-	L	-	-	-	-	-	M	-	L
<b>CO5</b>	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 for 5G

**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”,2<sup>nd</sup>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”, 3<sup>rd</sup> edition,TMH, 2009.
2. Stephen Boyd , Lieven Vandenberghe, “Convex Optimization”, 1<sup>st</sup> 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”, 1<sup>st</sup> 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](http://home.iitk.ac.in/~rohitbr/index_ml_course.html)
2. <http://aimaterials.blogspot.com/p/syllabus.html>

*Ashwin*

Dr.A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Estb. on 8 of AUGUST 1988

<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC142</b>	<b>OPTIMIZATION FOR WIRELESS AND MACHINE LEARNING</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a. Course Category**

Honor 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:

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on revised Bloom's Taxonomy)</b>
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
<b>CO1</b>	M	H	M	-	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	M	H	L	-	L	L	-	L	L	L	-	L	-
<b>CO3</b>	H	M	M	-	-	L	L	L	L	L	L	-	L	-
<b>CO4</b>	M	H	L	L	L	-	-	L	L	L	-	L	L	-
<b>CO5</b>	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](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](#)

*Aswini*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. on 11 of Dec. 1988

Course Code	Course Title	L	T	P	C
10212EC143	MICROWAVE AND MILLIMETER WAVE COMMUNICATION	3	0	0	3

**a) Course Category**

Honor 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
<b>CO1</b>	M	M	L	L	L	-	-	L	L	L	L	L	-	-
<b>CO2</b>	M	M	L	L	M	-	-	-	M	M	-	M	-	-
<b>CO3</b>	M	M	L	-	H	-	M	L	L	M	L	M	M	-
<b>CO4</b>	M	M	M	L	H	L	-	-	-	-	L	M	M	-
<b>CO5</b>	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](https://link.springer.com/chapter/10.1007/978-3-030-92188-0_14)

*Asim 18/11/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Instt. with 8 of UGC's AEC, 1982

Course Code	Course Title	L	T	P	C
10212EC144	ARTIFICIAL INTELLIGENCE IN OPTICAL COMMUNICATION	3	0	0	3

**a) Course Category**

Honors 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
<b>CO1</b>	L	L	L	M	L	L	-	-	-	L	-	-	-	-
<b>CO2</b>	L	M	M	M	-	M	-	-	L	L	-	L	-	-
<b>CO3</b>	L	M	L	L	M	M	L	-	-	L	L	L	-	-
<b>CO4</b>	L	L	M	M	-	L	L	L	M	L	-	-	L	-
<b>CO5</b>	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.

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=nCIPAfPGgt0>
4. <https://www.youtube.com/watch?v=dWaKPc26-sw>

*Asst. Prof. Dr. A. Selwin Mith Priyadharson*  
Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Road, on 8 of AUG, 1982)

Course Code	Course Title	L	T	P	C
10212EC218	SMART ANTENNAS FOR 5G COMMUNICATION	2	0	2	3

**a) Course Category**

Honor 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
<b>CO1</b>	H	H	L	L	L	-	-	L	L	L	L	M	L	-
<b>CO2</b>	H	M	H	M	M	-	-	M	-	-	-	L	-	-
<b>CO3</b>	L	L	H	H	H	-	H	L	L	L	L	H	M	-
<b>CO4</b>	L	L	H	H	H	-	H	-	-	L	-	M	M	-
<b>CO5</b>	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

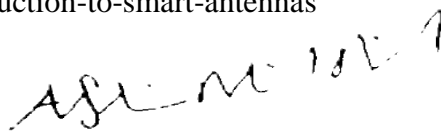
1. Frank Gross, "Smart antennas for wireless communications", McGraw-Hill Education, 2005.
2. Constantine A. Balanis, Panayiotis I. Ioannides, "Introduction to Smart Antennas (Synthesis Lectures on Antennas)", Morgan & Claypool Publishers, 2007.

##### 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>

  
 Dr. A. Selwin Mich Priyadharson  
 Head of the Department  
 Electronics & Communication Engineering  
**Vel Tech**  
 Rangarajan Dr. Sagunthala  
 R&D Institute of Science and Technology  
Established as Vel Tech on 21st of Dec 1990



## **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](http://www.NPTEL/lectures/lowpowervlsi)

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Road, on 8 of AUGUST 1982



Course Code	Course Title	L	T	P	C
10212EC146	MIXED SIGNAL VLSI DESIGN	3	0	0	3

**a) Course Category**

Program 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 filter, 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, 33<sup>rd</sup> 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=PLLDC70psjvq5vtrb0EdII4xIKA15ec-Ij&index=10&ab\\_channel=kashyapB](https://www.youtube.com/watch?v=zVXzcUjOBjM&list=PLLDC70psjvq5vtrb0EdII4xIKA15ec-Ij&index=10&ab_channel=kashyapB)

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as an Autonomous Inst. on 8 of Dec. 1988)

Course Code	Course Title	L	T	P	C
10212EC147	IC TECHNOLOGY	3	0	0	3

**a) Course Category**

Program 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**

	<b>PO 1</b>	<b>PO 2</b>	<b>PO 3</b>	<b>PO 4</b>	<b>PO 5</b>	<b>PO 6</b>	<b>PO 7</b>	<b>PO 8</b>	<b>PO 9</b>	<b>PO 10</b>	<b>PO 11</b>	<b>PO 12</b>	<b>PSO 1</b>	<b>PSO 2</b>
<b>CO1</b>	M	M	-	L	-	L	L	-	-	M	-	M	-	-
<b>CO2</b>	H	M	-	M	-	-	-	-	-	L	-	M	-	-
<b>CO3</b>	H	H	-	L	-	-	L	-	L	L	-	M	-	-
<b>CO4</b>	H	H	-	L	L	-	-	-	L	M	-	M	L	-
<b>CO5</b>	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 SiO<sub>2</sub>, 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

*Agim m*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
Vellore Institute of Science and Technology  
Established as the University East, on 8 of March, 1988

Course Code	Course Title	L	T	P	C
10212EC148	TESTING OF VLSI CIRCUITS	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	M	L	L	L	L	L	-	-	-	L	L	L	-
<b>CO2</b>	M	H	L	M	L	-	-	-	L	-	L	L	L	-
<b>CO3</b>	H	M	M	L	L	-	-	-	L	-	L	M	L	-
<b>CO4</b>	M	M	L	L	M	-	-	-	L	-	L	M	L	-
<b>CO5</b>	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-Pseudo 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>

*Asin 10/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the Veltech Inst. of Eng. & Tech. in 1988)

Course Code	Course Title	L	T	P	C
10212EC149	VLSI SIGNAL PROCESSING	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	M	L	L	L	-	L	-	-	L	-	-	L	-
<b>CO2</b>	M	H	M	M	L	-	-	-	-	-	-	-	L	L
<b>CO3</b>	M	H	M	M	M	-	-	-	L	M	-	M	L	L
<b>CO4</b>	H	M	M	M	H	L	-	-	L	L	-	M	M	L
<b>CO5</b>	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 PIPELINING, 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/>

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Road, at 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC219	ANALOG CIRCUIT IC DESIGN	2	0	2	3

**a) Course Category**

Program 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's Taxonomy)
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
<b>CO1</b>	H	L	L	-	-	-	-	-	-	-	-	-	-	-
<b>CO2</b>	H	L	L	L	M	-	-	L	L	-	-	L	L	-
<b>CO3</b>	M	H	H	H	M	-	L	L	-	-	-	L	L	-
<b>CO4</b>	M	M	L	L	M	-	-	L	-	-	-	L	L	-
<b>CO5</b>	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 cascode 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, 2<sup>nd</sup> Edition, 2003
2. Yannis Tsividis, "Mixed Analog-Digital VLSI Devices and Technology", McGraw-Hill Publication, 2<sup>nd</sup> Edition, 1999

##### Reference Books

1. Vineetha P.Geji Analog and Mixed Mode Design - Prentice Hall, 1st Edition ,2011
2. JeyaGowriAnalogandMixedModeDesign-SapnapublishingHouse2011

##### Online Resources

1. [https://onlinecourses.nptel.ac.in/noc20\\_ee26/preview/](https://onlinecourses.nptel.ac.in/noc20_ee26/preview/)
2. <https://www.youtube.com/watch?v=311XkpNGs8c>

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sakunthala  
RAD Institute of Science and Technology  
Established as the Government Rank 1st & 2nd of 1987 Act, 1986

Course Code	Course Title	L	T	P	C
10212EC220	PHYSICAL DESIGN OF CMOS IC	1	0	4	3

**a) Course Category**

Program 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**

<b>S. No</b>	<b>CO Mapping</b>	<b>Practical Exercises(60 Hours)</b>
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](https://www.youtube.com/watch?v=q3po_gNaTBw)
3. <http://www.verilog.com/>

*Asin 10/11/17*

Dr.A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
VET Institute of Science and Technology  
Established as an Autonomous Inst. on 8 of March, 1995

Course Code	Course Title	L	T	P	C
10212EC221	RECONFIGURABLE COMPUTING WITH FPGA	1	0	4	3

**a) Course Category**

Program 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
<b>CO1</b>	M	M	H	M	H	L	L	-	-	L	-	M	M	-
<b>CO2</b>	M	L	H	M	H	L	L	-	-	L	-	M	M	-
<b>CO3</b>	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-computing-architectural-and-design-tool-challenges/>
3. <http://www.verilog.com/>

*Agarwal*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank, on 8 of 1980 Act, 1980

Course Code	Course Title	L	T	P	C
10212EC161	SECURITY IN COMMUNICATION AND NETWORKING SYSTEMS	3	0	0	3

**a) Course Category**

Minor 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](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/>

*Asim*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established on the Centenary Year of UGC Act, 1956)

Course Code	Course Title	L	T	P	C
10212EC162	VEHICULAR COMMUNICATION AND INTERNETWORKING TECHNOLOGIES	3	0	0	3

**a) Course Category**

Minor 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.

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/>

*Asst. Prof. Dr. A. Selwin Mitha Priyadharson*  
Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Centre on 8 of AUGUST 1988

Course Code	Course Title	L	T	P	C
10212EC163	SENSORS AND WEARABLE TECHNOLOGY	3	0	0	3

**a) Course Category**

Minor 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
<b>CO1</b>	H	M	M	-	-	-	-	L	-	-	L	L	-	-
<b>CO2</b>	H	M	M	M	-	-	-	-	-	-	-	L	-	-
<b>CO3</b>	M	M	M	-	-	-	L	L	-	-	-	L	M	-
<b>CO4</b>	M	M	M	-	-	-	-	-	-	-	-	L	M	-
<b>CO5</b>	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.

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>

*Asst. Prof. Dr. A. Selwin Mitha Priyadharson*  
Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 062

Course Code	Course Title	L	T	P	C
10212EC164	SENSORS FOR STRUCTURAL HEALTH MONITORING	3	0	0	3

**a) Course Category**

Minor 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](https://www.ndt.net/events/NDTCanada2014/app/content/Slides/40_Tamutus.pdf)

*Asim 18/11/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-60 006

Course Code	Course Title	L	T	P	C
10212EC165	IOT IN AUTOMOTIVE SYSTEMS	3	0	0	3

**a) Course Category**

Minor 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	-	-	-	-	-
CO4	H	H	L	-	-	L	-	-	L	-	-	L	-	-
CO5	L	H	L	-	-	L	-	-	L	-	-	M	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.

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, Iwao Yokomori, “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](https://onlinecourses.nptel.ac.in/noc21_ee85/preview)
- 3 <https://www.allaboutcircuits.com/technical-articles/internet-of-things-communication-protocols-iot-data-protocols/>
- 5 <https://www.slideshare.net/abdulrabbasi33/sensors-actuators>

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC166</b>	<b>M2M COMMUNICATION WITH IoT AND LTE</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Minor 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

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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
<b>CO1</b>	M	L	L	L	L	-	-	-	L	L	-	-	-	-
<b>CO2</b>	M	L	L	L	-	-	-	-	L	L	-	-	-	-
<b>CO3</b>	H	L	L	L	-	M	-	-	-	L	-	L	L	-
<b>CO4</b>	H	L	M	L	L	M		-	-	L	-	L	L	-
<b>CO5</b>	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.

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. Madiseti, “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](https://onlinecourses.nptel.ac.in/noc20_cs66)
3. [https://www.youtube.com/watch?v=Am9SW1T\\_Qvs](https://www.youtube.com/watch?v=Am9SW1T_Qvs)

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Rank. No. 1 of UGC Act, 1956



Course Code	Course Title	L	T	P	C
10212EC167	<b>FLEXIBLE ELECTRONICS FOR AUTOMOBILE APPLICATIONS</b>	3	0	0	3

a. **Course Category:**  
Minor 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 MICROPROCESSORS IN 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, 2<sup>ND</sup> 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>

*Asim*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Road, 11 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC168	BASICS OF EMBEDDED SYSTEM	3	0	0	3

**a) Course Category**

Minor 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
<b>CO1</b>	M	-	-	-	-	-	-	-	-	-	-	L	L	-
<b>CO2</b>	M	-	-	-	-	-	-	-	-	-	-	L	L	-
<b>CO3</b>	M	-	-	-	-	-	-	H	-	-	-	-	M	M
<b>CO4</b>	M	-	L	-	-	-	-	-	-	-	-	M	L	-
<b>CO5</b>	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**

**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#>

*Asi m 10/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Inst. with 8 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC169	SENSORS AND TRANSDUCERS	3	0	0	3

**a) Course Category**

Minor 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	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	M	L	-	-	-	-	-	-	-	-	-	L	M	L
<b>CO2</b>	M	L	M	L	L	-		L	-	-	-	L	M	L
<b>CO3</b>	M	L	-	M	-	-	L	-	L	L	-	-	L	L
<b>CO4</b>	M	L	L	M	M	-		L	L	L	-	-	M	L
<b>CO5</b>	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, Inclometers.

**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.



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, Dhanpat Rai 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/>

*Asst. Prof. Dr. A. Selwin Mithi Priyadharson*  
Dr. A. Selwin Mithi Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 062

Course Code	Course Title	L	T	P	C
10212EC170	EMBEDDED SECURITY	3	0	0	3

**a) Course Category**

Minor 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	PO13	PO14
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](http://www.cs.vsb.cz/ochodkova/courses/kpb/cryptography-and-network-security_-principles-and-practice-7th-global-edition.pdf)

*ASL M 10/11*

Dr.A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Road, on 8 of 1980, Aug 1980

Course Code	Course Title	L	T	P	C
10212EC171	FLEXIBLE ELECTRONICS	3	0	0	3

**a) Course Category**

Minor 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](https://www.youtube.com/watch?v=vCvwPAZx_o0)

*Asim*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
VIT Institute of Science and Technology  
Established as the University Rank. No. 2 of UGC Act, 1956

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC172</b>	<b>SMART CITY</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**a) Course Category**

Minor 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:

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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
<b>CO 1</b>	H	H	-	-	-	-	-	L	-	-	-	-	-	-
<b>CO 2</b>	H	H	L	L	-	-	L	L	-	-	-	-	-	-
<b>CO 3</b>	H	H	M	-	-	-	-	L	M	-	-	-	-	-
<b>CO 4</b>	H	H	-	-	-	-	L	L	-	-	-	-	M	--
<b>CO 5</b>	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 Governancel, 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>

*Asst. Prof. Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. in 1983 of UGC Act, 1956

Course Code	Course Title	L	T	P	C
10212EC173	INTEGRATED PRODUCT DEVELOPMENT	3	0	0	3

**a) Course Category**

Minor 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**

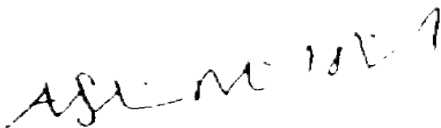
1. Karl TUI rich and Stephen D Eppinger, "Product Design and Development", Tata McGraw Hill, Fifth Edition, New Delhi, 2011
2. John W Newstormand Keith Davis, "Organizational Behavior", Tata McGraw Hill, Eleventh Edition, New Delhi, 2005.

#### **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 TUI 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\\_XM9cvjLL\\_O\\_Azt1FkgPhpH&index=2](https://www.youtube.com/watch?v=P_PP76flZfw&list=PLyqSpQzTE6M_XM9cvjLL_O_Azt1FkgPhpH&index=2)

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank on 8 of 1980 Act, 1980

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

**a) Course Category**

Minor 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 Beginner'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](http://www.avr-asm-download.de/beginner_en)



Course Code	Course Title	L	T	P	C
10212EC231	EMBEDDED IoT	2	0	2	3

**a) Course Category**

Minor 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
<b>CO1</b>	L	-	-	-	-	-	-	-	-	-	-	H	-	-
<b>CO2</b>	L	H	H	L	H	-	-	L	M	M	H	H	H	H
<b>CO3</b>	L	M	-	L	-	-	-	-	-	-	-	-	-	-
<b>CO4</b>	L	-	-	L	-	-	-	-	-	-	-	L	-	-
<b>CO5</b>	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 PHYSICAL 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>

*Agil M. 10/12/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the Veltech Institute on 2 of Dec 1992

Course Code	Course Title	L	T	P	C
10212EC181	WIRELESS COMMUNICATION	3	0	0	3

**a) Course Category**

Program 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**

<b>UNIT I</b>	<b>FUNDAMENTALS OF CELLULAR SYSTEM</b>	<b>9</b>
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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](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>

*Asim*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Instt. Act. II of 1987 Act, 1988

Course Code	Course Title	L	T	P	C
10212EC182	5G TECHNOLOGY	3	0	0	3

**a) Course Category**

Program 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, 1<sup>st</sup> Edition, 2016.
2. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, “Millimeter Wave Wireless Communication”, Prentice Hall, 1<sup>st</sup> 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>

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
VET Institute of Science and Technology  
Established as an Autonomous Inst. on 8 of March, 1998

Course Code	Course Title	L	T	P	C
10212EC183	5G NEW RADIO ACCESS TECHNOLOGY	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	M	-	-	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	M	-	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	M	-	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	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, 2<sup>nd</sup> Edition, 2020.

### **Reference books**

1. Saad Z. Asif, “5G Mobile Communications Concepts and Technologies, CRC Press, 1<sup>st</sup> 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, 1<sup>st</sup> 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>

*Agil M. 18/12/19*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute with U of Madras Act, 1959

Course Code	Course Title	L	T	P	C
10212EC184	MILLIMETER WAVE TECHNOLOGY	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	H	L	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](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>

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Road, on 8 of OCTOBER 1989



Course Code	Course Title	L	T	P	C
10212EC185	5G NETWORKS	3	0	0	3

**a) Course Category**

Program 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/>

*Asim*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the 1st-aided Inst. in 1983)

Course Code	Course Title	L	T	P	C
10212EC186	MIMO WIRELESS COMMUNICATION	3	0	0	3

**a) Course Category**

Program 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
<b>CO1</b>	H	M	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	H	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 Ghayeb, "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. Marzetta, 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](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>

*Asim*

Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank, No. 1 of UGC, Aug. 1999

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
<b>CO1</b>	M	L	L	-	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	M	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	L	L	L	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	M	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	M	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, 1<sup>st</sup> 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](https://onlinecourses.nptel.ac.in/noc22_cs90/preview)
3. 5G Wireless Standard Design (NPTEL)  
[https://onlinecourses.nptel.ac.in/noc24\\_ee152/preview](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](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](https://onlinecourses.nptel.ac.in/noc24_ee79/preview)

*Asim*

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Established as the University Road, on 8 of AUGUST 1998

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
<b>CO1</b>	M	-	-	-	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	M	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	M	L	L	-	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	M	L	L	L	-	-	-	-	L	L	-	L	-	-

**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>

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Instt. on 8 of March, 1998

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
<b>CO1</b>	H	L	L	L	-	-	-	-	L	L	-	-	-	-
<b>CO2</b>	H	L	L	L	-	L	L	-	L	L	-	-	-	-
<b>CO3</b>	H	L	L	L	-	L	L	-	L	L	-	-	-	-
<b>CO4</b>	H	L	L	L	-	L	L	-	L	L	-	L	-	-
<b>CO5</b>	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, bridge 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](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](https://www.youtube.com/watch?v=_FMK-LqHloU&ab_channel=edX).
3. Introduction to semiconductor devices- Course (nptel.ac.in).

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. on 8 of Dec 2004 Act. 1986

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
<b>CO1</b>	H	M	M	L	-	-	-	-	-	M	-	M	-	-
<b>CO2</b>	H	M	M	M	-	-	-	-	-	L	-	M	-	-
<b>CO3</b>	H	M	M	L	-	-	-	-	L	L	-	M	-	-
<b>CO4</b>	H	M	M	L	-	-	-	-	L	M	-	M	-	-
<b>CO5</b>	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**

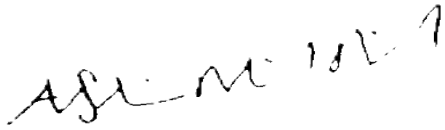
1. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", Tata McGraw- Hill Professional, Sixth edition, 2014.
2. Nandita Das Gupta and Amitava Das Gupta, "Semiconductor Devices modelling and Technology", PHI, 2013.
3. S.K. Gandhi, "VLSI Fabrication Principles", John 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)

  
Dr. A. Selwin Mithi Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute on 11 of Dec 2002

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
<b>CO1</b>	H	L	L	L	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	L	L	L	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	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 inverter, 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. 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](https://www.youtube.com/watch?v=YFQO_cZiGPY)
3. Introduction to CMOS circuits: <https://nptel.ac.in/courses/117101105>

*Asim 18/11/21*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute with 8 of UGC Act, 1956

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
<b>CO1</b>	H	H	H	-	-	-	-	-	L	M	-	M	-	-
<b>CO2</b>	H	M	M	M	-	-	-	-	-	L	-	M	-	-
<b>CO3</b>	H	M	M	-	-	-	-	-	L	L	-	M	-	-
<b>CO4</b>	H	M	-	H	-	-	-	-	L	M	-	M	-	-
<b>CO5</b>	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)

*Aswini*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Deemed to be University Est. on 8 of Dec 1988



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
<b>CO1</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO5</b>	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](https://nptel.ac.in))
2. Digital VLSI Testing: Course ([nptel.ac.in](https://nptel.ac.in))

*Asim*

Dr. A. Selwin Mitha Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Institute of UGC Act, 1956

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
<b>CO1</b>	H	L	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	L	M	-	-	-	-	L	L	-	M	-	-
<b>CO5</b>	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](http://nptel.ac.in)).
4. Introduction to Quantum Computing: Course ([nptel.ac.in](http://nptel.ac.in)).
5. Introduction to Quantum Computing: Quantum Algorithms and Qiskit - Course ([nptel.ac.in](http://nptel.ac.in)).

*ASE M 18/11/21*

**Dr. A. Selwin Mich Priyadharsan**  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Rank, No. 1 of 2002 AEC, 1996)

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
<b>CO1</b>	H	M	M	L	-	-	-	-	-	L	-	L	-	-
<b>CO2</b>	H	M	M	M	-	-	-	-	-	L	-	L	-	-
<b>CO3</b>	H	M	M	L	-	-	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	M	L	-	-	-	-	L	L	-	M	-	-
<b>CO5</b>	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:  $\text{Cu}_2\text{ZnSn(S,Se)}$  related materials -solar cell characterization.

**Total : 45 Hrs**



## **h) Learning Resources**

### **Text Books**

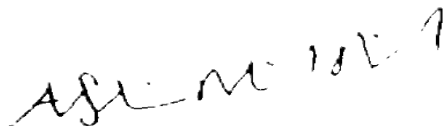
1. Pallab Bhattacharya, “Semiconductor Optoelectronic Devices”, PHI, Second Edition, 2017.
2. Niloy K Dutta , Xiang Zhang, “ Opto electronic detectors”, World Scientific Publishing”, 2018.

### **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)

  
Dr. A. Selwin Mich Priyadharsan  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-60 University Rank no. 2 of 1990 AEC 1990

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10212EC235</b>	<b>FPGA BASED SYSTEM DESIGN</b>	<b>1</b>	<b>0</b>	<b>4</b>	<b>3</b>

**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

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Dave's Taxonomy)</b>
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
<b>CO1</b>	M	M	H	M	H	-	-	-	-	L	-	M	-	-
<b>CO2</b>	M	L	H	M	H	L	L	-	-	L	-	M	-	-
<b>CO3</b>	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\\_j72Ftq8](https://youtu.be/5_H_j72Ftq8)<http://www.verilog.com/>
3. Digital Design with Verilog: Course (nptel.ac.in).

*Aswini M. 18V.1*

**Dr. A. Selwin Mich Priyadharson**  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-60 006

<b>Course Code</b>	<b>Course Title</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10213EC101</b>	<b>INTRODUCTION TO ROBOTICS</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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

<b>CO Nos.</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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 Rehgl, “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. Yoram Koren, “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\\_PP76fIZfw&list=PLyqSpQzTE6M\\_XM9cvjLLO\\_Azt1Fk\\_gPhpH&index=2](https://www.youtube.com/watch?v=P_PP76fIZfw&list=PLyqSpQzTE6M_XM9cvjLLO_Azt1Fk_gPhpH&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>

*Agarwal*

Dr. A. Selwin Mith Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established on the University Rank, vol. II of UGC Act, 1956

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
<b>CO 1</b>	H	-	L	-	-	-	-	-	-	-	L	L	M	M
<b>CO 2</b>	M	L	L	-	L	-	L	M	-	-	-	-	-	L
<b>CO 3</b>	M	L	L	M	M	L	-	-	-	-	L	L	L	-
<b>CO 4</b>	M	L	-	-	L	L	-	-	-	-	-	M	M	-
<b>CO 5</b>	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](https://www.youtube.com/watch?v=AQ1EPl_4O2w)
4. <https://www.youtube.com/watch?v=mhrRjgzRfh0>

*Asi m 10/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Chartered as an Autonomous Inst. on 8 of March, 1995)

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
<b>CO 1</b>	M	L	-	-	-	-	M	-	-	-	L	L	M	L
<b>CO 2</b>	M	L	M	L	L	-	-	L	-	-	-	L	M	L
<b>CO 3</b>	M	L	-	M	-	-	L	-	L	L	-	-	L	L
<b>CO 4</b>	M	L	L	M	M	-	-	L	L	L	-	-	M	L
<b>CO 5</b>	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](https://www.youtube.com/watch?v=vCvwPAZx_o0)

*Asim*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as the University Rank. No. 2 of UGC Act. 1956)

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
<b>CO1</b>	L	L	L	-	-	-	-	-	-	-	-	-	-	-
<b>CO2</b>	L	L	L	-	-	-	-	-	-	-	-	-	-	-
<b>CO3</b>	M	L	L	-	-	-	-	-	-	-	-	L	-	-
<b>CO4</b>	L	L	L	-	-	-	-	-	-	-	-	L	-	-
<b>CO5</b>	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

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): Bluetooth802.15.1, 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, Third Edition, 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](http://www.nptelvideos.in/2012/12/wireless-communication.html)
2. [nptel.ac.in/courses/117105076/pdf/2.2%20Lesson%203%20.pdf](http://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

*Asst. Prof. Dr. A. Selwin*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Inst. on 8 of OCTOBER, 1998



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
<b>CO1</b>	H	M	L	L	M	-	-	-	L	L	-	L	-	-
<b>CO2</b>	H	M	L	L	M	-	-	-	L	L	-	L	-	-
<b>CO3</b>	H	M	L	L	M	L	-	-	L	L	-	L	-	-
<b>CO4</b>	H	M	L	L	M	-	-	-	L	L	-	L	-	-
<b>CO5</b>	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

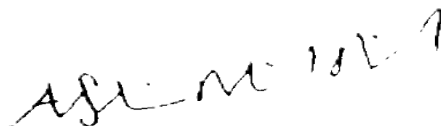
1. Allan V. Oppenheim, S. Willsky and S. H. Nawab, "Signals and Systems", Pearson, 2015.(Unit I-IV)

#### 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](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)

  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Centre, with E of UGC, AUC, 1982

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's Taxonomy)
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
<b>CO1</b>	M	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO2</b>	M	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO4</b>	M	M	L	L	L	-	-	-	L	L	-	L	-	-
<b>CO5</b>	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 of Visual 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", Tata Mc 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](https://onlinecourses.nptel.ac.in/noc22_ee116)
3. <https://www.udemy.com/topic/image-processing>

*Dr. A. Selwin Mich Priyadharson*  
Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering  
**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute with II of UGC Act, 1956

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
<b>CO1</b>	M	L	L	-	-	-	M	-	L	L	-	-	-	-
<b>CO2</b>	M	-	-	-	-	-	-	-	L	L	-	L	M	-
<b>CO3</b>	M	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO4</b>	M	L	L	-	-	-	M	-	L	L	-	L	-	-
<b>CO5</b>	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 3<sup>rd</sup> edition – 2009.
2. F. G Shinsky Process Control Systems, McGrawhill Publications, 1996.
3. Curtis D. Johnson "Prentice Process control Instrumentation Technology"–Hall India, 8<sup>th</sup> edition, 2006
4. Thomas Hughes, "Programmable Logic Controller", ISA Publication
5. Stuart A. Boyer, "SCADA supervisory control and data acquisition", ISA Publication.
6. McMillan G.K, "Process/ Industrial instrument and handbook", McGraw-Hill, New York, 1999
7. Vojislav B. Misic, Jelenam Misic, 'Machine- to-machine communications', edited CRC Press Taylor & Francis group–2015.
8. Arshdeep Bahga, Vijay Madisetti, '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. Stuart A. 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=PLIn3BHg93SQ9SEN8jXvhyxcAeFcmkITNs>
3. <https://www.classcentral.com/course/swayam-industrial-automation-and-control-5222>
4. <https://library.automationdirect.com/industry-resources/>

*Agil M. 18/12/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Established as an Autonomous Instt. with U of Madras Act, 1956)

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	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
<b>CO1</b>	M	L	L	-	-	-	M	-	L	L	-	-	-	-
<b>CO2</b>	M	-	-	-	-	-	-	-	L	L	-	L	-	-
<b>CO3</b>	M	-	-	-	-	-	-	-	L	L	-	-	-	-
<b>CO4</b>	M	L	L	-	-	-	M	-	L	L	-	L	-	-
<b>CO5</b>	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](https://www.youtube.com/watch?v=OeVt4_5GLxQ)
4. <https://www.coursera.org/projects/building-test-automation-framework-using-selenium-and-testng>

*Asim*

Dr. A. Selwin Mithi Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 090

<b>COURSE CODE</b>	<b>COURSE TITLE</b>	<b>L</b>	<b>T</b>	<b>P</b>	<b>C</b>
<b>10213EC109</b>	<b>EMBEDDED SYSTEMS</b>	<b>3</b>	<b>0</b>	<b>0</b>	<b>3</b>

**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:

<b>CO Nos</b>	<b>Course Outcomes</b>	<b>Knowledge Level (Based on Revised Bloom's Taxonomy)</b>
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
<b>CO1</b>	M	L	M	L	-	-	-	-	L	L	-	L	L	M
<b>CO2</b>	M	M	H	L	-	-	-	-	M	L	-	L	-	L
<b>CO3</b>	M	L	L	M	-	-	-	-	-	L	-	-	-	L
<b>CO4</b>	M	L	L	L	-	-	-	-	-	L	-	-	M	L
<b>CO5</b>	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 (3<sup>rd</sup> 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>

*Asin M. 18V. 1*

Dr. A. Selwin Mith Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Chennai-600 062

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
<b>CO1</b>	M	M	M	L	L	-	-	-	-	-	-	M	M	L
<b>CO2</b>	M	L	M	M	M	-	-	-	-	-	-	L	M	L
<b>CO3</b>	M	L	H	M	H	M	-	-	-	-	-	L	L	
<b>CO4</b>	H	H	M	H	H	M	-	-	-	-	-	M	M	L
<b>CO5</b>	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/>

*Asim*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
VET Institute of Science and Technology  
Established as an Autonomous Institute under the Act of 1982

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
<b>CO1</b>	L	L	-	-	-	-	-	-	M	L	-	L	-	-
<b>CO2</b>	L	L	L	L	L	-	-	-	M	L	-	M	-	-
<b>CO3</b>	L	L	M	M	M	-	-	-	M	L	-	M	-	-
<b>CO4</b>	L	L	M	M	M	-	-	-	M	L	-	H	-	-
<b>CO5</b>	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      ITS 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>

*Asim 10/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as an Autonomous Institute on 11 of October, 1998

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
<b>CO1</b>	H	L	L	-	-	-	-	-	-	-	-	-	-	-
<b>CO2</b>	H	M	M	-	-	-	-	L	L	-	-	-	-	L
<b>CO3</b>	H	M	M	-	L	-	-	L	L	-	-	-	-	-
<b>CO4</b>	H	M	L	-	L	-	-	L	L	-	-	L	-	M
<b>CO5</b>	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

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](https://onlinecourses.nptel.ac.in/noc21_ee66/preview)
3. <https://youtu.be/SljXFf0vgvw>
4. [https://onlinecourses.nptel.ac.in/noc22\\_ee65/preview](https://onlinecourses.nptel.ac.in/noc22_ee65/preview)
5. <https://archive.nptel.ac.in/courses/108/105/108105134/>

*Asim*

Dr. A. Selwin Mithi Priyadharsan  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank No. 1 of 1990, AICTE, 1990



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	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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 Aranz, Maria Dolores Valdes Pena, "FPGAs: Fundamentals, Advanced Features, and Applications in Industrial Electronics", CRC Press, 2020.
2. J Bhasker, "A Verilog HDL Primer", 3<sup>rd</sup> 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

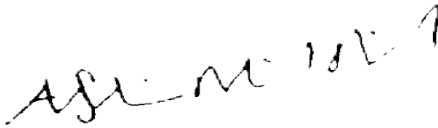
1. Old Field, R.Dorf, "Field Programmable Gate Arrays", John Wiley & Sons, New York, 1995.
2. S.Brown, R.Francis, J.Rose, Z.Vransic, "Field Programmable Gate Array", Kluwer Publications, 1992.
3. S.Trimberger, Edr. "Field Programmable Gate Array Technology", Kluwer Academic Publications, 1994.
4. Bob Zeidman, "Designing with FPGAs and CPLDs", Elsevier CMP Books, 2002.
5. Jon F Wakerly, "Digital Design: Principles and Practices", 4<sup>th</sup> 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/>

  
 Dr. A. Selwin Mithi Priyadharson  
 Head of the Department  
 Electronics & Communication Engineering  
**Vel Tech**  
 Rangarajan Dr. Sagunthala  
 Rath Institute of Science and Technology  
Established as the University Rank 4th of 1990 Act. 1956

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
<b>CO1</b>	M	-	-	-	-	-	-	-	-	-	-	L	L	-
<b>CO2</b>	M	-	-	-	-	-	-	-	-	-	-	L	L	-
<b>CO3</b>	M	-	-	-	-	-	-	H	-	-	-	-	M	M
<b>CO4</b>	M	-	L	-	-	-	-	-	-	-	-	M	L	-
<b>CO5</b>	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#>

*Asim 18/11/17*

Dr. A. Selwin Mich Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
(Declared as the University Rank, vol. II of UGC Act, 1956)

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	PO10	PO11	PO12	PSO1	PSO2
<b>CO1</b>	M	L	-	-	-	-	-	-	-	-	-	L	M	L
<b>CO2</b>	M	L	M	L	L	-		L	-	-	-	L	M	L
<b>CO3</b>	M	L	-	M	-	-	L	-	L	L	-	-	L	L
<b>CO4</b>	M	L	L	M	M	-		L	L	L	-	-	M	L
<b>CO5</b>	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, Inclometers.

**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.



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, Dhanpat Rai 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/>

*Asim 18/12/17*

Dr. A. Selwin Mitha Priyadharson  
Head of the Department  
Electronics & Communication Engineering

**Vel Tech**  
Rangarajan Dr. Sagunthala  
R&D Institute of Science and Technology  
Established as the University Rank 20 of UGC Act, 1956

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
<b>CO1</b>	M	L	L	-	-	-	-	-	-	-	-	L	L	-
<b>CO2</b>	M	M	M	-	-	-	-	-	-	-	-	L	L	-
<b>CO3</b>	M	-	M	-	M	-	-	-	-	-	-	-	L	-
<b>CO4</b>	M	M	L	L	L	L	L	L	-	-	-	L	L	-
<b>CO5</b>	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](https://ed.iitm.ac.in/~shankarram/Course_Files/ED5160/ED5160.html)

*Asst. Prof. Dr. A. Selwin Mich. Priyadharson*  
 Dr. A. Selwin Mich. Priyadharson  
 Head of the Department  
 Electronics & Communication Engineering  
**Vel Tech**  
 Rangarajan Dr. Sagunthala  
 R&D Institute of Science and Technology  
 Chennai-60  
 Established on the University Road, with a UGC-AICTE Approval