Vel Tech
Rangarajan Dr. Sagunthala
R&D Institute of Science and Technology
(Deemed to be University Estd. u/s 3 of UGC Act, 1956)

SCHOOL OF ELECTRICAL AND COMMUNICATION

DEPARTMENT OF ELECTRONICS AND COMMUNICATION ENGINEERING

VTR UGE 2021 CURRICULUM

S.No	Course Code	Programme Core	L	T	P	C
1	10211EC101	Circuit Theory	2	2	0	3
2	10211EC102	Analog Electronics	2	2	0	3
3	10211EC103	Digital Electronics	3	0	0	3
4	10211EC104	Linear Integrated Circuits	3	0	0	3
5	10211EC105	Control Systems	2	2	0	3
6	10211EC106	Signals and Systems	2	2	0	3
7	10211EC107	Electromagnetics and Transmission Lines	2	2	0	3
8	10211EC108	Communication Systems	2	2	0	3
9	10211EC109	Microprocessor and Microcontroller	3	0	0	3
10	10211EC110	Data Communication Networks	3	1	0	3
11	10211EC111	Discrete Time Signal Processing	2	2	0	3
12	10211EC112	Wireless Communication	2	2	0	3
13	10211EC113	Antenna Theory	2	2	0	3
14	10211EC114	VLSI Design	3	0	0	3
15	10211EC115	Optical and Microwave Communication Systems	2	2	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	Signals and Systems Lab	0	0	2	1
21	10211EC304	Microprocessor and Microcontroller Lab	0	0	2	1
22	10211EC305	Communication Lab	0	0	2	1
23	10211EC30	Optical and Microwave Engineering Lab	0	0	2	1

	6					
		TOTAL CREDIT				**58**

S.No	Course Code	Programme Elective	L	T	P	C
Communication System Domain						
1	10212EC101	RF and Microwave Integrated Circuits	3	0	0	3
2	10212EC102	Cellular Mobile Communication	3	0	0	3
3	10212EC103	Information Theory and Coding	3	0	0	3
4	10212EC104	Radar and Electronic Navigation Systems	3	0	0	3
5	10212EC105	Satellite Communication	3	0	0	3
6	10212EC106	Advanced Optical Communication Systems	3	0	0	3
7	10212EC107	Digital TV Engineering	3	0	0	3
8	10212EC108	Software Defined Radio	3	0	0	3
9	10212EC201	Electromagnetic Interference and Compatibility	2	0	2	3
10	10212EC202	MIMO Wireless Communication	2	0	2	3
11	10212EC203	Antenna Design and Application	2	0	2	3
Embedded System Domain						
12	10212EC109	Embedded System Design	3	0	0	3
13	10212EC110	Introduction to Robotics	3	0	0	3
14	10212EC111	Embedded Communication Protocols	3	0	0	3
15	10212EC112	Video Surveillance System	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
Networks Domain						
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
Signal Processing Domain						
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	10212EC213	Digital Image and Video Processing	2	0	2	3
40	10212EC214	Fundamentals of Machine Learning	2	0	2	3
41	10212EC215	Professional Python Programming	2	0	2	3
VLSI Domain						
42	10212EC127	Low Power VLSI Design	3	0	0	3
43	10212EC128	VLSI Design Techniques	3	0	0	3
44	10212EC129	VLSI for Wireless Communication	3	0	0	3
45	10212EC130	Solid State Devices	3	0	0	3
46	10212EC131	Architectural Design of Digital Integrated Circuits	3	0	0	3
47	10212EC132	Nano Scale Transistors	3	0	0	3
48	10212EC133	Opto Electronic Devices	3	0	0	3
49	10212EC134	Electronic Instrumentation	3	0	0	3
50	10212EC135	Nano Photonics	3	0	0	3

51	10212EC136	Fiber Lasers and Applications	3	0	0	3
52	10212EC137	Sensors and Transducers	3	0	0	3
53	10212EC216	FGPA Architecture Technologies and Tools	2	0	2	3
54	10212EC217	Electronic Circuit Simulation and PCB Design	1	0	4	3

S.No	Course Code	Specialization Electives	L	T	P	C
		Cyber Security				
1	10212EC150	Digital Forensic	3	0	0	3
2	10212EC151	Cryptography for Cyber and Network Security	3	0	0	3
3	10212EC152	Block Chain 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	10212EC403	Privacy and Security in Online Social Media	2	0	2	3
		Artificial Intelligence and Data Science				
10	10212EC155	Fundamentals of Data Science	3	0	0	3
11	10212EC156	Data Analysis and Visualization	3	0	0	3
12	10212EC157	Soft Computing	3	0	0	3
13	10212EC158	Statistical Inference Techniques	3	0	0	3
14	10212EC159	Machine Vision	3	0	0	3
15	10212EC225	Tools for Data Science	1	0	4	3
16	10212EC226	Machine Learning	2	0	2	3
17	10212EC227	Deep Learning	2	0	2	3
		Artificial Intelligence and Machine Learning				
18	10212EC157	Soft Computing	3	0	0	3
19	10212EC159	Machine Vision	3	0	0	3
20	10212EC160	Optimization Techniques	3	0	0	3
21	10212EC228	Data Science and Visualization	2	0	2	3
22	10212EC226	Machine Learning	2	0	2	3
23	10212EC227	Deep Learning	2	0	2	3
24	10212EC229	AI in Natural Language Processing	2	0	2	3
25	10212EC230	AI in Speech Processing	2	0	2	3

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 communication 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	10212EC401	Signal Processing for mm Wave Communication for 5G and beyond – NPTEL course	0	0	0	3
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	10212EC402	C-based VLSI Design – NPTEL course	0	0	0	3

S.No	Course Code	Minor Electives	L	T	P	C
Smart Communication Technologies						
1	10212EC161	Security in Communication and Networking Systems	3	0	0	3
2	10212EC162	Vehicular Communications and Inter-Networking Technologies	3	0	0	3
3	10212EC163	Sensors and Wearable Technology	3	0	0	3
4	10212EC164	Sensors for structural health Monitoring	3	0	0	3
5	10212EC165	IoT in Automotive Systems	3	0	0	3

6	10212EC166	M2M Communication with IoT and LTE	3	0	0	3
7	10212EC167	Flexible electronics for automobile applications	3	0	0	3
8	10212EC404	Introduction to Industry 4.0 and Industrial Internet of Things – NPTEL course	0	0	0	3
		Smart Automation				
9	10212EC168	Basics of Embedded System	3	0	0	3
10	10212EC169	Basics of Sensors and Transducers	3	0	0	3
11	10212EC170	Embedded Security	3	0	0	3
12	10212EC171	Basics of 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	10212EC405	Introduction to Embedded System Design – NPTEL course	0	0	0	3

S.No	**Course Code**	**Open Electives**	**L**	**T**	**P**	**C**
1	10213EC101	Introduction to Robotics	3	0	0	3
2	10213EC102	Video Surveillance System	3	0	0	3
3	10213EC103	Wearable Devices	3	0	0	3
4	10213EC104	Wireless Communication Networks	3	0	0	3
5	10213EC105	Basics of Signal Processing	2	2	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	10213EC108	Vehicle Electronics and Networks	2	0	2	3

Course Code	Course Title	L	T	P	C
10211EC101	**CIRCUIT THEORY**	**2**	**2**	**0**	**3**

a) Course Category

Program Core

b) Preamble

The aim of this course is to develop the necessary basics related to the concepts of circuits that lay the foundation for communication engineers in the analysis of electric circuits. The course deals with the analysis of circuits through Graph theory, Network theorems, Fundamentals of AC circuit analysis, concepts of resonance, coupled circuits, transients through differential equations and two port networks.

c) Prerequisite

Nil

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	Manipulate the basics of Circuit analysis and Graph theory	K3
CO2	Interpret Circuits using Network theorems	K3
CO3	Solve the problems on RL, RC and RLC DC transient circuits	K3
CO4	Illustrate the characteristics of AC steady state analysis and power analysis.	K3

CO5	Illustrate the parameters of the two port networks and the concepts of resonance, coupled circuits	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I BASICS OF CIRCUIT ANALYSIS & GRAPH THEORY 12

Review of Ohm's Law – Nodes, Branches, Loops - Resistors in series and parallel – Equivalent resistance using circuit reduction – Voltage and Current division rule – Graph theory: Graph – Types of graphs – Node, Link, Branches and Tree – Incidence Matrix– Basic cut set and Tie set Matrices for Planar networks – Duality & Dual networks.

UNIT II NETWORK THEOREMS 12

Source Transformation – Superposition Theorem – Thevenin's Theorem – Norton's Theorem – Maximum Power Transfer Theorem – Reciprocity Theorem – Tellegen's Theorem – Compensation Theorem and Milliman's Theorem.

UNIT III DC TRANSIENT ANALYSIS 12

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 12

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 COUPLED CIRCUITS 12

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 - Introduction to coupled circuits – Tuned circuits – Single tuned circuits.

Total: 60 Hrs

h) Learning Resources

Text Books

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

Reference Books

1 Joseph A. Edminister, "Electric Circuits" Schaum's outline series, McGraw-Hill 1987
2 A. Sudhakar, Shyammohan S. Palli, "Circuits and Networks", Tata McGraw-Hill,4th Ed, 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.

Online Resources

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

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

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 operation of basic semiconductor and its devices.	K2
CO2	Classify the performance of different biasing types used for transistor operation.	K2
CO3	Analyze the h parameters and small signal model for different transistor configuration	K3
CO4	Explain 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**

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

g) **Course Content**

UNIT I SEMICONDUCTOR DEVICES 12

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 SCR, UJT, IGBT.

UNIT II DC BIASING OF TRANSISTOR 12

Introduction–Working principle of BJT-Transistor characteristics-CB, CE, CC -Thermal runaway, thermal stability, DC Biasing-BJT: Fixed -Emitter-Stabilized-Voltage-Divider. Compensation techniques, Introduction-FET, MOSFET, Design of biasing for MOSFET.

UNIT III TRANSISTOR AMPLIFIER 12

Amplification in AC Domain, Two port system approach, The Hybrid Equivalent model, Approximate Hybrid equivalent circuit, Hybrid Π model: CE, CC and CB configurations, Small signal analysis of MOSFET-Source follower, common source and common gate amplifier.

UNIT IV FEEDBACK AMPLIFIER AND OSCILLATORS 12

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, Wienbridge. LC oscillators: Hartley, Colpitts, Clapp oscillator, crystal oscillator- oscillators design using LTspice.

UNIT V TUNED AND POWER AMPLIFIERS **12**

Tuned amplifier: Analysis of 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:60 Hrs

h) Learning Resources

Text Books

1. Boylestead & Neshelsky, Electronic Devices & Circuits, Pearson Education/PHI Ltd, 10th edition, 2010.
2. S.Salivahanan, N.Suresh Kumar and A.Vallavaraj, Electronic Devices and Circuits, McGraw-Hill, 3rd edition, 2012.
3. David .A. Bell, Electric Circuits And Electronic Devices Oxford University Press, 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. J. and Halkias .C., Integrated Electronics,2nd Edition, Tata McGraw-Hill, 2001
4. Sedra&Smith, Microelectronic circuits, Oxford University Press, 5th ed.
5. Donald L.Schilling and Charles Belove, 'Electronic Circuits', Tata McGraw Hill, 3rd Edition,2003.
6. Dr. R. S. Sedha, A Textbook of Electronic Circuits, S. Chand, 2014.

Online Resources

1. www.nptel.ac.in
2. http://bitsavers.trailing-edge.com/pdf/national/_appNotes/AN-0088.pdf

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	Illustrate the concept of Boolean minimization techniques and HDL.	K3
CO2	Apply the concept of Combinational circuits and write HDL Program for this circuits	K3
CO3	Apply the concept of sequential circuits for counters, shift registers etc. 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

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

g) Course Content

UNIT I DIGITAL FUNDAMENTALS AND COMBINATIONAL CIRCUITS 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.

UNIT II 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).

UNIT III 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)

UNIT IV 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

UNIT V APPLICATIONS OF DIGITAL ELECTRONICS 5

Multiplexing displays – Frequency counters – Time measurements – using the ADC0804 – Slope alone 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^{th} Edition, Prentice Hall of India Pvt. Ltd., Pearson Education (Singapore) Pvt. Ltd., New Delhi, 2013.

2. Donald. P. Leach, Digital principles and applications, 7^{th} Edition, McGraw-Hill, 2012

3. S.Salivahanan, S. Arivazhagan, Digital Circuits and Design, 5^{th} Edition, Oxford University Press, 2018

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
3. www.nptel.com/digitalelectronics/iitkanpur/
4. www.mooc.org

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

Analog Electronics

d) Related Courses

VLSI Design, Circuit 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	Describe the basic principles, configurations and Practical limitations of Op-Amp	K2
CO2	Illustrate the various linear and non-linear applications of Op-Amp	K3
CO3	Manipulate different waveform generator circuits using op-amp, IC555 and analyze Active filters using op-amp	K3
CO4	Interpret the performance of various types of ADC and DAC using Op-Amp, PLL operation and its applications	K3

CO5	Illustrate various applications of special function Op-Amp ICs and discuss the impact of IC manufacturing	K3

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
CO1	M	L	L	L	L	L	L	L	M	L	-	L	L
CO2	H	M	L	L	L	L	L	L	M	L	-	L	L
CO3	H	M	M	-	L	L	L	L	M	L	-	M	L
CO4	H	M	M	L	L	M	L	L	M	L	-	M	L
CO5	H	M	M	M	L	M	M	M	M	M	L	M	L

g) Course Content

UNIT I INTRODUCTION AND CHARACTERISTICS OF OP-AMP 9

Op-amp: symbol, terminals, packages, specifications, Block diagram representation of op-amp, op-amp equivalent circuits, ideal op-amp and practical op-amp – open loop & closed loop configurations – DC and AC performance characteristics of op-amp: non-ideal characteristics, Differential amplifiers, CMRR concept, frequency response, slew rate and Power Bandwidth

UNIT II LINEAR OPERATIONAL AMPLIFIER CIRCUITS 9

Basic op-amp circuits: Inverting and Non-inverting voltage amplifiers, summing, scaling and averaging amplifiers, voltage follower, Instrumentation amplifiers (application oriented), V to I and I to V converters, Differentiators, Integrators – Non-Linear Wave shaping circuits: Clampers & Active Limiters – Non-Linear: Log and Antilog Amplifiers, Precision Rectifiers

UNIT III WAVEFORM GENERATORS, TIMER AND ACTIVE FILTERS 9

Comparator and its applications, Design: sine wave generators, square wave generators, triangle wave generators, saw tooth wave function generator – Barkhausen criterion – one-shot multi vibrators – 555 Timer IC – Waveform generators: using op-amp and 555 Timer Active Filters: Comparison between passive and active filter, Design: LPF, HPF and BPF

UNIT IV PLL AND A/D & D/A CONVERTERS 9

PLL: Phase detector, comparator, VCO, Purpose of PLL, Closed loop analysis of PLL, PLL applications and Frequency synthesizers – D/A conversion: DAC specifications, D/A conversion techniques, Switches for DAC, weighted resistor DAC and R-2R Ladder DAC – A/D conversion: ADC specifications, A/D conversion techniques Flash type ADC, Monolithic ADC and Ramp type ADC

UNIT V APPLICATIONS OF OP-AMP ICs AND IMPACT OF IC MANUFACTURING 9

Design and prepare documentation on the op-amp based circuits: Frequency Multiplier using IC 565, Transistor Amplifier Circuit-12 Watts, As a Phase Shifter, Infrared Motion Detector Circuit (LM 1458 op-amp, IR diode) – Impact of Integrated Circuit Manufacturing with regards to Environmental & Health risks – Recycling of scrap integrated circuits

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. A. Bell, Solid state Pulse Circuits (4/e), PHI, 2009.

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. Milman Gravel: Micro-electronics, McGraw Hill, 1991.

Online Resources

1. www.electronicstutorials.com
2. www.circuitstoday.com
3. www.nptel.com

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

a) Course Category

Programme Core

b) Preamble

This course aims to provide a basic knowledge about what is a control system, its significance, transfer function, open and closed loop systems, mathematical model of electrical and mechanical systems, time domain and frequency domain analysis and its specifications, stability, 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	Construct the transfer function model of electrical, mechanical, and Electromechanical systems.	K3
CO2	Determine the Time response of I order and II order systems for various test signals and analyze the stability of the given system using Root locus and Routh - Hurwitz criteria	K3
CO3	Examine the system stability by various methods such as Bode plot, Polar plot, and Nyquist plot in frequency domain	K3
CO4	Construct and Design controllers and compensators for Control System analysis in Frequency domain	K3
CO5	Apply the concept of State-Space for Control System Analysis	K3

f) Correlation of Co's with Po's

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

g) Course Content

UNIT I CONTROL SYSTEM COMPONENTS AND MATHEMATICAL MODELING 12

Basic elements 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 - DC and AC servo Systems.

UNIT II TIME DOMAIN AND STABILITY ANALYSIS 12

Time response and Steady state response of first order systems and second order systems – System stability - dominant poles - Routh Hurwitz criterion: relative stability - Root locus Technique: Root loci, properties, and construction of root loci.

UNIT III FREQUENCY DOMAIN AND STABILITY ANALYSIS 12

Frequency response - correlation between time and frequency responses - Performance specification in frequency domain - Bode plot, Polar plot - Frequency domain specifications from the plots - Nyquist stability criterion - Nyquist plot.

UNIT IV DESIGN OF COMPENSATORS IN FREQUENCY DOMAIN 12

P, PI, PD and PID controllers: Introduction – transfer function model – characteristics; series, parallel and series - parallel compensation - Lead and Lag networks – Series compensator design for desired response using Bode diagrams

UNIT V ANALYSIS USING STATE SPACE APPROACH **12**

State variable representation – Canonical Realization - Conversion of state variable models to transfer functions - Conversion of transfer functions to state variable models - state transition Matrix - Solution of state equations - Concepts of Controllability and Observability – Concept of Stability in State Space approach.

Total: 60 Hrs

h) Learning Resources

Text Books

1. M. Gopal, “Control System – Principles and Design”, Tata McGraw Hill, 2nd Edition, 2002
2. J. Magrath and M. Gopal,” Control System Engineering”, New Age International Publishers, 5th Edition, 2007.

Reference Books

1. Ogata, K., “Modern Control Engineering”, Prentice Hall of India Ltd., 4th Edition, New Delhi, 2006.

Course Code	Course Title	L	T	P	C
10211EC106	**SIGNALS AND SYSTEMS**	**2**	**2**	**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

Transforms and Fourier series

d) Related Courses

Discrete Time Signal Processing

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	Identify the types of continuous time and discrete time signals, systems and their properties	K3
CO2	Apply Fourier series, Fourier Transform, Laplace transform and its properties to examine the continuous time signals.	K3
CO3	Apply Fourier series, Fourier Transform and Laplace transform to examine the continuous time system response with realizations and illustrate its applications.	K3

CO4	Use DTFT and Z transform and its properties for the analysis of discrete time signals	K3
CO5	Apply DTFT and Z transform to examine the Discrete time system response with realizations and illustrate its applications.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I CLASSIFICATION OF SIGNALS AND SYSTEMS 12

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 – Response of LTI system, Properties, LTI systems – Differential / Difference equation representation.

UNIT II CONTINUOUS TIME SIGNALS 12

Fourier analysis of continuous time signals: Trigonometric Fourier series, exponential series, complex Fourier series, Fourier transform - Properties of continuous time FT, Laplace Transform, Properties of Laplace Transform

UNIT III CONTINUOUS TIME SYSTEMS **12**

Solving differential equation with initial conditions, Convolution Integral, Frequency response of continuous time LTI systems using Fourier Transform and Laplace Transform, Block Diagram Representation, Realization of CT systems - direct forms, cascade and parallel, Application of CT Systems

UNIT IV DISCRETE TIME SIGNALS **12**

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 **12**

Solving difference equation with initial conditions, convolution sum, Frequency response of discrete time LTI systems using Discrete Time Fourier Transform, Z Transform, Block Diagram Representation, Realization of DT systems, Applications of DT systems

Total: 60 Hrs

h) Learning Resources

Text Books

1. Allan V. Oppenheim et al, “Signals, Systems and Inference”, Pearson Education Global edition - 2022

Reference Books

1. S Salivahanan, “Signals and Systems”, McGraw-Hill International, 2018.
2. Douglas K.Lindner, “Signals and Systems”, McGraw-Hill International, 1999.
3. S.Haykin and B. VanVeen “Signals and Systems” Second edition Paper back - I, Wiley, 2021.
4. M. Mandal and A. Asif, “Continuous and Discrete Time Signals and Systems, Cambridge, 2007.
5. Michael J. Roberts, “Fundamentals of Signals and Systems”, book by Michael J. Roberts, McGraw-Hill Higher Education, 2008.

Course Code	Course Title	L	T	P	C
10211EC107	ELECTROMAGNETICS AND TRANSMISSION LINES	2	2	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, magneto static 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

Nil

d) Related Courses

Antenna Theory, 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	Apply the concept and derivation of Electrostatic theorems and laws	K3
CO2	Describe the basic Magneto static 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

	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	L	-
CO2	H	H	L	-	-	-	-	-	L	-	-	L	L	-
CO3	H	M	M	-	-	-	M	L	L	-	-	M	-	-
CO4	H	H	M	L	L	L	M	L	L	L	-	M	-	-
CO5	H	M	M	M	L	L	M	L	L	L	-	M	-	-

g) Course Content

UNIT I ELECTROSTATIC FIELDS 12

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

UNIT II STEADY MAGNETIC FIELDS 12

Magnetic fields of steady currents : Biot- Savart's and Ampere's laws and simple applications- Magnetic flux density, Inductance of loops and solenoids, The Lorentz force equation for a moving charge and applications – Magnetic moment – Magnetic vector potential – Magnetic boundary conditions, Inductance and inductors, Magnetic energy, Magnetic forces and torques.

UNIT III MAXWELLS EQUATIONS AND PLANE WAVE 12

Continuity equation - Displacement current - Maxwell's equation - Boundary conditions - Plane wave equation and its solution in conducting and non-conducting media, Phasor notation, Phase velocity, Group velocity, Depth of penetration, Conductors and dielectrics, Impedance of conducting medium, Polarization, Reflection and refraction of plane waves at plane boundaries, Brewster Angle, Poynting vectors and Poynting theorem.

UNIT IV TRANSMISSION LINE **12**

A line of cascaded T sections : Line parameters - Transmission line equation & solutions, Physical significance of solutions, Propagation constants, Characteristic impedance, Wavelength, Velocity of propagation - Reflection on a Line not terminated in Zo, Reflection Coefficient - Input and Transfer Impedance - Open and Short Circuited Lines - Reflection Factor and Reflection Loss, Insertion Loss.

UNIT V LINE AT HIGH FREQUENCIES **12**

Dissipation less line: Voltage and current on the dissipation-less line - Input impedance of the dissipation-less line - Open and short-circuited lines - Power and impedance measurements- Standing waves and standing wave ratio on a line Reflection and Reflection Co-efficient – One eighth wave line - The quarter wave line and half wave line - Smith chart: Solutions of problems using Smith chart - Single and double stub matching using Smith chart.

Total: 60 Hours

h) Learning Resources

Text Books

1. E C Jordan and K G Balmain, "Electromagnetic Waves and Radiating Systems", , PHI, 2nd Ed,2015
2. W.H Hayt. and J.A. Buck: "Engineering Electromagnetics", McGraw Hill Publications, 6th Ed, 2017
3. J.D.Ryder "Networks, Lines and Fields", PHI, 2nd Ed, 1978
4. Raju G.S.N, "Electromagnetic Field Theory and Transmission Lines", Pearson Education, First Indian print, 2005.

Reference Books

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

Online Resources

1. http://ocw.mit.edu/resources/res-6-001-electromagnetic-fields-and-energy-spring 2008.
2. http://nptel.ac.in/courses/117103065/1.

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

a) Course Category

Program Core

b) Preamble

This course provides an introduction about all types of analog modulation and demodulation techniques and 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

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	Characterize and design the behavior of amplitude modulation and detection schemes	K3
CO2	Design the various features of angle modulation and demodulation techniques and compare their performances	K3
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	Apply the baseband transmission techniques and modulation schemes in pass band transmission.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I AMPLITUDE MODULATION 12

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

UNIT II ANGLE MODULATION 12

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

UNIT III RANDOM PROCESS AND NOISE THEORY 12

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

UNIT IV SAMPLING PROCESS AND WAVE FORM CODING 12

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 - Linear prediction.

UNIT IV BASEBAND PULSE AND PASS BAND TRANSMISSION 12

Matched filter – Intersymbol Interference- Nyquist's criterion for Distortion less Transmission-Correlative coding -Adaptive Equalization-Eye patterns, Gram-Schmidt Orthogonalization Procedure, Digital modulation schemes: Generation-Detection-BW-PSD of ASK, FSK, PSK, QPSK, QAM.

Total: 60 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

Online Resources

1 http://nptel.iitm.ac.in/courses/-0DataCommunication
2 http://www.sp4comm.org/docs/chapter12.pdf
3 http://www.talkingelectronics.com/Download%20eBooks/Principles%20of%20electronics/CH-16.pdf
4 http://nptel.ac.in/courses/IITMADRAS/Principles_Of_Communication/pdf/Lecture23-24_AngleModulation.pdf

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	Illustrate the functionalities of 8085 Microprocessor architectures and develop Assembly language programming.	K3
CO2	Illustrate the functionalities of 8086 Microprocessor architectures and develop Assembly language programming.	K3
CO3	Illustrate the functionalities of 8051 Microcontroller architectures and develop Assembly language and C programming.	K3
CO4	Review the operations of various peripheral devices such as 8255, 8253, 8251, 8279, 8259, 8237 and RTC.	K2
CO5	Explore the architectures and features of PIC and ARM Microcontrollers and generalize their applications using case studies.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I 8085 MICROPROCESSOR **9**

Introduction to 8085 Architecture, Addressing Modes, Instruction Formats, Instruction Set , Timing Diagram, memory mapping and Assembly Language Programming.

UNIT II 8086 MICROPROCESSOR **9**

Introduction to 8086 Architecture, Features, Signals, Addressing Modes, Instruction Formats, Instruction Set, I/O and Memory Interfacing, Interrupts, Minimum Mode and Maximum Mode Operation, Assembly Language Programming.

UNIT III 8051 ARCHITECTURE **10**

Hardware features, Architecture, Internal RAM structure, Special Function Registers, Addressing Modes, Instruction Set, Memory Organization, I/O Ports and Circuits, Timers, Interrupts, Interfacing of External Memory, Assembly Language Programming and C Programming.

UNIT IV PERIPHERAL DEVICES **9**

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

UNIT V PIC MICROCONTROLLER AND ARM PROCESSOR **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: 45 Hrs

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 Pearsoneducation Asia.
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 Books

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

Online Resources

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

Course Code	Course Title	L	T	P	C
10211EC110	**DATA COMMUNICATION NETWORKS**	**3**	**1**	**0**	**3**

a) Course Category

Program Core

b) Preamble

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

c) Prerequisite

NIL

d) Related Courses

Network Security, Network Management, High Performance Communication Networks

e) Course Outcomes

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 concepts of data communication networks. Explain layered architecture of OSI and TCP/IP 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

	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	-	-
CO3	H	M	L	L	L	-	-	-	L	-	-	L	-	-
CO4	H	M		-	L	-	-	L	L	-	-	L	-	-
CO5	H	M	L	-	-	-	-	-	L	L	-	L	-	-

g) Course Content

UNIT I INTRODUCTION TO DATA COMMUNICATION AND NETWORKING DEVICES 12

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

UNIT II DATA LINK LAYER & LOCAL AREA NETWORK 12

Logical Link Control –Types of error: Single bit error – Burst error – Error Detection Techniques: CRC – Checksum – Error Correction Technique: Hamming code – Transmission control protocol: ARQ protocols – Framing: HDLC – Medium Access Control: Random Access Protocols – Scheduling approaches to MAC – Ethernet: IEEE 802.3 – Virtual LAN: IEEE 802.1Q – Wireless LAN: IEEE802.11 – Bluetooth – ZigBee.

UNIT III SWITCHING & ROUTING TECHNOLOGIES 12

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 AND SECURITY 12

Process-process delivery: Basics of Port addressing and Sockets – TCP, UDP and SCTP – TCP – Congestion control – Application protocols: WWW, HTTP, SMTP, FTP – Network security: HTTPs – SSL.

UNIT V QUEUING MODELS & ADVANCED SWITCHING 12

Markov chain theory – Queuing model basics and L – M/M/1 and its variants – M/G/1, G/M/1– Applications of queuing model – Recent advances in Switching Approaches – Introduction to Software Defined Networking.

Total: 60 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

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

Transforms and Fourier series, Signals and Systems

d) Related Courses

Advanced Digital Signal Processing, Statistical Signal Processing, Digital Image and Video Processing

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revisd Bloom's Taxonomy)
CO1	Compute Discrete Fourier Transform for the given signals	K3
CO2	Model a Digital Infinite Impulse Response Filters(IIR) for the given specifications	K3
CO3	Analyze different windowing and sampling techniques to design FIR filter	K4
CO4	Analyze the finite word length effects in filters	K4
CO5	Explain the basics of Multirate Signal Processing & its applications	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I DISCRETE FOURIER TRANSFORMS 13

Linear & Circular Convolution Methods – Linear filtering – Overlap add and overlap save methods – DFT and properties of DFT– FFT algorithms: Radix-2 FFT algorithms, Decimation in Time, Decimation in Frequency algorithms – Use of FFT algorithms in Linear Filtering and correlation – MATLAB exercise on DFT and FFT.

UNIT II IIR FILTER DESIGN 14

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, BPF, BRF) using frequency translation – Structures of IIR: Direct form I, Direct form II, Cascade, Parallel and Lattice structures – MATLAB exercises on filter design.

UNIT III FIR FILTER DESIGN 14

Linear phase FIR filter - Filter design using windowing techniques (Rectangular Window, Hamming Window and Hanning Window) – Frequency sampling techniques – Structures of FIR: direct form I, Direct form II, Cascade, Parallel and Lattice structures – MATLAB exercises on filter design.

UNIT IV FINITE WORD LENGTH EFFECTS 9

Quantization- Truncation and Rounding errors - Quantization noise- Input output Quantization noise error – Coefficient quantization error – Product quantization error – Overflow error – Limit cycle oscillations – Scaling.

UNIT V MULTIRATE SIGNAL PROCESSING & APPLICATIONS 10

Decimation – Interpolation – Sampling rate conversion by a rational factor – Design of Decimators and Interpolators – Application – Sub band coding – Musical Sound processing, Digital Audio sampling rate conversion – Oversampling A/D&D/A – MATLAB exercises on interpolation and decimation.

Total: 60 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

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

a) Course Category

Program Core

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

Communication Systems

d) Related Courses

MIMO Wireless Communication, 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	Discuss the characteristics of wireless communication channels.	K2
CO2	Describe the diversity principles and MIMO concept in wireless communication	K2
CO3	Interpret the concepts of Multipath Mitigation Techniques.	K2
CO4	Explain multiple access techniques for Wireless Communication	K2
CO5	Describe the various wireless networks and give emphasis on trending technologies.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I OVERVIEW OF WIRELESS CHANNEL 12

Overview of wireless communication, Cellular concept: Frequency reuse, Hand off, System capacity - Radio Propagation: Large scale path loss, Reflection, Diffraction, Scattering, Link Budget design - Small scale fading: Doppler shift, Time dispersion parameters, Coherence bandwidth, Doppler spread & Coherence time – Types of fading: Flat fading, Frequency selective fading, fast fading, slow fading.

UNIT II DIVERSITY TECHNOLOGIES &MIMO COMMUNICATIONS 12

Diversity- Receiver Diversity - Transmitter Diversity - SISO, SIMO, MISO, MIMO model: Parallel decomposition, channel capacity, Diversity Gain - Beam forming -Multiplexing trade-offs - Space-time Modulation and coding: STBC, STTC - Spatial Multiplexing and BLAST Architectures- MIMO Detection Techniques- Zero forcing and Maximum Likelihood detection.

UNIT III MULTIPATH MITIGATION TECHNIQUES 12

Equalization - Adaptive equalization - Linear and Non-Linear equalization - Zero Forcing, and Minimum Mean Square Error Algorithms - Diversity - Micro and Macro diversity -Diversity combining techniques - Error probability in fading channels with diversity reception - Rake receiver.

UNIT IV MULTI USER SYSTEMS 12

Multiple Access : FDMA, TDMA, CDMA, SDMA - Hybrid techniques - Random Access –ALOHA - Slotted ALOHA – CSMA – Scheduling - Power control - uplink-downlink channel capacity - multiuser diversity - MU-MIMO systems.

UNIT V WIRELESS COMMUNICATION STANDARDS 12

Evolution - 3G Overview - Migration path to UMTS - UMTS Basics - Air Interface - 3GPP Network Architecture - 4G features and challenges - Technology path - IMS Architecture-LTE architecture - Differences between IMS and LTE.

Total: 60 Hrs

h) Learning Resources

Text Books

1. Rappaport. T.S., "Wireless communications", Pearson Education, 2nd Edition, 2010.
2. Andreas.F. Molisch, "Wireless Communications", John Wiley – India, 2006.
3. Simon Haykin & Michael Moher, "Modern Wireless Communications", Pearson Education, 2007.
4. Andrea Goldsmith, Wireless Communications, Cambridge University Press, 2007.
5. William Stallings, "Wireless Communications and networks" Pearson / Prentice Hall of India, 2nd Ed., 2007

Reference Books

1. Vijay. K. Garg, "Wireless Communication and Networking", Morgan Kaufmann Publishers, http://books.elsevier.com/9780123735805:, 2007.
2. Sumit Kasera and Nishit Narang, "3G Networks – Architecture, Protocols and Procedures", Tata McGraw Hill, 2007.
3. Kaveth Pahlavan,. K. Prashanth Krishnamurthy, "Principles of Wireless Networks", Prentice Hall of India, 2006.
4. Harry R. Anderson, "Fixed Broadband Wireless System Design" John Wiley – India, 2003.
5. Clint Smith. P.E., and Daniel Collins, "3G Wireless Networks", 2nd Edition, Tata McGraw Hill, 2007.

Online Resources

1. http://nptel.iitm.ac.in/courses/-0Data Communication
2. http://www.sp4comm.org/docs/chapter12.pdf
3. https://nptel.ac.in/courses/117104099

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

a) Course Category

Program Core

b) Preamble

This course provides an introduction to the basic concepts of Radio Propagation in guided systems and to learn its application. The quality of signals at receiver depends on type of transmitting and receiving antennas, their orientation, transmitting frequency and geographical terrain. For installation & maintenance of wireless systems, the basic knowledge of wave propagation theory is essential.

c) Prerequisite

Electromagnetics and Transmission lines

d) Related Courses

Optical & Microwave Communication Systems, RF and Microwave Integrated Circuits

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	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

	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 12

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 - Bessel's differential equation and Bessel function - TM and TE waves in Circular wave guides - Rectangular and circular cavity Resonators.

UNIT II ANTENNA FUNDAMENTALS 12

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 infinite simile dipole - short dipole - half wave dipole - Measurement of radiation pattern – gain - directivity and impedance of antenna.

UNIT III ANTENNA ARRAYS 12

Two element Array - N-Element Linear Array: Uniform Amplitude and Spacing, Directivity, Design Procedure - Principle of pattern multiplication - N-Element Linear Array: Uniform Spacing and Non uniform Amplitude, Super directivity - Grating lobes - Planar Array - Design consideration: Design of Broadside, End fire & Binomial arrays, Design of Dolph Chebyshev arrays - Circular Array.

UNIT IV SPECIAL ANTENNAS 12

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 - Principle of smart antenna: CORDIC algorithm for DOA estimation.

UNIT V RADIO WAVE PROPAGATION 12

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 - fading and diversity techniques.

Total: 60 Hrs

h) Learning Resources

Text Books

1 E.C. Jordan and K.G.Balmain "Electro Magnetic Waves and Radiating System, Pearson Education, 2nd Edition, 2015.

2 Warren L Stutzman and Gary A Thiele, "Antenna Theory and Design", John Wiley and Sons, 2nd Edition, 2009.

Reference Books

1 A. Balanis, "Antenna Theory: Analysis and Design", Wiley Publications. 3rd Edition, 2016.

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

Online Resources

1. http://nptel.ac.in/courses/117101056.
2. www.antenna-theory.com.
3. http://www.dxzone.com/catalog/Antennas
4. http://www.engr.sjsu.edu/rkwok/EE172/Antenna_Fundamental.pdf.

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

a) Course Category

Program Core

b) Preamble

This course introduces the fundamentals of the VLSI and implementation of digital circuit through the CMOS Transistors.

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	Describe CMOS logic implementation for combinational gates and VLSI design flow.	K2
CO2	Describe the CMOS fabrication and processing technology.	K2
CO3	Explain the I-V, C-V and DC characteristics of CMOS transistors.	K2
CO4	Construct the sequential circuits using CMOS transistors	K2
CO5	Illustrate the arithmetic building blocks and memories using CMOS circuits.	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	PS O1	PS O2
CO1	M	M	L	L	L	-	-	-	-	-	-	H	-	-
CO2	M	L	M	M	L	-	L	-	-	-	-	L	-	-
CO3	M	L	L	M	L	M	-	-	L	-	-	L	-	-
CO4	H	M	M	H	M	L	-	-	-	-	-	L	L	L
CO5	H	M	H	H	M	L	-	L	L	L	-	H	L	L

g) Course Content

UNIT I CMOS LOGIC AND VLSI DESIGN FLOW 9

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

UNIT II CMOS FABRICATION AND PROCESSING TECHNOLOGY 9

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

UNIT III CMOS THEORY 9

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

UNIT IV SEQUENTIAL CIRCUITS 9

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

UNIT V ARITHMETIC BUILDING BLOCKS AND MEMORY ARCHITECTURE 9

Adders: Single bit Addition, Carry-Ripple Adder, Carry Skip Adder, Carry-Look ahead Adder –Multipliers: Binary Multiplication, Array Multiplier – Shifters: Funnel Shifter source Generator, Funnel Shifter, Barrel Shifter – Comparator – Counters - Memories: one bit SRAM, one bit DRAM, Case study: Switch level modelling in Verilog HDL.

Total: 45 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

Online Resources

1. www.nptelvideos.in/2012/12/digital-vlsi-system-design.html
2. http://www.cmosvlsi.com/coursematerials.html
3. http://freevideolectures.com/Subject/VLSI-and-ASIC-Design.

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

a) Course Category

Program Core

b) Preamble

Fiber optic communication provides the basic concepts of optical fibers, light propagation, effect of losses and dispersion. Microwave Engineering enlightens the formulation of Scattering matrix for various microwave components and its properties, operation of solid state based devices, O and M tubes for microwave signal generation and illustrating different microwave measurement techniques.

c) Prerequisite

Antenna Theory

d) Related Courses

RF & Microwave Integrated circuits, Satellite Communication, Radar and Electronic Navigational system.

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 basics of optical fibers and its Mode Characteristics.	K2
CO2	Explain different losses, dispersion and distortion of light in optical fibers.	K2
CO3	Apply the properties of S parameters to study the characteristics of microwave components.	K3
CO4	Explain the working principle of different solid state based devices.	K2
CO5	Describe the working principle of linear beam and cross field device and techniques used for measurements.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I OPTICAL FIBERS FUNDAMENTALS 12

Evolution of Fiber Optic Systems - Basic Optical Laws - Propagation of light inside fiber - Fiber Types - Splicing Techniques and Connectors - Losses: Attenuation Loss, Absorption Loss, Scattering Loss, Bending Loss, Core and Cladding Loss - Dispersion: Group-Delay, Material Dispersion, Pulse dispersion, Waveguide Dispersion, Intermodal Distortion. Dispersion Shifted Fibers, Dispersion Compensating Fibers- Modal analysis: Classification of modes.

UNIT II OPTICAL SOURCES, DETECTORS AND SYSTEMS 12

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-SNR-detector response time-Avalanche multiplication noise-temperature effects. System design consideration link design –Link power budget, WDM –Passive DWDM Components.

UNIT III MICROWAVE COMPONENTS AND TWO PORT NETWORKS 12

Microwave frequencies - advantages and applications, scattering matrix formulation: Concept of N port scattering matrix representation - S parameters properties, Passive microwave devices: bends – corners – attenuators - phase changers, S Matrix Calculations for 2 port Junction: E plane and H plane Tees - Magic Tee - Faraday rotation, Directional Coupler - Circulator and Isolator- Cavity resonators, Strip line & Micro stripline components.

UNIT IV MICROWAVE SOLID STATE DEVICES AND TUBES 15

Transit time limitations in Microwave Bipolar Transistors, Power frequency limitations Microwave Field Effect Transistors, Gunn effect: RWH theory - High-field domain and modes of operation - microwave amplification, Avalanche transit time devices: IMPATT and TRAPATT diodes. Microwave vacuum tube based devices, two cavity Klystron - velocity modulation – multi-cavity klystron - Traveling wave tube, Magnetron.

UNIT V MICROWAVE APPLICATIONS 9

Microwave applications in terrestrial and satellite communications, radar, remote sensing, wireless communications and their system requirements. Propagation modes of transmission lines- Planar Technology models, Modeling of discontinuities, junctions and circuits impedance transformers, Antenna, filters, solid state amplifiers and oscillators. Microwave computer aided design examples Using HFSS.

Total: 60 Hrs

h) Learning Resources

Text Books

1 John M. Senior , “Optical Fiber Communication”, Second Edition, Pearson Education, 2007
2 Samuel Y Liao, “Microwave Devices & Circuits” Third Edition Prentice Hall of India, 2006.
3 David M. Pozar, "Microwave Engineering", Third Edition, Wiley India.2012.
4 Thomas H Lee, “Planar Microwave Engineering: A Practical Guide to Theory, Measurements and Circuits”, Cambridge University Press, 2004.
5 Mathew M Radmanesh, “RF and Microwave Electronics”, Prentice Hall, 2000.

Reference Books

1. J.Gower, "Optical Communication System", Prentice Hall of India, 2001.
2. Gerd Keiser, "Optical Fiber Communication" McGraw -Hill International, 4th Edition, 2010.
3. R.E.Collin, "Foundations for Microwave Engineering", Second edition, IEEE Press.Citations 2000.
4. Annapurna Das and Sisir K Das, “Microwave Engineering”, Third edition Tata McGraw Hill Inc., 2009.

Online Resources

1 https://en.wikipedia.org/wiki/Microwave_engineering
2 http://www.microwaveeng.com

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.a	Explore the basic concepts of operating system and RTOS objects.	K2
CO1.b	Develop and simulate RTX51 based embedded OS code for 8051 microcontroller using Keil IDE and report on the code execution statistics by identify the time consuming module for optimization.	S3
CO2	Familiarize the concept of board support package.	K2
CO3	Describe the concept of embedded storage architecture.	K2
CO4.a	Explain various embedded file systems and storage space optimization techniques.	K2
CO4.b	Install Linux for specified configuration, develop Linux C programs and implement Linux file system.	S3
CO5.a	Illustrate the Linux device driver development process for communication interfaces and basic peripherals.	K2

CO5.b	Implement loadable kernel modules to be run in kernel space and develop Linux drivers for basic devices.	S3
CO6	Develop an RTOS based system to demonstrate a sustainable system incorporating the legal and safety standards while handling open source tools.	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	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1.a	M	L	M		M							H		L
CO1.b				M	H			L	M	M	H		H	H
CO2	L		L		H								L	L
CO3	L		L		H								L	L
CO4.a	M											L		
CO4.b				M	H			L	M	M	H		H	H
CO5.a	L													
CO5.b			M	M	H			L	M	M	H	H	H	H
CO6	L	M	M		H	M	M	L	M	L	M		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^2C Subsystem on Linux - USB Gadgets.

Practical Exercises **30 Hrs**

		CO	Skill Level
1	Exploring the features of Keil and RTX51	CO1.b	S3
2	Introductory Embedded C Programming	CO1.b	S3
3	Task Creation and Deletion using RTX51 in Keil	CO1.b	S3
4	Task scheduling using RTX51 in Keil	CO1.b	S3
5	Processing Critical Section using RTX51 in Keil	CO1.b	S3
6	Task Synchronization using RTX51 semaphores in Keil	CO1.b	S3
7	Task Communication using shared memory in Keil	CO1.b	S3
8	Linux Installation	CO4.b	S3
9	Basic Linux Programming	CO4.b	S3
10	Creating Linux Loadable kernel Modules	CO5.b	S3
11	Linux Serial Driver	CO5.b	S3
12	Mini Project	CO6	S3

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 Books

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

Online Resources

1. https://www.youtube.com/watch?v=PEzpOembKNc
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 on the core technologies that make up the Internet of Things (IoT) and intents to produce skilled graduates with not only basic understanding of IoT but also ability to apply to the different domains. It will help to know the components of IoT products and services including the devices for sensing,actuation, processing, and protocols for data communication and networking.

c) Prerequisite

Data Communication Networks, Digital Electronics

d) Related Courses

Embedded System

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	Handle the various IoT layered protocols for optimization, routing and data acquisition.	K2
CO3	Illustrate the IoT concepts by interfacing devices like Rasperry Pi/Arduino using IDE and Python programming.	K3
CO4	Articulate the IoT perceptions using data analytics of cloud services.	K3
CO5	Summarize different models of IoT to solve real time scenario for various smart applications.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUNDAMENTALS OF IoT 6

Evolution of Internet of Things – Enabling Technologies – IoT standards: oneM2M, IoT World Forum (IoTWF) and Alternative IoT models – Simplified IoT Architecture and Core IoT Functional Stack -– Fog, Edge and Cloud in IoT – Functional blocks of IoT ecosystem – Sensors, Actuators, Smart Objects and Connecting Smart Objects.

UNIT II IoT PROTOCOLS 6

IoT Access Technologies: Physical and MAC layers, topology – Network Layer: IP versions, Constrained Nodes and Constrained Networks – Optimizing IP for IoT: From 6LoWPAN to 6Lo, Routing over Low Power and Lossy Network – Application Transport Methods: Supervisory Control and Data Acquisition – Application Layer Protocols: CoAP and MQTT.

UNIT III IoT INTERFACING 6

Design Methodology – Embedded computing logic – Microcontroller, – Arduino – Board details, IDE programming – Raspberry Pi – Interfaces and Raspberry Pi with Python Programming.

UNIT IV DATA ANALYTICS AND SUPPORTING SERVICES 6

Structured & Unstructured Data and Data in Motion & Data in Rest – Role of Machine Learning – NoSQL Databases – Hadoop Ecosystem – Apache Kafka, Apache Spark, Apache storm – Edge Streaming Analytics and Network Analytics – Xively Cloud for IoT, Python Web Application Framework – Django – AWS, Azure, Google cloud for IoT .

UNIT V INDUSTRIAL APPLICATIONS 6

Converged Plant wide Ethernet Model (CPwE) – Power Utility Industry – Grid Blocks Reference Model – Smart and Connected Cities: Layered architecture, Smart Lighting, Smart Parking Architecture and Smart Traffic Control, Smart Health care, Smart Agriculture, Public safety & security, Smart retail.

Total: 30 Hrs

List of experiments

S. No	Practical Exercises (30 Hours)
1	Familiarization with the concept of IOT, Arduino / Raspberry Pi and perform necessary software installation.
2	Design an MCU to control GPIO Pins.
3	Design an MCU to Interface with various sensors.
4	Design an MCU to control HTTP client.
5	Create an IoT Connected sensor network using MQTT protocol.
6	Create wireless MCU to connect to a website and search a string.
7	Design a smart home system.
8	Design a smart agriculture system.
9	Design a system to analyse the sensor values in cloud (Thingspeak).
10	AWS IoT basic configuration.
11	Mini Project.

Total: 60 Hrs

h) Learning Resources

Text Book

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.

Reference Books:

1. Arshdeep Bahga, Vijay Madisetti, ―Internet of Things – A hands-on approach, Universities Press, 2015
2. Olivier Hersent, David Boswarthick, Omar Elloumi , ―The Internet of Things – Key applications and Protocols, Wiley, 2012 (for Unit 2).
3. Jan Ho¨ ller, Vlasios Tsiatsis , Catherine Mulligan, Stamatis , Karnouskos, Stefan Avesand. David Boyle, "From Machine-to-Machine to the Internet of Things – Introduction to a New Age of Intelligence", Elsevier, 2014.
4. Dieter Uckelmann, Mark Harrison, Michahelles, Florian (Eds), ―Architecting the Internet of Things, Springer, 2011.
5. Michael Margolis, Arduino Cookbook, Recipes to Begin, Expand, and Enhance Your Projects, 2nd Edition, O'Reilly Media, 2011.

Online resources

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

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

a) Course Category

Program core

b) Preamble

The aim of this course is to understand the fundamentals and design of Analog electronic circuits using transistor, op-amp and MOS.

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	Operate, check and test electronic components using measuring equipment.	S3
CO2	Simulate, compare and analyze the electronic circuits using LT SPICE and through hardware implementation	S3
CO3	Illustrate the applications of demonstrated analog electronic circuits	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	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	-	-	-	-	-	L	-	L	M	-

g) Course Content

List of Experiments
[Design and testing of following Circuits and Simulation using LTSPICE]

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

12.	Design a three stage Ring Oscillator using CMOS transistors	CO1, CO2, CO3	S3

Total: 60 Hrs

h) Learning Resources

Text Books

1. Boylestead & Neshelsky, Electronic Devices & Circuits, Pearson Education/PHI Ltd, 10th edition, 2010.
2. S.Salivahanan, N.Suresh Kumar and A.Vallavaraj, Electronic Devices and Circuits, McGraw-Hill, 3rd edition, 2012.
3. Behzad Razavi, "Design of Analog CMOS Integrated Circuits", Tata McGraw-Hill, 2007

References

1. David .A. Bell, Electric Circuits And Electronic Devices Oxford University Press, 2010.Kumar,A. Vallavaraj.Bapat K N, Electronic Devices & Circuits, Mc Graw Hill, 1992.
2. J. Millman and Halkias .C, Integrated Electronics, 2nd Edition, Tata McGraw-Hill, 2001.
3. Donald L.Schilling and Charles Belove, Electronic Circuits, Tata McGraw Hill, 3rd Edition, 2003

Online Resources

1. https://www.youtube.com/watch?v=kN2qA9W7W-A
3. http://bitsavers.trailing-edge.com/pdf/national/_appNotes/AN-0088.pdf
4. http://nptel.ac.in/courses/117106034/55
5. https://www.fairchildsemi.com/application-notes/AN/AN-88.pdf
6. http://nptel.ac.in/courses/117103063/34

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

CO Nos.	Course Outcomes	Skill Level (Based on Dave's Taxonomy)
CO1	Program 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

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

g) **Course Content:**

List of Experiments

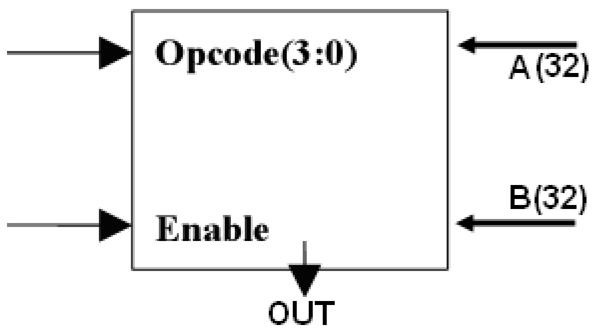
<u>Module 1 – Software</u> (CO1)

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

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

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

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



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

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

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

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

<u>Module 2 – Hardware (CO2</u>)

7. <u>Realization of logic functions with the help of Universal Gates (NAND, NOR)</u>

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.

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. www.nptel.com/digitalelectronics/iitkanpur/
2. http://asic-world.com/
3. http://www.learnabout-electronics.org

Course Code	Course Title	L	T	P	C
10211EC303	**SIGNALS AND SYSTEMS LAB**	**0**	**0**	**2**	**1**

a) Course Category

Program Core

b) Preamble

Signals & Systems laboratory course uses simulation software to demonstrate the generation and basic operations of signals like shifting, scaling and convolution etc. Students will also understand the applications of transformation techniques.

c) Prerequisite

Nil

d) Related Courses

Discrete Time Signal Processing, Digital Image and Video Processing

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	Perform basic signal processing concepts on signals and systems.	S2
CO2	Implement transformation techniques to analyze signals & systems.	S2

f) Correlation of COs with POs

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

g) Course Content

LIST OF EXPERIMENTS

Experiment No.	Experiment Title	COs
MATLAB/SIMULINK based experiments		
1.	Generation of Signals	CO1
2.	Basic Operations on Signals	CO1
3.	Linear convolution of sequences and signals	CO1
4.	Auto correlation and cross correlation of sequences	CO1
5.	Properties of systems	CO1
6.	Fourier series representation of continuous time signals	CO1
7.	Fourier transform of continuous time signals	CO2
8.	Laplace transform of continuous time signals	CO2
9.	Sampling theorem	CO1
10.	Computation of Discrete time Fourier Transform	CO2
11.	Computation of DFT	CO2
12.	Z transform of discrete time signals	CO2
13.	System responses using SIMULINK	CO2
14.	Analysis of DT LTI systems using transforms	CO2
15.	Computation of frequency spectrum for the modulated signal	CO2

Total: 30 Hrs

h) Learning Resources

Text Books

1. Alex Palamides, Anastasia Veloni, "Signals and Systems Laboratory with Matlab", CRC Press, Taylor and Francis Group, London, New York, 2010.
2. Zahir M. Hussain, Amin Z. Sadik, Peter O'Shea, "Digital Signal Processing: An Introduction with MATLAB and Applications", Springer-Verlag, 2011.
3. John W. Leis, "Digital Signal Processing Using MATLAB for Students and Researchers", Wiley, New Jersey, 2011.
4. Samuel D. Stearns, Donald R. Hush, "Digital Signal Processing with Examples in MATLAB", Second Edition, CRC Press, New York, 2002.

Online Resources

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

Course Code	Course Title	L	T	P	C
10211EC304	**MICROPROCESSOR AND MICROCONTROLLER 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 and Implement assembly language program for performing basic ALU manipulation using 8085 microprocessor.	S3
CO2	Develop and Implement assembly language program to perform basic ALU manipulation and peripheral interfacing using8086 microprocessor.	S3
CO3	Develop and Implement assembly language/ C program for performing bit manipulations and timer, serial port and interrupt programming using 8051 microcontroller	S3
CO4	Develop and Implement C program for performing real time interfacing using 8051 and PIC microcontroller	S3
CO5	Develop a mini project in a team to address the solution for societal and environmental issues using 8051/ PIC Microcontroller.	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	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	M	-	L	M	-	-	-	-	-	-	-	-	-
CO2	M	M	L	L	M	-	-	-	-	-	-	-	-	-
CO3	H	M	L	L	H	-	-	-	-	-	-	-	-	-
CO4	H	M	L	L	H	-	-	-	-	-	-	-	-	-
CO5	H	M	-	-	H	L	L	L	L	L	L	L	L	L

g) Course Content

EXP NO	**EXPERIMENT NAME**	**CO**
1	Program for ALU operations-8 bit (8085)	CO1
2	Program for ALU operations-16 bit (8086)	CO2
3	Peripheral devices programming using 8255 (8086)	CO2
4	Peripheral devices programming using 8279 (8086)	CO2
5	Program for bit manipulation and masking for the given input (8051).	CO3
6	Timer programming using Keil C.	CO3
7	Serial port programming using Keil C.	CO3
8	Interrupt program using Keil C.	CO3
9	ADC and DAC Interfacing with 8051.	CO4
10	Interfacing of DC motor / stepper motor with 8051.	CO4
11	Musical tone or Elevator 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
14	Mini Project	CO5

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 and Analog Communication Systems

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	Analyze the performance of AM and FM modulation and demodulation circuits.	S2
CO2	Visualize the effects of sampling, Error Control Codes, ASK, FSK, PSK, PAM, ISI, and Digital Modulation Techniques	S2
CO3	Analyze the performance of various digital modulation techniques, fading channel, and channel coding techniques.	S2
CO4	Acquire knowledge about network analyzers.	S2

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	PSO1	PSO2
CO1	M	L	M	M	-	L	L	-	L	-	L	-	L	-
CO2	M	L	L	L	H	M	M	-	-	-	M	L	L	L
CO3	M	L	L	L	H	M	M	-	-	-	M	L	L	L
CO4	M	-	L	L	M	M	M	L	L	-	M	-	-	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	Pulse code modulation and Demodulation of a signal.	CO2
5	Simulation and Performance Analysis of Binary ASK in a AWGN environment.	CO3
6	Analyze the process of Time Division Multiplexing and De-multiplexing (TDM)	CO3
7	Test the performance of the circuit for generation and detection of Amplitude shift keying. (Hardware)	CO3
8	Simulation and Performance Analysis of FSK in a AWGN environment.	CO3
9	Design and testing of FSK Modulation and Demodulation. (Hardware)	CO3

10	Simulation and Performance Analysis of Binary PSK in a AWGN environment.	CO3
11	Simulation and Performance Analysis of QAM in a AWGN environment.	CO3
12	Simulation and Performance Analysis of digital modulation technique in Rayleigh fading channel.	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 test the performance of BPSK modulation using a Network Analyzer. (Hardware)	CO4

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 conceptsin optical devices and microwave systems in a laboratory setting with an emphasison measurement techniques. The listed experiment provides the practical analysis of scattering matrix for various microwave components and its properties, operation of solid state based devices.

c) Prerequisite

Nil

d) Related Courses

Optical & Microwave 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	Design and simulate the characteristics of microstrip transmission line, distributed elements, Tee junctions and couplers using ANSYS HFSS software.	S2
CO2	Setup microwave bench using Reflex klystron/Gunn source, and study its characteristics.	S2
CO3	Design an appropriate length of fibre optic cable with less attenuation and dispersion and simulate the performance of the link using Opti performer tool.	S2
CO4	Explore the applications of Microwave Integrated circuits, devices and optical systems.	S2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	M	M	H	L	L	-	L	-	L	L	L	L
CO2	M	L	L	L	H	M	M	L	L	-	M	L	L	L
CO3	M	L	L	L	L	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 Micros trip transmission lineusing 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.	Study of Characteristics Of Led and Photodiode	CO3
14.	To Explore the MMIC (Monolithic Microwave Integrated Circuit)Amplifier Characteristics. Measurement of gain, 1dB compression point, reverse isolation.	CO4

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. Further new numerical analysis techniques as well as radio architectures are also introduced

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 strip line techniques.	K2
CO3	Explain the basics of Microwave Integrated Circuits	K2
CO4	Explain the fabrication method of MIC and different measurement setups	K2
CO5	Discuss the application specific MIC Systems	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO 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.

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 INTRODUCTION TO MICROWAVE INTEGRATED CIRCUITS 9

Introduction to MIC – advantages and applications – MMIC technology: Active device Technologies, design approaches- multichip module technology – substrates. Inductors – Capacitors – Resistors – Micro-strip components - Coplanar circuits - Multilayer techniques – Micro machined passive components - Switches & Attenuators- Filter Design

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. D.M.Pozar, “Microwave Engineering”, 3rd edition, John Wiley, 2004.
2. B.Bhat and S.Koul, “Strip line Like transmission lines for MICS”, John Wiley, 1989.
3. T. Itoh, editor, “Numerical Techniques for Microwave and Millimeter-wave Passive Structures”, Wiley, NY, 1989.
4. Habil. MBA Frank Ellinger, “Radio frequency integrated circuits and technologies”, Springer- Varlag Berlin Heidelberg, 2007.
5. 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.

Online Resources

1. http://bulletin.engineering.nyu.edu/preview_course_nopop.php?catoid=4&coid=6687
2. http://home.sandiego.edu/~ekim/e194rfs01/
3. http://www.ece.mcmaster.ca/faculty/nikolova/4FJ4_6FJ4.html
4. https://apps.ep.jhu.edu/course-homepages/2602-525.787-microwave-monolithic-integrated-circuit-mmic-design-penn-thompson
5. http://www.ece.ucsb.edu/Faculty/rodwell/Classes/ECE218a/ECE218a.html.

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 provides an introduction to the basic concepts and techniques of cellular radio Communication, mathematically analyze mobile radio propagation mechanisms, design Base Station (BS), Mobile Station (MS) parameters, analyze the antenna configurations and types, to study the recent trends adopted in cellular and wireless systems and standards.

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 cellular radio and capacity improvement techniques.	K2
CO2	Apply the concepts of mobile radio propagation models.	K3
CO3	Illustrate fading mechanism, equalization techniques and Diversity concepts.	K2
CO4	Classify Speech coding techniques and multiple access techniques.	K2
CO5	Describe various wireless technologies and standards.	K2

f) Correlation of COs with Pos

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

g) Course Content

UNITI INTRODUCTION TO WIRELESS COMMUNICATION 9

History and evolution of mobile radio communication-Generations-Cellular Concepts-Frequency reuse-Channel Assignment strategies-Handoff strategies-Interference-Trucking and Grade of service-Improving Coverage and capacity of cellular system.

UNITII MOBILE RADIO PROPAGATION 9

Radio wave propagation-Free space propagation model-Basic propagation mechanism-Ground reflection model, Knife edge diffraction model, radar cross section model-Practical Link budget design using Path Loss Models -Indoor and outdoor propagation model-Okumura, Hata, PCS Extension to Hata Model.

UNITIII SMALL SCALE FADING AND EQUALIZATION 9

Small-Scale Fading: Small scale multipath propagation-Small scale Multipath measurements-parameters of mobile multipath channels-types of small scale fading-Rayleigh and Ricean Distributions, statistical models for multipath fading channels. Equalization: Survey of Equalization Techniques, Linear Equalization, Non-Linear Equalization-Algorithms for Adaptive Equalization-Interleaving and Diversity Techniques-Rake Receiver.

UNITIV CODING AND MULTIPLE ACCESS TECHNIQUES 9

Coding: RS codes for CDPD-Vocoders-Linear Predictive Coders-Selection of Speech Coders for Mobile Communications-GSM Codec. Multiple Access Techniques: FDMA, TDMA, CDMA, SDMA, Capacity of Cellular CDMA and SDMA

UNITV WIRELESS SYSTEMS AND STANDARDS 9

AMPS-GSM-CDMA-3G-4G (LTE)-NFC systems-WLAN technology-WLL-Adhoc networks-Bluetooth-WIFI-5G Opportunities and Challenges a case study.

Total: 45 Hrs

h) Learning Resources

Text Books

1. T.S.Rappaport, "Wireless Communications: Principles and Practice", Second Edition, Pearson Education/Prentice Hall of India, Third Indian Reprint 2003.
2. W.C.Y.Lee,"Mobile Communication Design Fundamentals", second edition, john Wiley & sons,1993

Reference Books

1. Muthu Chidambaram Nathan, Wireless Communications, PHI, 1stedition 2008.
2. Goldsmith, Wireless Communications, Cambridge University Press,1stedition 2005.
3. R.Blake, "Wireless Communication Technology", Thomson Delmar,1st edition 2000.
4. W.C.Y.Lee,"Mobile Communications Engineering: Theory and applications", Second Edition, McGraw-Hill International, 1998.

Online Resources

1. www. networks,com/categories
2. www.nptel/lectures/networking
3. http://www.see.ed.ac.uk/~hxh/adccoursematerial/4.rc.2.pdf
4. http://www.diva-portal.org/smash/get/diva2:501119/fulltext01.pdf
5. http://www.durofy.com/multiple-access-techniques-fdma-tdma-cdma/
6. www.nptel.in

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

a) Course Category

Program Elective

b) Preamble

Information is produced in many forms such as text, image, audio, video etc. If directly sent through communication system, it will be received with error and has security and liability issues. It occupies more storage area too. This course discusses about the various forms of information and its storage methods. The course focuses on different methods to correct errors and add security solutions.

c) Prerequisite

Digital Electronics

d) Related Courses

Wireless Digital 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 theories	K2
CO2	Discuss the various capacity reduction-based coding techniques for text, audio and speech type of data	K2
CO3	Compare various capacity reduction-based coding techniques for image and video type of data	K2
CO4	Illustrate various security-oriented coding techniques for Block codes	K2
CO5	Implement various error control techniques for Convolutional codes	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INFORMATION THEORY 9

Information theory: 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, Psychoacoustic model, MEG 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

Definitions and Principles: 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-Principle 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”, Pearson Education Asia, 2002

Reference Books

1. K Sayood, “Introduction to Data Compression” 3/e, Elsevier 2006.
2. S Gravano, “Introduction to Error Control Codes”, Oxford University Press 2007.
3. Amitabha Bhattacharya, “Digital Communication”, TMH 2006.

Online Resources

1. https://nptel.ac.in/courses/117101053

Course Code	Course Title	L	T	P	C
10212EC104	**RADAR AND ELECTRONIC NAVIGATION SYSTEMS**	**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 system and applications	K2
CO2	Describe principles of MTI radar system, CW pulse Doppler radar and FMCW radar	K2
CO3	Describe the principles of various tracking techniques and radar	K2
CO4	Discuss the characteristics of radar clutter and conventional navigational methods	K2
CO5	Explain various advanced navigation techniques and systems	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I BASIC CONCEPTS AND RADAR EQUATIONS 9

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

UNIT II CW, FMCW AND MTI RADAR 9

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

UNIT III TRACKING RADAR 9

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

UNIT IV RADAR CLUTTER AND BASIC NAVIGATIONAL RADAR SYSTEM 9

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

UNIT V ADVANCED NAVIGATIONAL SYSTEM 9

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

Total: 45 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

Online Resources

1. www. NPTEL.ac.in
2. https://ocw.mit.edu/resources/res-ll-001-introduction-to-radar-systems
3. www.radartutorial.eu/index.en.html
4. https://pe.gatech.edu/courses/basic-radar-concepts
5. http://www.geo.uzh.ch/microsite/rsldocuments/research/SARlab/GMTILiterature/PDF/ Skolnik90.pdf

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

a) Course Category

Program Elective

b) Preamble

The principles of radio communication have wider applications, but the unique attributes of orbiting satellites and the techniques used for communication via these satellites requires a specialized course. This course gives students a broad treatment of the diverse subsystems that make up a complete satellite communication system

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 Launching	K2
CO2	Describe about link design between earth station and satellite	K2
CO3	Illustrate direct broadcast satellite television, radio systems and earth station technology	K2
CO4	Classify various access methods in space segment and explain onboard processing	K2
CO5	Discuss the services rendered by the satellite and its future applications	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	PO1 0	PO1 1	PO1 2	PSO 1	PSO2
CO1	M	L	L	M	-	L	L	L	L	L	-	L	M	M
CO2	M	M	M	L	L	-	L	L	L	L	-	L	-	-
CO3	L	L	M	L	M	L	L	L	L	L	L	L	L	-
CO4	L	M	M	L	L	L	L	L	L	L	-	L	L	-
CO5	L	M	M	L	L	L	L	L	L	L	-	L	L	-

g) Course Content

UNIT I INTRODUCTION TO SATELLITE COMMUNICATION 9

Orbital mechanisms: Origin and Brief History - Basic laws (Kepler's law & Newton's law), Orbital mechanics: Equation of Orbit- Geostationary Orbit- Location of Satellite in Orbit- Orbital Elements, Orbital Perturbations, Eclipses, Sun Transit Outage, Satellite Stabilization. Look Angle Determination: Elevation and Azimuthal Calculation, Launching Techniques. 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, System Noise: Noise Temperature and Noise Figure – G/T Ratio, Downlink and uplink system design, Design of satellite links for specified C/N

UNIT III DIRECT BROADCAST SATELLITE TELEVISION AND RADIO 9

Introduction-C-Band and Ku-Band Home Satellite TV, Digital DBS TV, DBSTV System Design, DBS-TV Link Budget, Error Control in Digital DBS-TV, Master Control Station and Uplink, Installation of DBSTV Antennas, Satellite Radio Broadcasting, Digital Video Broadcast (DVB) Standards, receive – Only home TV systems – Outdoor unit – Indoor unit for analog (FM) TV, Master antenna TV system, Community antenna TV system, transmit – Receive earth stations.

UNIT IV 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 V SATELLITE APPLICATIONS 9

INTELSAT Series, INSAT, VSAT, Mobile satellite services: GSM, GPS, INMARSAT, LEO, MEO, Satellite Navigational System. Direct to home Broadcast (DTH), Digital audio broadcast (DAB)- World space services, Business TV(BTV), GRAMSAT, Specialized services – E – mail, Video conferencing, Internet, 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.
2. Pritchend and Sciulli, "Satellite communication systems engineering", PHI Learning, 1986.
3. Robert M. Gagliendi, "Satellite communication", John Wiley and Sons, 1988.
4. M. Richharia, "Satellite communication system design and analysis", Mc-Millan, 1996

Online Resources

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

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

a) Course Category

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	Explain the concepts of optical TDM and Soliton	K2
CO5	Discuss the physical layer concepts in optical communication	K2

f) Correlation of COs with POs

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

UNIT V PHYSICAL LAYER 9

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

Total: 45 Hrs

h) Learning Resources

Text Books

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

Reference Books

1. Max Ming-Kang Liu ,Principles and Applications of Optical Communication,Tata McGraw Hill Education Pvt., Ltd., New Delhi, 2010.
2. Le Ngyyen Binh ,Digital Optical Communications, CRC Press – Taylor and Francis Group – Indian reprint 2012.
3. Rajiv Ramaswami and Kumar N. Sivarajan, Optical Networks: A Practical Perspective, Harcourt Asia Pte Ltd., Second Edition 2006.
4. P.E. Green, Fiber Optic Networks, Jr., Prentice Hall, NJ, 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

Course Code	Course Title	L	T	P	C
10212EC107	**DIGITAL TV ENGINEERING**	**3**	**0**	**0**	**3**

a) Course Category

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

Antenna Theory

d) Related Courses

Communication 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 digital TV transmission and reception, processors such as audio and video.	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 such as MPEG. Digital Video Broadcasting	K2
CO4	Discuss the elements of digital TV system.	K2
CO5	Summarize the high definition TV standards and its Components.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I DIGITAL TELEVISION 9

Merits of Digital technology-Digital TV signals-Digitized video parameters-digital transmission and reception-codec Functions-codec MAA2100-Video processor-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-analog to digital TV- transmitter requirements.

UNIT II TV CAMERAC 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-HOT picture tube controls-Delta gun-PIL-Trinitron-color camera-picture tubes purity-convergence-automatic degaussing.

UNIT III DIGITAL TRANSMISSION AND RECEPTION 9

Digital TV: Digitized Video, Source coding of Digitized Video – Compression of Frames – DCT based – (JPED) - 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 - Display Technologies –basic working of Plasma - LCD and LED Displays.

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. Color TV system: Principle of color signal transmission and reception – PAL- NTSC - SECAM (block schematic description)-Picture tube – delta gun.

UNIT V HIGH DEFINITION TV 9

Component coding-MAC signals - MAC encoding format-scanning frequencies-D2- MAC Packet Signal-Duobinary Coding-HDTV Standards & compatibility -colorimetric characteristics & parameters of HDTV LCD TV System - LCD Technology -LCD Matrix types & operations-LCD screen for TV. LCD color Receiver Plasma TV System: 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

Text Books

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

Reference Books

1. S.P. Bali Colour Television Theory and Practice, TMH, 2nd edition, 1994.
2. A.M. Dhake, Television and Video Engineering -, 2nd Edition, 2017

Online Resources

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

Course Code	Course Title	L	T	P	C
10212EC108	**SOFTWARE DEFINED RADIO**	**2**	**0**	**2**	**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

Communication Systems, 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	Interpret the various functional blocks of software defined radio architecture.	K2
CO3	Demonstrate the various signal processing components in Software architecture	K2
CO4	Apply the knowledge of wireless communication systems in software Defined Radio.	K3
CO5	Interpret the SDR applications in various applications through case study.	K2

f) Correlation of Cos with POs

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

g) Course Content

UNIT I INTRODUCTION TO SOFTWARE DEFINED RADIO 6

Introduction –Need for Software Defined Radio – Characteristics and Benefits of a Software Radio- Challenges and issues for the implementation of SDR –Technology Tradeoff

UNIT II FUNCTIONAL BLOCKS IN SOFTWARE DEFINED RADIO ARCHITECTURE 6

Overview of 3G/4G/5G Radio Architectures-Hybrid Radio Architecture- Specific Architecture and standards for Software Radio - Band pass Signal Generation, Parameters of Data converters, ADC and DAC architectures- Direct Digital synthesis

UNIT III SIGNAL PROCESSING IN SDR 6

Digital Signal Processing techniques for SDR -–Reconfigurable processors -Multirate signal Processing: Sample Rate Conversion principles, Digital Filter banks -Polyphase Filters – Timing recovery in digital receivers

UNIT IV SDR FOR WIRELESS COMMUNICATION 6

Characteristics of SDR in terms of baseband processing –Pulse Shaping, Matched Filtering – Baseband Modulation – Synchronization –Multicarrier Communication: OFDM Transceiver - FBMC transceiver.

UNIT V APPLICATIONS OF SOFTWARE DEFINED RADIO 6

5G services -Evolution of Cognitive Radio –Vehicular Networking -Case studies – Wireless Information Transfer System, SDR-3000 digital transceiver subsystem

List of Experiments

S. No	Practical Exercises (30 Hours)	Cos
1.	Design and Implement the sample rate conversion	CO3
2.	Design and Implement the Digital Filter for Software Defined Radio	CO3
3.	Design and Implement the Polyphase Filter Banks for Software Defined Radio	CO3
4.	Develop the baseband digital transmission and reception	CO4
5.	Implement the baseband pi/4 πQPSK Modulation and Demodulation Transceiver system	CO4
6.	Implement the baseband QAM modulation and Demodulation Transceiver system	CO4
7.	Pulse Shaping and Matched Filtering	CO4
8.	Implementation of OFDM Transceiver system	CO4
9	Synchronization in OFDM systems	CO4
10	Implementation of FBMC Transceiver	CO4
11	Implementation and Testing of Digital Transceiver System	CO5
12	Study of 2x1 MIMO Transceiver	CO5

Total: 60 Hrs

h) Learning Resources

Text Books

1. Paul Burns, "Software Defined Radio for 3G", Artech House, 2002.
2. Jeffrey H. Reed, "Software Radio: A Modern Approach to Radio Engineering" Pearson Education, 2002
3. Travis F. Collins, Robin Getz, Di Pu, and Alexander M. Wyglinski, "Software-Defined Radio for Engineers", Artech House Publishers 2018
4. Robert M.Heath "Digital Communication, Physical Layer Exploration Lab using the NI USRP" National Technology and Science Press,2012

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.

Online Resources

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

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

a) Course Category

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	Describe the concept of EMI / EMC related to product design & development	K2
CO2	Describe the different EM coupling principles and its impact on performance of electronic system.	K2
CO3	Describe the electromagnetic interference, highlighting the concepts of both susceptibility and immunity.	K2
CO4	Analyze various EM compatibility issues with regard to the design of PCBs and ways to improve the overall system performance.	K3
CO5	Describe various EM radiation measurement techniques and the present leading edge industry standards in different countries	K2

f) Correlation of Cos with POs

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

g) Course Content

UNIT I EMI/EMC CONCEPTS 6

EMI: EMIC definitions and Units of Parameters- Sources and Victim of EMI- Conducted and Radiated EMI Emission and Susceptibility- Transient EMI- ESD- Radiation Hazards

UNIT II EMI COUPLING PRINCIPLES 6

Conducted and Radiated 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

UNIT III 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

UNIT IV 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 and Terminations

UNIT V EMI MEASUREMENTSANDSTANDARDS 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 analyze-; Civilian Standards: CISPR, FCC, IEC, EN; Military Standards –Frequency Allocation and Spectrum Utilization comparisons.

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.	Measurement of Transfer Impedance	CO2,CO3
5.	Concept of Cross Talk Basic Phenomena	CO2,CO4
6.	EMI effects on Cross Talk problem	CO2,CO4
7.	EMI effects on Inductance and Capacitance with various VIAs and Terminations	CO4
8.	EMI effects on Inductance and Capacitance with Radial and SMD components	CO4
9.	Determination of discontinuities in signal Traces: Discontinuities stubs	CO4
10.	Determination of discontinuities in Ground Apertures: Discontinuities Ground aperture	CO4
11.	EMI effects on Ground Bounce for Symmetric IC Power Pins	CO4
12.	EMI effects on Ground Bounce with Difference Between Symmetric and Asymmetric IC Power Pins	CO4

Total: 60 Hrs

h) Learning Resources

Text Books

1. V. P. Kodali, Engineering EMC Principles, Measurements and Technologies, IEEE Press, New York, 1996.
2. Henry W. O., Noise Reduction Techniques in Electronic Systems, A Wiley Inter Science Publications, John Wiley and Sons, New York, 1988.

Reference Books

1. Bemhard Keiser, Principles of Electromagnetic Compatibility, 3rd Ed, Artech House, Norwood, 1986.
2. C. R. Paul, “Introduction to Electromagnetic Compatibility, John Wiley and Sons, Inc, 1992

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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 the students to design wireless communication systems that can 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	Classify and explain the diversity schemes involved in MIMO with advantages, applications, fading channel models with error/outage probability and power allocation	K2
CO2	Calculate the capacity of deterministic and random, non-coherent MIMO channels and fading channels	K3
CO3	Discuss transmit diversity with the different space time coding techniques like STBCs, STTCs and Space time turbo codes	K2
CO4	Describe various algorithms used to detect the received signal in MIMO systems like Maximum likelihood, MMSE, ZFE, iterative decoding	K2
CO5	Illustrate the advances in MIMO communication systems such as cooperative, cognitive, 5G and RADAR communications	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTIONTO 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, Power allocation in MIMO: Uniform - adaptive - near optimal power allocation

UNIT II MIMO CHANNEL CAPACITY 6

Capacity and Information rates of noisy, AWGN and fading channels, Capacity for deterministic MIMO Channels, Capacity of random MIMO channels (Unity Channel Matrix, Identity Channel Matrix), Capacity of independent identically distributed channels, Capacity of separately correlated Rayleigh fading MIMO channels, Capacity of non-coherent MIMO channels, Capacity of keyhole Rayleigh fading MIMO channel

UNIT III SPACE-TIME BLOCK AND TRELLIS CODES 6

Transmit diversity with two antennas: Advantages, code design criteria, Alamouti space-time codes, Orthogonal. and Quasi-orthogonal space-time block codes – Linear dispersion codes, SER analysis of Alamouti space-time code over fading channels, Space-time trellis codes, Performance analysis of Space- time codes over separately correlated MIMO channel, Space-time turbo codes, BLAST Architectures: VBLAST – HBLAST – SCBLAST - DBLAST

UNIT IV MIMO DETECTION TECHNIQUES 6

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

UNIT V ADVANCES IN MIMO 6

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

List of Experiments

S. No	Practical Exercises (30 Hours)	CO's
1.	Performance analysis of 2 x 2 MIMO system using different modulation techniques with detection algorithms	CO1, CO2
2.	Performance analysis of 2 x 2 MIMO system using different modulation techniques with ML detection algorithm in correlated channel conditions	CO1, CO2
3.	Performance analysis of 2 x 2 MIMO system using different modulation techniques with ML detection algorithms in uncorrelated channel conditions	CO1, CO2
4.	Performanceanalysisof2x2MIMOsystemusingdifferentmodulation techniqueswithV- Blast detection algorithm	CO3
5.	Performance analysis of 2 x 2 MIMO system using different space time coding techniques with ML detection algorithm	CO3
6.	Performance analysis of 2 x 2 MIMO system using different space time coding techniques with V-Blast detection algorithm	CO3
7.	Performance analysis of Multi-user MIMO system using BPSK modulation technique with SIC and V-Blast detection algorithm	CO3
8.	Performance analysis of 2 x 2 MIMO system using Iterative Decoding	CO3
9	Performance analysis of 4-port MIMO system using various detection mechanism i. Zero Forcing ii. MMSE iii. Successive Interference Cancellation	CO4

10	Analyze a MIMO channel using Lattice Reduction based detection	CO4
11	Write a MATLAB code for multiuser MIMO with beamforming scenario	CO5
12	Performance analysis of MIMO system over 5G broadband Wi-Fi systems	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. “MIMOWireless Communications” Cambridge University Press,2007
3. R. S. Kshetrimayum, “Fundamentals of MIMO Wireless Communications”, Cambridge University Press, 2017

Reference Books

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

Online Resources

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

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

a) Course Category

Program Elective

b) Preamble

This course provides advanced information on concepts of antennas and its array. And also, to understand the design principles involves in modelling 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 antennas and its measurement techniques.	K2
CO2	Classify the design concepts in antenna arrays and beamforming antennas.	K2
CO3	Analyze of Microstrip patch antennas and its feeding techniques.	K4
CO4	Explain about various antennas and materials used in modern applications.	K2
CO5	Analyze the various applications of SIW, RFID, RNSS antennas and its applications.	K4

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUNDAMENTAL CONCEPTS 6

Antenna Fundamentals: Physical concept of radiation, Radiation pattern, near and far field regions, reciprocity, directivity and gain, effective aperture, polarization, input impedance, efficiency – Friis transmission equation – Far-field measurement: Absolute Gain, Gain transfer method.

UNIT II ANTENNA ARRAYS AND CLASSICAL BEAMFORMING 6

Introduction: Arrays with two elements – uniform linear arrays – Broadside array – end fire array – scanning, binomial – retro-directive array – planar array – circular array – Adaptive antenna array – Angle of estimation: MUSIC, ESPRIT.

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

Introduction: Broadband antennas - Antenna design - electromagnetic band gap – Artificial Magnetic surface – frequency selective surface – photonic band gap – Meta materials – 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 of Broad Side and End fire array antennas using HFSS	CO2
2.	Analyze MUSIC AoA estimation algorithm using MATLAB	CO2
3.	Analyze various feeding methods using HFSS	CO3
4.	Design of Microstrip patch antenna for mobile applications	CO3
5.	Design of Rectangular Patch antenna using HFSS	CO3
6.	Design of frequency selective surface structure using HFSS	CO4
7.	Design and develop an antenna to receive AM and FM radio	CO4
8.	Design Yagi-Uda Antenna at very high frequency band	CO4
9.	Design of sierpinski gasket monopole antenna using HFSS	CO4
10.	Design of substrate integrated waveguide for a given operating frequency using HFSS	CO5
11.	Design of SIW based leaky wave Antenna using HFSS	CO4 CO5
12.	Design of SIW based H-Plane Horn Antenna using HFSS	CO5

Total: 60 Hours

h) Learning Resources

Text Books

1. Constantine A. Balanis, “Antenna Theory: Analysis and Design”, 4th Ed, Wiley, 2016.
2. Thomas A. Milligan, “Modern Antenna Design”, 2nd Ed, Wiley, 2005.
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 ISBN: 978-1-119-99367-4

Reference Books

1. Anil Pandey “Practical Microstrip and Printed Antenna Design” Artech House, 2019.
2. Douglas H. Werner, “Broadband Metamaterials in Electromagnetics: Technology and Applications”, 1st Ed, Jenny Stanford Publishing, 2017.

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

Program 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

Microprocessor & Microcontroller

d) Related Courses

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 functional blocks of an embedded system and its software development processes.	K2
CO2	Illustrate the theoretical background in the design and development of sophisticated embedded system.	K2
CO3	Identify the importance of safety and reliability in Contemporary Embedded system design.	K2
CO4	Describe the Embedded system design techniques for performance optimization.	K2
CO5	Enumerate the knowledge of Embedded system in the areas of Distributed Embedded System.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUNDAMENTALS OF EMBEDDED SYSTEM 9

Introduction - Introduction of embedded system, Processor-Memory, Peripherals, Software, Algorithms, Microcontroller, Microprocessor based, board based.
Compilation Process in Embedded System – Compiling code, Pre-processor, compilation, linking & Loading, Symbols, references and relocation, linker/loader.
Debugging Techniques - High Level language simulation, low level simulation, on board debugger, task level debugging, symbolic Debug, Emulation.

UNIT II HARDWARE-SOFTWARE CO-DESIGN 9

Introduction and Motivation, Co-design Process Overview - Development Lifecycles- Specification - Modeling Tools and Languages - Techniques of Hardware Software Co-design –Partitioning - Co-Simulation - Co-Synthesis - Co-Verification.

UNIT III SAFETY AND RELIABILITY 9

Safety and Reliability Techniques, Proactive Approach - Software Solutions – Approaches. Hardware Solutions – Approaches, steps to a Safe Design, Extreme Reliability - Long Life Applications, Critical Components, Dealing with Failure, Specification.

UNIT IV OPTIMIZATION AND PERFORMANCE ANALYSIS 9

Introduction, Basic Measures, Real-time Considerations – Hard, Soft, Firm. Time Loading – Simulation, Instrumentation. Response Time, Memory Loading, Performance Evaluation, Performance Optimization, Hardware Accelerators, Hardware Platforms - Microprocessors and FPGAS, Optimizing Power Consumption, Trade-offs.

UNIT V DISTRIBUTED SYSTEMS 9

Introduction, Local and Remote Models, Intra and Inter System Communication, Protocols, Error Management – Failure Detection, Reconfiguration, Recovery idempotent Systems. Pipes, Streams, and Sockets, Remote Services and Procedures, Design Issues, Synchronous and Asynchronous Procedures

Total: 45 Hrs

h) Learning Resources

Text Books

1. Steve Heath “Embedded Systems Design” Second Edition, Elsevier.
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/SoftwareIntroduction”, 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.
4. David E.Simon “An Embedded Software primer” Pearson Publication.

Online Resources

1. .https://www.youtube.com/watch?v=4CPIjYGIYqc
2. .https://www.youtube.com/watch?v=y70V0qHAFNQ
3. .https://www.youtube.com/watch?v=yAOfqK1kQso

Course Code	Course Title	L	T	P	C
10212EC110	**INTRODUCTION TO ROBOTICS**	**3**	**0**	**0**	**3**

a) Course Category

Program 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

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 elements of Robotics.	K2
CO2	Discuss the classifications of sensors and actuators.	K2
CO3	Describe kinematics, movement and joints of robots.	K2
CO4	Interpret Robot Programming and Robot Controllers.	K2
CO5	Discuss robot applications in automation.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION ROBOTICS 9

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

UNIT II SENSORS AND ACTUATORS 9

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

UNIT III ROBOTIC KINEMATICS 9

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

UNIT IV ROBOT PROGRAMMING & ROBOT CONTROLLERS 9

Robot Programming & Robot Controllers: Teach-in, Teach-Through, High-Level languages –robot talk, Comparison of teaching and programming methods, Software speedup, Robot Controllers – essential components, joint actuation and Sensing, Overload, over current and stall detection methods, Position, Speed, Direction Sensing.

UNIT V DEVELOPMENTS IN SENSOR TECHNOLOGY 9

Developments in sensor technology, sensory control. Programming Language: Variable Assembly Language (VAL), RAIL, A Manufacturing Language (AML). 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. H.R.Everett, "Sensors for Mobile Robots – Theory and Applications", A.K.Peteres Ltd. 1995.
3. Fu,K.S. ,et al "Robotics- Control, Sensing, Vision and Intelligence ", McGraw – Hill. Inc., Singapore,1987.
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=PEzpOembKNc
2. https://www.youtube.com/watch?v=mCs21yByQqk

Course Code	Course Title	L	T	P	C
10212EC111	**EMBEDDED COMMUNICATION PROTOCOLS**	**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	Relate the serial and parallel communication protocol to embedded networking.	K2
CO2	Extend USB Bus for embedded systems.	K2
CO3	Extend CAN Bus for embedded systems.	K2
CO4	Generalize the concepts of Ethernet communication.	K2
CO5	Extrapolate Ethernet communication to embedded applications.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I SERIAL AND PARALLEL COMMUNICATION 9

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

UNIT II USB BUS 9

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

UNIT III CAN BUS 9

Introduction to CAN bus – CAN standard – CAN controller and bus adapter – device drivers – interaction layer – Protocol Stack implementation and Configuration – CAN open 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 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

Online Resources

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

Course Code	Course Title	L	T	P	C
10212EC112	VIDEO SURVEILLANCE SYSTEM	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	Discuss 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.	K2
CO3	Describe video management system of video analytics, trouble shooting, recording, storage and security.	K2
CO4	Discuss the video networking concepts, delivery methods and trouble shooting.	K2
CO5	Explain CCTV characteristics, components and case study of ATM and vehicle parking system.	K2

f) Correlation of COs with POs

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

References Books

1. Murat A. Tekalp, "Digital Video Processing", Prentice Hall, 1995.

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

a) Course Category

Program 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

Linear Integrated Circuits

e) Course Outcomes

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Identify and understand the need for development of wearable devices and its influence on various sectors.	K2
CO2	Discus the applications of various wearable inertial sensors for biomedical applications.	K2
CO3	Comprehend the design and development of various wearable bio-electrode and physiological activity monitoring devices for use in healthcare applications.	K2
CO4	Identify the use of various wearable locomotive tools for safety and security, navigation.	K2
CO5	Acquaint the usage of wearable devices as assistive devices, diagnostic devices and other modern applications.	K2

f) Correlation of CO's with PO's

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

g) Course Content

UNIT I INTRODUCTION TO WEARABLE DEVICES 9

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

UNIT II 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. 2. Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications" Elsevier, 2014
3. 3. "Seamless Healthcare Monitoring", Toshiyo Tamura and Wenxi Chen, Springer 2018
4. "Wearable Sensors -Fundamentals, Implementation and Applications", by Edward
5. Sazonov and Michael R. Neuman, Elsevier Inc., 2014.

Reference Book

1. A.K. Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpatRai.

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

a) Course Category

Program Elective

b) Preamble

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

c) Prerequisite

Control Systems

d) Related Courses

Linear Integrated Circuits, Control Systems. Sensors and Transducers.

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 process dynamics and mathematical model of flow, level, pressure, and temperature processes.	K2
CO2	Describe the concepts of various control schemes and their operation.	K2
CO3	Illustrate the evaluation criteria and controller tuning methods for feedback controllers.	K2
CO4	Explain the various final control elements in process control instrumentation.	K2
CO5	Discuss the various advanced control schemes and its applications.	K3

f) Correlation of COs with POs

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

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 - Mathematical model of flow, Level, Pressure and Thermal processes – Interacting and non-interacting systems – Continuous and batch processes – Self regulation – Servo and regulatory operations - Process lag, load disturbance and their effect on processes.

UNIT II FEEDBACK CONTROLLERS 9

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

UNIT III TUNING OF CONTROLLERS 9

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

UNIT IV PROCESS CONTROL INSTRUMENTATION IN PLANT DESIGN 9

Sensors and transducers for Industrial Variables: pressure, flow, level and temperature - Overview of different Final control elements: I/P converter, P/I converter, Pneumatic and electric actuators, Control Valves - Industrial Communication Protocols - Overview of Piping and Instrumentation (P&I) diagram.

UNIT V ADVANCED CONTROL SYSTEMS 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, SCADA.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Bequette, B.W., "Process Control Modeling, Design and Simulation", Prentice Hall of India, 2004
2. Stephanopoulos, G., "Chemical Process Control - An Introduction to Theory and practice", Pearson 2015.

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., 2003
4. Steve Mackay, Edwin Wright, John Park, "Practical Data Communications for Instrumentation and Control", Newness Publications, UK, 2003

Online Resources

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

Course Code	Course Title	L	T	P	C
10212EC204	**EMBEDDED C PROGRAMMING**	**2**	**0**	**2**	**3**

a) **Course Category**
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 no 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**
Microprocessor and Microcontroller

d) **Related Courses**
Embedded OS and Device Drivers, Embedded Processor, Real Time Operating System, System on Chip, 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	Explores the Embedded System development life cycle and identify various ARM Cortex architecture.	K2
CO2	Discover Embedded C programming components and concepts.	K3
CO3	Associate Embedded C programming concepts with basic peripherals of ARM and its programming techniques.	K3
CO4	Associate Embedded C programming concepts with Communication peripherals of ARM and its programming techniques.	K3
CO5	Apply Embedded C programming concepts for the desired application with ARM.	K3
CO6	Develop, simulate and implement Embedded Cprograms for ARM based systems for the givenspecifications.	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	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	M	L				L	L	L	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
CO6	L		M	M	H	L	L		M	M	H	H	H	H

g) Course Content

UNIT I INTRODUCTION TO 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 CortexM0.

UNIT II INTRODUCTION TO EMBEDDED C PROGRAMMING 6

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

UNIT III BASIC PERIPHERALS PROGRAMMING 6

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

UNIT IV ADVANCED PERIPHERALS PROGRAMMING 6

Serial Communication: Universal Asynchronous Receiver Transmitter, Serial Peripheral Interface, Inter Integrated Circuits, Direct Memory Addressing.

UNIT V INTERFACINGS AND APPLICATIONS 6

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

Practical Exercises **30 Hrs**

		CO	Skill Level
1	Demonstration of Proteus IDE	CO6	S3
2	Demonstration of Keil IDE	CO6	S3
3	Introduction to ARM development board	CO6	S3
4	LED,7-Segment Interface	CO6	S3
5	Switch, Keypad Interface	CO6	S3
6	LCD Interface	CO6	S3
7	ADC Interface	CO6	S3
8	DAC Interface	CO6	S3
9	PWM, Sine Wave Generation	CO6	S3
10	UART Interface	CO6	S3
11	Stepper Motor Interface	CO6	S3
12	Implement Watch Dog Timer	CO6	S3
13	Develop Real Time Clock	CO6	S3

Total: 60 Hrs

h) Learning Resources

Text Books

1. Jonathan W Valvano "Introduction to ARM Cortex M microcontroller" Fifth Edition2014.
2. Cortex-M0+DevicesGenericUserGuide, ARM Limited.

Reference Books

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

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
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 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	Generalize the concept of embedded Linux OS.	K2
CO2	Develop and demonstrate an embedded Linux system.	S3
CO3	Develop and demonstrate an embedded Linux device driver application.	S3
CO4	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

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

g) Course Content

Theory **15**

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, Bootloader. Loadable kernel modules, makefiles, character device driver.

Practical Exercises **60 Hrs**

		CO	**Skill Level**
1	Develop a host system	CO2	S3
2	Understand basic Linux Commands	CO2	S3
3	Build native toolchain	CO2	S3
4	Native Compile Linux Kernel	CO2	S3
5	Native Linux C programming	CO2	S3
6	Makefile creation	CO2	S3
7	Build cross toolchain	CO2	S3
8	Cross Compile Linux Kernel	CO2	S3
9	Configure target system bootloader	CO2	S3
10	Cross Linux C programming	CO2	S3
11	Emulate target Linux system	CO2	S3
12	Deploy to target Linux System	CO2	S3
13	Loadable Kernel module programming with makefile	CO3	S3

14	Loadable Kernel module programming with argument passing	CO3	S3
15	GPIO device driver development	CO3	S3
16	LCD device driver development	CO3	S3
17	Serial port device driver development	CO3	S3
18	Project	CO4	S3

Total: 60 Hrs

h) 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.

Reference Books

1. Gene Sally, "Pro Linux Embedded Systems", Apress, 2010.
2. J.Corbet, A. Rubini, G.K.Hartman, "Linux Device Drivers", O'Reilly, 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
10212EC206	**EMBEDDED SYSTEMS AND ROBOTICS**	**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 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	Demonstrate PIC based embedded systems	S3
CO2	Design and demonstrate real time systems using Arduino	S3
CO3	Design robots using Webots based on e-puck for the given specification and demonstrate it	S3

f) Correlation of COs with Pos

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	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

<table>
<tr><td colspan="8">g) Examination Scheme for Practical Dominated Course</td></tr>
<tr><td colspan="8">Internal Evaluation (40M)</td></tr>
<tr><td colspan="5">Laboratory Experiment(15M)</td><td colspan="3">Model laboratory Test (25M)</td></tr>
<tr><td>Performance in conducting experiment (5)</td><td>Resultand analysis (3)</td><td>Viva voce (3)</td><td colspan="2">Record (4)</td><td>Performance in conducting experiment (15)</td><td>Result and analysis (5)</td><td>Viva Voce (5)</td></tr>
<tr><td colspan="8">Semester End Evaluation(60M)</td></tr>
<tr><td>Part-A(20M)</td><td colspan="7">Part-B(40M)</td></tr>
<tr><td>Theory questions to evaluate the knowledge and understanding (20)</td><td colspan="3">Performance in conducting experiment (25)</td><td colspan="2">Resultand analysis (10)</td><td colspan="2">Viva Voce (5)</td></tr>
</table>

h) Course Content

Theory **15 Hrs**

PIC-Architecture, pin diagram, ports, on chip peripherals Embedded C programming – General Structure, Data types. 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. RTOS fundamentals.

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	PWM generation using PIC
7.	CO1	Motor speed control using PIC
8.	CO2	Exploring the features of Arduino IDE and Boards
9.	CO2	LED Interfacing using Arduino
10.	CO2	RGB LED interface using Arduino
11.	CO2	LCD Interfacing using Arduino.
12.	CO2	LDR Interfacing using Arduino.
13.	CO2	IR sensor interfacing using Arduino
14.	CO2	Ultrasonic sensor interface using Arduino
15.	CO2	Temperature sensor interfacing using Arduino.
16.	CO2	Motor interface using Arduino
17.	CO2	Bluetooth Interfacing using Arduino
18.	CO2	GSM module Interfacing using Arduino

19.	CO2	WiFi Interfacing using Arduino
20.	CO3	Building a Robot Car
21.	CO3	Programming the Robot Car using Arduino
22.	CO3	Exploring the features of Webots
23.	CO3	LED Control of e-puck Robot in Webots
24.	CO3	Motor Control of e-puck Robot in Webots
25.	CO3	LED and Motor Control of e-puck Robot using keyboard in Webots
26.	CO3	Line Follower e-puck Robot in Webots

Total 75hrs

h) Learning Resources

Textbooks

1. Massimo Banzi, "Getting Started with Arduino" 2 nd edition. O'Reilly, 2011.
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.
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-1984.
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.

Online Resources

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

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

a) Course Category

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 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	Recreate the Functionality of Soft Core and Hard Cores	S4
CO2	Enact the Sub Modules of Programmable SoC	S4
CO3	Demonstrate the Programmable System on Chip Interfacing with Peripheral Devices	S4

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	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

g) Examination Scheme for Practical Dominated Course

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</table>

h) Course Content

THEORY **15 hrs**

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.

LIST OF EXPERIMENTS

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

Total: 75 Hrs

h) Learning Resources

Textbooks

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

List of Major Equipment/ Instrument/Software with Broad Specifications

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

List of Software/Learning Websites

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

Online Resources

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

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

a) Course Category

Program 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

Control Systems. 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	a) Explain and illustrate the architecture of Virtual instrumentation and analyse its performance in comparison with conventional Instruments. b) Perform the basic VI programming using GUI functions in LabVIEW.	K2 S3
CO2	Apply the graphical programming functions in VI to simulate the application specific analog and digital circuits.	S3
CO3	a) Explain the Interface techniques and standards to connect with DAQ hardware. b) Demonstrate the real time data acquisition using DAQ devices, control, and analysis of basic I/O devices.	K2 S4

e) Correlation of COs with POs

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

f) Examination pattern for Lab Dominated Course

<table>
<tr><th colspan="7">Internal Evaluation (40M)</th></tr>
<tr><th colspan="4">Laboratory Experiment(15M)</th><th colspan="3">Model laboratory Test (25M)</th></tr>
<tr><td>Performance in conducting experiment (5)</td><td>Resultand analysis (3)</td><td>Viva voce (3)</td><td>Record (4)</td><td>Performance in conducting experiment (15)</td><td>Result and analysis (5)</td><td>Viva Voce (5)</td></tr>
</table>

<table>
<tr><th colspan="4">Semester End Evaluation(60M)</th></tr>
<tr><th>Part-A(20M)</th><th colspan="3">Part-B(40M)</th></tr>
<tr><td>Theory questions to evaluate the knowledge and understanding (20)</td><td>Performance in conducting experiment (25)</td><td>Resultand analysis (10)</td><td>Viva Voce (5)</td></tr>
</table>

g) Course Content

THEORY **15 Hrs**

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 Hrs

List of Experiments	CO Mapping
Introduction to Graphical Programming (6 Hours) 1. Build a VI using Numeric controls and indicators to perform various arithmetic operations 2. Build a VI using Boolean controls and indicators to perform various Boolean operations. 3. Build a VI using String controls and indicators to perform various String operations.	CO1
Operations using Data Types (6 Hours) 4. Create a Sub VI to compute area and volume of planes and solids. 5. Develop a VI using to solve a quadratic equation $ax^2 + bx + c = 0$ and display whether the roots are real or imaginary. 6. Build a VI to implement and verify adder circuits using logic gates.	CO2
Loops (6 Hours) 7. Build a VI to monitor the level of tank using loop functions. 8. Simulate a VI to indicate charging of a battery level. Use appropriate functions and display notification messages.	CO2
Arrays (6 Hours) 9. Build a VI using to create a 1-D array. Perform the operations such as indexing, insertion, deletion and search of an element. 10. Build a VI to generate Fibonacci series using loop and array functions. 11. Build a VI to perform sorting of given numbers in ascending order using loop and array functions.	CO2

Case Structure (6 Hours) 12. Build a VI for temperature monitoring system using Case structures. Display the safe and emergency alarms using LEDs of varying colours. 13. Design a VI to display a 7-segment LED using caste structures.	CO2
Charts and Graphs (6 Hours) 14. Simulate a sine wave and square of variable amplitude and frequency and display the waveform using graph. Manipulate the waveforms by changing its width and colour. 15. Develop a VI program to demonstrate Frequency modulation and amplitude modulation using Formula node.	CO2
Sequence Structures (6 Hours) 16. Build a VI for traffic light control for varying time delays using sequence structures. 17. Design a Ticket vending machine system using the concept of state machine in LabVIEW. 18. Perform READ/WRITE operations on a file using sequence structures and loops.	CO2
Clusters (6 Hours) 19. Create a student database and display the student details with CGPA above 8.0 using Clusters in LabVIEW. 20. Create a VI to calculate Body Mass Index (BMI) using Clusters and display the BMI status using LED and pop-up message.	CO2
Data Acquisition (12 Hours) 21. Study of DAQ module and Measurement & Automation Explorer. 22. Develop a VI to export data from DAQ assistant device and to spreadsheet. 23. Build a VI to measure temperature using thermocouple and DAQ. 24. Build a VI for image acquisition and processing using USB camera. 25. Study of Instrument control using Instrument Assistant for READ/WRITE operation using Interface VISA commands.	CO3

Total: 75 Hrs

h) Learning Resources

Text Books

1. Labview Graphical Programming by Johnson, 4th Edition, McGraw Hill, 2011.
2. Introduction to LabVIEW for Scientists and Engineers by John Essic, 4th Edition, Oxford University Press, 2018.
3. Robert H.Bishop, "Learning with Lab VIEW", Prentice Hall, 2003

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., 2003
4. Steve Mackay, Edwin Wright, John Park, "Practical Data Communications for Instrumentation and Control", Newness Publications, UK, 2003

Online Resources

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

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	Apply the knowledge of queuing in packet switching Networks	K3
CO3	Illustrate Congestion control in TCP, ATM and traffic management in ATM.	K2
CO4	Outline the concepts of integrated and differentiated services.	K2
CO5	Paraphrase the concepts of various protocols for quality of service.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	-	-	-	-	-	-	-	L	L	-	-	-	-
CO2	H	M	L	L	L	-	-	-	L	L	-	L	-	-
CO3	H	M	L	L	L	-	-	-	L	L	-	L	-	-
CO4	H	-	-	-	-	-	-	-	L	L	-	L	-	-
CO5	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 Apcar, “MPLS and VPN architecture”, Cisco Press, Volume 1 and 2, 2003

Online Resources

1. www. Networks,com/categories
2. www.NPTEL/lectures/networking

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

a) Course Category

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	Discuss the need of authentication and various authentication methods HASH, MD5, SHA, etc.,	K2
CO5	Articulate various threats and attacks in Internet and Mobile networks.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I BASIC CIPHERS 9

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

UNIT II BLOCK CIPHERS 9

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

UNIT III PUBLIC KEY SYSTEM 9

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

UNIT IV AUTHENTICATION SYSTEM 9

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

UNIT V INTERNET AND MOBILE SECURITY 9

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

Total: 45 Hrs

h) Learning Resources

Text Books

1. William Stallings, Cryptography and Network Security, 7th edition, Pearson Education
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 32843
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	Discuss Network management organization models and functional models	K2
CO3	Infer network management tools and system utilities	K2
CO4	Paraphrase fundamental network management, architecture and applications	K2
CO5	Outline the ATM, broad band access and wirelessnetwork management.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	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 12

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 12

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 12

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 12

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

UNIT V ATM AND BROADBAND NETWORK MANAGEMENT 12

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

Total: 60 Hrs

h) Learning Resources

Text Books

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

Reference Books

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

Online Resources

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

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

a) Course Category

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	Discuss the 5G functional and physical architecture and its requirements. Infer the millimeter wave architecture, Beamforming and hardware technologies for Deployment scenarios.	K2
CO3	Outline the requirements and fundamental techniques for MTC. Explain the radio resource management, Multi-hop and Multi-operator for D2D Communications.	K2
CO4	Classify the various radio access technologies for 5G networks.	K2

CO5	Describe the fundamentals, resource allocation and transceiver algorithms for Massive MIMO.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I DRIVERS FOR 5G 9

Historical Trend for Wireless Communication - Mobile Communications Generations: 1G 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 – SpectrumAccess 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 – Physicallayer 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-hopD2D Communications for Proximity and Emergency Services – Multi-operator D2D Communication

UNIT IV 5G RADIO ACCESS TECHNOLOGIES 9

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

UNIT V MASSIVE MULTIPLE-INPUT MULTIPLE –OUTPUT SYSTEMS 9

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

Total: 45 Hrs

h) Learning Resources

Text Books

1. Asif Oseiran, Jose F.Monserrat and Patrick Marsch, "5G Mobile and Wireless Communications Technology", Cambridge University Press, 2016.
2. Jonathan Rodriquez, "Fundamentals of 5G Mobile Networks", Wiley, 2015.
3. Patrick Marsch, Omer Bulakci, Olav Queseth and Mauro Boldi, "5G System Design – Architectural and Functional Considerations and Long Term Research", Wiley, 2018.

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

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

Data Communication Networks

d) Related Courses

Wireless Adhoc and Sensor Networks

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the technical information and challenges in body area networks (WBAN)	K2
CO2	Describe 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	Discuss the various smart applications in real time scenarios for WBAN.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO WBAN 9

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

UNIT II HARDWARE FOR WBAN 9

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

UNIT III SIGNAL PROCESSING 9

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

UNIT IV ENERGY HARVESTING FOR WEARABLE DEVICES 9

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

UNIT V APPLICATIONS OF WBAN 9

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

Total: 45 Hrs

h) Learning Resources

Text Books

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

References

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

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	Interpret the SDN data plane devices and Open flow Protocols	K2
CO3	Implement the operation of SDN control plane with different controllers	K3
CO4	Apply techniques that enable applications to control the underlying network using SDN	K3
CO5	Describe Network Functions Virtualization components and their roles in SDN	K2

f) Correlation of COs with POs

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

g) Course Content

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

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– spectrum overlay– spectrum handoff

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.

Total: 30 Hrs

Lab **Total: 30 Hrs**

List of experiments

S. No	Practical Exercises (30 Hrs)
1	Network Topology creation and REST API introduction.
2	Influencing flows via c URL commands.
3	Create a network and run a simple performance test.
4	Use “ovs-vsctl” command to directly control open v switch.
5	Dynamically change the network parameters—link delay analysis.
6	Dynamically change the forwarding rules.
7	Mininet Random Topology Generator.

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
3. SDN - Software Defined Networks by Thomas D. Nadeau & Ken Gray, O'Reilly, 2013

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 (2014): 87-98.

2. Kreutz, Diego, et al. "Software-defined networking: A comprehensive survey." Proceedings of the IEEE 103.1 (2015): 14-76.

Online Resources

1. https://www.digimat.in/nptel/courses/video/108107107/L01.html
2. https://www.digimat.in/nptel/courses/video/108107107/L03.html

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	Interpret the various spectrum sensing techniques for single and multi-band applications	K3
CO3	Recognize 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 countermeasures	K2

f) Correlation of COs with POs

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

g) Course Content

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 and trade- 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– spectrum overlay– spectrum handoff

UNIT IV MAC PROTOCOLS AND NETWORK LAYER DESIGN 6

Functionality of MAC protocol in spectrum access –classification –Inter frame spacing and MAC challenges – QOS –Spectrum sharing in CRAHN –CRAHN models – CSMA/CA based MAC protocols for CRAHN – Routing in CRN– Centralized and Distributed protocols – Geographical Protocol

UNIT V TRUSTED COGNITIVE RADIO NETWORKS 6

Trust for CRN: Fundamentals – Models – Effects of Trust Management –Security properties in CRN – Route Disruption attacks –Jamming attacks –PU Emulation attacks.

Total: 30 Hrs

Lab **Total: 30 Hrs**

List of experiments

S. No	Practical Exercises (30 Hrs)
1	Analyze the impact of pulse shaping and matched filtering using Software Defined Radio.
2	Simulate small scale fading and large scale fading in wireless networ Simulate small scale fading and large scale fading in wireless network.
3	Plot SNR vs Probability of Detection for energy detection in Cognitive Radio systems.
4	Plot SNR vs Probability of Detection for matched filter detection in Cognitive Radio Systems.
5	Plot SNR vs Probability of False Alarm for Spectrum Sensing in Cognitive Radio Networks.
6	Plot Detection Probability vs False Alarm Probability for matched filter Detection in Cognitive Radio Systems.
7	Optimization in Cooperative Spectrum Sensing in Cognitive Radio Systems.
8	Study of CRCN Simulator (Cognitive Radio Cognitive Network) using NS3.
9	Mini Project.

Total: 60 Hrs

h) Learning Resources

Text Books

1. Mohamed Ibnkahla, “Cooperative Cognitive Radio Networks: The complete Spectrum Cycle” I edition.
2. Ahamed Khattab, Dmitri Perkins, Bagdy Byoumi, “Cognitive Radio Networks from Theory to practice” 2013th edition.

Reference Books

1. Kwang– Cheng Chen and Ramjee Prasad, “Cognitive Radio Networks, Wiley Pub
2. Alexander M. Wyglinski, Maziar Nekovee, Thomas Hou,” Cognitive Radio Communications and Networks”. I edition.

Online resources

1. www. NPTEL/Cognitive Radio and Wireless Communications
2. https://www.iitk.ac.in/eeold/archive/courses/2013/wireless/topics.html

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	Discuss 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

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

g) Course Content

UNIT I INTRODUCTION 9

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, Operating systems and execution environments, Physical layer and transceiver design considerations in Wireless Sensor Networks.

UNIT II MAC PROTOCOLS FOR WSN 9

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, Sensor-MAC, Zebra-MAC.

UNIT III ROUTING PROTOCOLS FOR WSN 9

Routing Protocols for Wireless Sensor Networks Fundamentals of Routing Protocols, Performance Requirements, outing Strategies in Wireless Sensor Networks - Flooding and its variants, LEACH, Power-Efficient Gathering in Sensor Information Systems, Directed diffusion, Geographical routing.

UNIT IV TRANSPORT LAYER IN WSN 9

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 9

Time synchronization protocols based on sender/receiver synchronization, Localization approaches- proximity, trilateration and triangulation. Sensor node hardware-Berkeley Motes, Node level software platforms-NS2/NS3 & Cup carbon Simulator-Case study: Clustering-Energy-Routing-Localization-QoS Models.

Total: 45 Hrs

h) Lab **Total : 15 Hrs**

List of experiments

S. No	Practical Exercises (15 Hrs)
1	Node creation and deployment
2	Cluster formation
3	Cluster head selection using LEACH protocol
4	Routing in wireless sensor network using AODV protocol
5	Localization using TOA
6	Security in WSN using RSA algorithm
7	Creating attacks in WSN

Total: 60 Hrs

i) Learning Resources

Text Books

1. C. Siva Ram Murthy, and B. S. Manoj, "Ad Hoc Wireless Networks: Architectures and Protocols ", Pearson Education, 2008.
2. Labiod. H, “Wireless Adhoc and Sensor Networks”, Wiley, 2008.
3. Li, X, “Wireless ad -hoc and sensor Networks: theory and applications”, Cambridge University Press, 2008.

References

1. Carlos De Morais Cordeiro, Dharma Prakash Agrawal “Ad Hoc & Sensor Networks: Theory and Applications”, World Scientific Publishing Company, 2nd edition, 2011.
2. Feng Zhao and Leonides Guibas, "Wireless Sensor Networks", Elsevier Publication Holger Karl and Andreas Willig “Protocols and Architectures for Wireless Sensor Networks”, Wiley, 2005 (soft copy available)

3. Kazem Sohraby, Daniel Minoli, & Taieb Znati, "Wireless Sensor Networks Technology, Protocols, and Applications", John Wiley, 2007. (soft copy available)
4. Anna Hac, "Wireless Sensor Network Designs", John Wiley, 2003.(soft copy available)

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 Arial Vehicle category aircraft. Students will get in-depth skill set on design and fabrication techniques of Unmanned Arial Vehicle.

c) Prerequisite

Nil

d) Related Courses

Network Security, Internet of Things

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Paraphrase the fundamental concepts of Aerodynamics, Propulsion & Structures of Model Aircrafts	K2
CO2	Classify the payloads, sensors and measuring devices using in UAV.	K2
CO3	Describe the concept of Navigation and Guidance System of Aerial Robot	K2
CO4	Demonstrate the design process of drones and software tools	K3
CO5	Demonstrate the drone application for Plant health monitoring and soil field analysis	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I UNMANNED AERIAL VEHICLE 9

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 9

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 9

Flight Control System –Path planning- Way point Navigation system-GPS – GCS- Telemetry – Transmitter & Receiver.

UNIT IV DRONE SOFTWARE TOOL AND TELEMETRY 9

Introduction to ArduPilot, System components, peripheral hardware, Mission planner, MavProxy. Wireless communication modules and topology, Zig-bee, Bluetooth, LORA, Zero power devices, Energy Harvesting technology.

UNIT V PLANT HEALTH MONITORING AND TECHNOLOGIES FOR FARMING 9

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

Total: 45 Hrs

Lab **Total: 15 Hrs**

List of experiments

S. No	Practical Exercises (15 Hrs)
1	Making of Drone
2	Auto Pilot Simulation
3	Path Planning for UAV
4	Swarm of UAV's
5	Communication among UAV's
6	Communication with drones
7	Smart Irrigation systems
8	Smart Farming systems

Total: 60 Hrs

h) Learning Resources

Text Books

1. Andey Lennon "Basics of R/C model Aircraft design" Model airplane news publication October 1996.

References

1. Smart Agriculture: An Approach towards Better Agriculture Management: Editor: Prof. Dr. Aqeel-ur-Rehman, OMICS.
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/

Course Code	Course Title	L	T	P	C
10212EC120	**ADVANCED DIGITAL SIGNAL PROCESSING**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

The course on Advanced Digital Signal Processing techniques and analysis, includes theoretical concepts of estimation and prediction of signals. It covers parametric and nonparametric models of spectrum estimation, linear prediction, adaptive filtering techniques and methods of signal analysis. This course also introduces time-frequency transforms in signal processing applications.

c) Prerequisite

Discrete Time Signal Processing.

d) Related Courses

DSP Algorithms and Architecture, Statistical Signal Processing

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	Make use of various parametric power spectrum estimation techniques to analyze the signals.	K3
CO2	Make use of various non-parametric power spectrum estimation techniques to analyze the signals.	K3
CO3	Apply the concepts of linear estimation and prediction on discrete time signals.	K3
CO4	Illustrate the various adaptive filter algorithms and their applications.	K2

CO5	Apply the different transformation techniques for analyzing the signals.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I PARAMETRIC POWER SPECTRUM ESTIMATION 9

Parametric Methods for Power Spectrum Estimation: Relationship between Auto Correlation and Model Parameters – Model based approach: AR–MA - ARMA Signal modelling, The Yule Walker method for the AR model parameters - The Burg's method for the AR model parameters. MATLAB exercises on parametric power spectrum estimation

UNIT II NON-PARAMETRIC POWER SPECTRUM ESTIMATION 9

Periodogram, Modified Periodogram, Bartlett method - Welch method - Blackman Tukey method – Performance comparisons - Minimum variance spectrum estimation, Maximum entropy method, Frequency estimation method - MATLAB exercises on non-parametric power spectrum estimation

UNIT III LINEAR ESTIMATION AND PREDICTION 9

Maximum likelihood criterion - Efficiency of estimator - Least mean squared error criterion – Wiener filter: FIR Wiener Filter, IIR Wiener Filter-Recursive estimators Forward and backward linear prediction-Prediction error-Levinson recursion algorithm for solving Toeplitz system of equations – MATLAB exercises on estimation and prediction

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 canceller-Adaptive noise cancellation-Adaptive recursive filters – Recursive least squares – Recursive Kalman estimator and predictor.

UNIT V TIME-FREQUENCY AND FREQUENCY TRANSFORM BASED SIGNAL ANALYSIS **9**

Discrete cosine transform, Discrete sine transform, KL transform, Hadamard transform, Walsh transform, Short Time Fourier Transform and Wavelet transform - MATLAB implementation of transforms

Total: 45 Hrs

h) Learning Resources

Text Books

1. John G.Proakis and Dimitris G. Manolakis, "Digital Signal Processing, Principles, Algorithms and Applications", 3rd edition, Prentice Hall of India, 2001.
2. Monson H.Hayes, "Statistical Digital Signal Processing and Modeling", John Wiley & Sons, 2002.
3. Saeed V. Vaseghi, "Advanced Digital Signal Processing and Noise Reduction", 2nd Edition, John Wiley and Sons, 2008.

Reference Books

1. Simon Haykin,"AdaptiveFilterTheory",2nd Edition, Prentice Hall India, 2001.
2. S. M. Bozic, "Digital & Kalman Filtering", 2nd Edition, Dover Publications, Inc. Mineola, New York.
3. Roberto Crist, "Modern Digital Signal Processing", Thomson Brooks/Cole, 2004.
4. Raghuveer. M. Rao and Ajit S.Bopardikar, "Wavelet Transforms: Introduction to Theory and Applications", Pearson Education, Asia, 2000.
5. Alfred Mertins, "Signal Analysis: Wavelets, Filter Banks, Time-Frequency Transforms and Applications", John Wiley & sons, 1999.

Online Resources

1. www.redcedar.com/resources.htm
2. eleceng.dit.ie/dorran/moodle/
3. ocw.mit.edu › Supplemental Resources
4. www.ifp.illinois.edu/~minhdo/teaching/wavelets.htm
5. https://nptel.ac.in/courses/117101001

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

Upon 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	Illustrate concepts related to Parameter Estimation Techniques	K2
CO3	Summarize the various Practical Estimators	K2
CO4	Explain the different Bayesian Estimators	K2
CO5	Apply the Wiener filtering techniques in signal processing applications	K3

f) Correlation of COs with POs

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

Basic introduction to random variables, Spectral representation of random signals, Wiener Khinchine theorem, Properties of power spectral density, Gaussian Process and White noise process, Linear System with random input, Spectral factorization theorem and its importance.

UNIT II PARAMETER ESTIMATION THEORY 9

Principle of estimation and applications, Properties of estimates, unbiased and consistent estimators, Minimum Variance Unbiased Estimates (MVUE), Cramer-Rao bound.

UNIT III PRACTICAL ESTIMATORS 9

BLUE, Maximum likelihood estimators, Asymptotic properties of MLE, Least squares, Linear and Nonlinear techniques, Method of moments

UNIT IV BAYESIAN ESTIMATORS 9

Risk functions, MMSE estimators, MAP estimators, Linear Bayesian estimators, Vector parameter estimation, Sequential estimators

UNIT V GAUSSIAN NOISE SIGNAL ESTIMATORS 9

Wiener filters, Noise Cancellation, Lattice Representation for the FIR Wiener Filter, IIR Weiner Filter Kalman filters, MATLAB implementation of Wiener filters

Total 45 Hrs

h) Learning Resources

Text Books

1. Fundamentals of Statistical Signal Processing: Estimation Theory, Volume I, Steven M Kay, Pearson, 2010

2. Monson H. Hayes, "Statistical Digital Signal Processing and Modeling," John Wiley & Sons, 2008.
3. H. Stark and J. Woods, "Probability and Random Processes with Applications to Signal Processing", 3rd edition, Pearson Education, 2001

Reference Books

1. John G. Proakis "Algorithms for Statistical Signal Processing", Pearson Education, 2002.
2. Dimitris G. Manolakis "Statistical and Adaptive Signal Processing", Tata McGraw Hill, 2000.
3. Papoulis and S. Unnikrishna Pillai, "Probability, Random Variables and Stochastic Processes",Fourth Edition, McGraw Hill, 2002.

Online Resources:

1. https://www.coursera.org
2. https://www.upgrad.com
3. https://www.udemy.com

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

a) Course Category

Program Elective

b) Preamble

DSP algorithms and Architecture course provides an introduction on the industry based DSP processor's architecture and their algorithms. Students will 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 for Speech Recognition

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 Digital Signal Processing algorithm and the various architectures.	K2
CO2	Summarize the basic signal processing concepts and architectures of DSP processor.	K2
CO3	Illustrate the interfacing concepts of external memory, serial and parallel I/O devices.	K2
CO4	Make use of 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

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

g) Course Content

UNIT I ARCHITECTURES FOR PROGRAMMABLE DIGITAL SIGNAL PROCESSORS 9

Introduction: Basic Architectural Features – An overview of Motorola and Analog Device DSPs. 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. Avtar Singh and S. Srinivasan, "Digital Signal Processing", 4th edition, Thomson Publications, 2004
2. Sen M. Kuo, Woon-Seng S. Gan, "Digital Signal Processor - Architectures, Implementation and Applications", Pearson Prentice Hall, 2005.

Reference Books

1. Peter Pirsch, "Architectures for Digital Signal Processing", 2nd edition, John Weily,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", 4th edition, Pearson Education, 2004.
4. J.G.Proakis, "Algorithms for Statistical Signal Processing", 4th edition, Pearson, 2002.
5. TMS320C50, TMS320C54XX, TMS320C6713 data books.

Online Resources

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

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. Speech signal recognition is important for speech-to-text and text-to-speech conversion of signal. This course also covers the basic speech recognition techniques and distortion measures to analyze the speech signal.

c) Prerequisite

Signals and Systems,

d) Related Courses

Digital Image and Video Processing

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 speech and speech production system	K2
CO2	Explain the speech analysis techniques in time domain	K3
CO3	Explain the speech analysis techniques in frequency domain	K2
CO4	Illustrate the Hidden Markov Models for a given application.	K2
CO5	Explain the architecture and basic blocks of large speech recognition system and performance metrics	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I BASIC CONCEPTS 8

Fundamentals of speech recognition, Speech signal-speech production process, representing speech in the Time and Frequency Domains, Speech sounds and features, Automatic Speech Recognition-Acoustic- phonetic, statistical pattern- Recognition, Basics of AI in Speech Recognition.

UNIT II SPEECH SIGNAL ANALYSIS IN TIME DOMAIN 9

Speech signal analysis – segmental, sub-segmental and supra-segmental levels - Time domain parameters of speech signal – Methods for extracting the parameters Energy, Average Magnitude – Zero crossing Rate – Silence Discrimination using ZCR and energy – Short Time Auto Correlation Function – Pitch period estimation using Auto Correlation Function.

UNIT III SPEECH SIGNAL ANALYSIS IN FREQUENCY DOMAIN 10

Short Time Fourier analysis – Filter bank analysis – Formant extraction – Pitch Extraction – Homomorphic speech analysis - Cepstral analysis of Speech – Formant and Pitch Estimation. Linear Predictive analysis of speech - Autocorrelation method – Covariance method – Solution of LPC equations – Durbin's Recursive algorithm –Application of LPC parameters – Pitch detection using LPC parameters – Formant analysis.

UNIT IV INTRODUCTION TO HIDDEN MARKOV MODELS 8

Hidden Markov Model: Introduction, Discrete Markov Processes, Extension to HMMs, three basic problems for HMM, Types of HMM, Implementation issues.

UNIT V SPEECH RECOGNITION 10

Large Vocabulary Continuous Speech Recognition: Architecture of a large vocabulary continuous speech recognition system, language models-statistical, perplexity, context dependent sub-word units. Performance and evaluation of speech recognition systems, Case Study – Gender Identification using Pitch Frequency calculation using MATLAB, Isolated word recognition.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Lawrence Rabiner and Biing-Hwang Juang, “Fundamentals of Speech Recognition”, 1st edition, Pearson Education, 2003.
2. L.R. Rabiner and S. W. Schafer, “Digital Processing of Speech Signals”, Pearson Education, 2007
3. Ben Gold and Nelson Morgan, Speech and Audio Signal Processing, John Wiley and Sons Inc., Singapore, 2004

Reference Books

1. Thomas F Quatieri, “Discrete-Time Speech Signal Processing – Principles and Practice”, PearsonEducation, 2006
2. Frederick Jelinek, “Statistical Methods of Speech Recognition”, MIT Press, 1998
3. Daniel Jurafsky and James H Martin, “Speech and Language Processing - An Introductionto Natural Language Processing, Computational Linguistics, and Speech Recognition”, 2ndedition, Pearson Education, 2002.

Online resources

1. NOC | Digital speech processing (nptel.ac.in)

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 andpromising segments of Artificial Intelligence and machine learning technologies. However, with the increased availability of vast amounts of data and computational capability, it has evolved to a field of its own. In the last few years with numerous applications in computer vision, speech analysis, healthcare, agriculture, and understanding climate change etc. Thus, this course aims to provide basic knowledge about the deep learning
.

c) Prerequisite

Nil

d) Related Courses

Digital Image and Video Processing, Fundamentals of Machine Learning,
Fuzzy Neural Systems

e) Course Outcome

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 in Neural Networks and applications	K2
CO2	Summarize feed forward networks and their training issues	K2
CO3	Compare different types of ANN architectures	K2
CO4	Explain the deep learning concepts using Back Propagation Network	K2
CO5	Illustrate Convolution Neural Network model and its application in Object Detection	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO ARTIFICIAL NEURAL NETWORKS 9

Fundamentals of Neural Networks – Model of Artificial Neuron – McCulloch Pitts model, linear separability, Hebb model – Learning Methods – Taxonomy of Neural Network Architectures – Applications

UNIT II FEED FORWARD NEURAL NETWORKS 9

Perceptron Models: Discrete, Continuous and Multi-Category –Training Algorithms: Discrete and Continuous Perceptron Networks – Limitations of the Perceptron Model – Generalized Delta Rule, MLP, Derivation of Back propagation (BP) Training algorithm

UNIT III OTHER ANN ARCHITECTURES 9

Associative Memory – Exponential BAM – Associative Memory For Real Coded Pattern Pairs – Applications Adaptive Resonance Theory: Introduction – ART 1 – ART2 – Applications – Neural Networks Based On Competition – Kohenen Self Organizing Maps – Learning Vector Quantization – Counter Propagation Networks – Industrial Applications

UNIT IV DEEP LEARNING 9

Deep Feed Forward network, Training Deep Neural Networks, Activation functions, problem and solution of under fitting and over fitting, Cross Validation, Regularization, Hyper parameters-Gradient Descent and Back propagation, Python Exercises

UNIT V CONVOLUTIONAL NEURAL NETWORK 9

Introduction to CNNs, Architectural Overview, Layers, Filters, Convolution and Pooling Operation, Parameter sharing, Regularization, Case Studies: AlexNet, VGGNet, GoogLeNet, Mobilenet v1, ResNet – Application- Object Detection, Python Exercises

Total: 45 Hrs

h) Learning Resources

Text Books

1. Goodfellow, I., Bengio,Y., and Courville, A., Deep Learning, MIT Press, 2016.
2. Yegnanarayana, B., Artificial Neural Networks PHI Learning Pvt. Ltd, 2009.
3. CharuC.Aggarwal “Neural Networks and Deep learning” Springer International Publishing,2018
4. Satish Kumar, “Neural Networks, A Classroom Approach”, Tata McGraw - Hill, 2007.
5. Simon Haykin, “Neural Networks, A Comprehensive Foundation”, 2nd Edition, Addison Wesley Longman, 2001.

Reference Books

1. Josh Patterson, Adam Gibson, Deep Learning: A Practitioner's Approach, OReilly, 2017.
2. Bishop, Christopher M. Pattern Recognition and Machine Learning. Springer, 2006
3. Duda, Richard, Peter Hart, and David Stork. Pattern Classification. 2nd ed. New York, NY: Wiley-Interscience, 2000.

Online Resources

1. Michael Nielsen, “Neural Networks and Deep Learning”, Determination Press, 2015 http://neuralnetworksanddeeplearning.com/

Course Code	Course Title	L	T	P	C
10212EC125	**FUZZY- NEURAL SYSTEMS**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

This course covers the fundaments of Fuzzy systems and Neural Networks to applications. Fuzzy logic is form of multi-valued logic to deal with reasoning that is approximate rather than precise. Hence fuzzy logic approach is used to handle ambiguity and uncertainty existing in the complex problem. Neural networks have the ability to learn and can be used to model complex patterns and prediction problems. ANFIS has the ability to combine both into single framework, hence it has the learning capability and incorporates human decision making in solving complex real-world problems.

c) Prerequisite

Nil

d) Related Courses

ANN and Deep Learning, Soft computing

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Explain the fundamentals of Fuzzy set theory	K2
CO2	Compare the various Fuzzy Inference System	K2
CO3	Summarize the basics of Neural Network, Supervised Learning Networks, TDNN and Unsupervised Learning Network	K2
CO4	Explain the applications of Neural Network and Fuzzy Logic.	K2

CO5	Illustrate the Adaptive Neuro-Fuzzy Inference System and its applications	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUZZY SETS 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 network - supervised learning network: Perceptron networks - adaptive linear neuron, multiple adaptive linear neuron, RBF, TDNN associative memory network: auto-associative memory network, hetero-associative memory network, BAM, hopfield networks, iterative auto associative memory network & iterative associative memory network –unsupervised learning network: CP networks.

UNIT IV NEURAL NETWORK AND FUZZY LOGIC APPLICATIONS 9

Neural network applications: Process identification, control, fault diagnosis and load forecasting. Fuzzy logic applications: Fuzzy logic control and Fuzzy classification.

UNIT V ADAPTIVE NEURO-FUZZY INFERENCE SYSTEMS AND APPLICATIONS 9

Adaptive Neuro-Fuzzy Inference Systems – ANFIS Architecture – Applications - Non-linear system Identification – Channel Equalization – Adaptive Noise cancellation

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.
2. Laurene Fausett, "Fundamentals of Neural Networks”, Pearson Education, 2004.
3. S.Rajasekaran and G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm: Synthesis & Applications", Prentice-Hall of India Pvt. Ltd., 2006.

Reference Books

1. Timothy J. Ross, " Fuzzy Logic With Engineering Applications", Tata McGraw-
2. Hill Inc. 2000
3. George J. Klir and Bo Yuan, “Fuzzy Sets and Fuzzy Logic-Theory and Applications”, Prentice Hall, 1995.
4. James A. Freeman and David M. Skapura, “Neural Networks Algorithms, Applications and Programming Techniques”, Pearson Edn., 2003.
5. Satish Kumar, “Neural Network, A Classroom Approach”, Tata McGraw – Hill, 2007.
6. Simon Haykin, “Neural Network, A Comprehensive Foundation”, 2nd Edition Pearson Prentice Hall, 2005.
7. 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
2. https://nptel.ac.in/courses/117105084/

Course Code	Course Title	L	T	P	C
10212EC126	BIOMEDICAL INSTRUMENTATION AND IMAGING	3	0	0	3

a) Course Category

Program Elective

b) Preamble

This course is designed to make the student to acquire an adequate knowledge of the Systems/parts of the human body and relate them to the parameters that have clinical importance. Also, it inculcates knowledge of the fundamental principles of the various parameter measurement and imaging techniques used in clinical analysis.

c) Prerequisite

Nil.

d) Related Courses

Digital Image Processing, Image Analysis

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 physiology of significant parts of the body and basic instrumentation system.	K2
CO2	Explain the various electrical and non-electrical physiological measurements used in clinical analysis.	K2
CO3	Summarize the functionality of basic Medical Imaging Systems	K2
CO4	Illustrate the functionality and output of various special Imaging techniques.	K3
CO5	Summarize the safety measures and various therapeutic & assisting equipment.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I PHYSIOLOGYAND 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 ELECTRICAL AND NONELECTRICAL 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

Cineradiography, Cinefluorography, stereoscopic radiography, magnification radiography, microradiography, tomography, Neutron radiography. Cine angiogram– LASER imaging– endoscopy

UNIT V ASSISTING & THERAPEUTIC EQUIPMENT AND SAFETY MEASURES 9

Physiotherapy and electrotherapy - short ware, microwave diathermy –defibrillators – cardio vector –hearing aid – dialysis machine, pace makers. patient safety & monitoring – electrical safety, patient electrical safety, types of hazards, natural protective mechanism, leakage current, patient isolation, hazards in operation rooms, grounding conditions in hospital environment.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Leslie Cromwell, Fred.J. Weibell and Erich.A. Pfeiffer, "Biomedical Instrumentation and Measurements",2nd Edition,PHI,2007.
2. R.S.Khandpar, "Hand Book of Biomedical Instrumentation and measurement", McGraw Hill publishing Co.,1990
3. John G.Webster, "Medical Instrumentation Application and Design", John Wi ley and sons,NewYork,2009

Reference Books

1. Claudio Becchetti, Alessandro Neri, "Medical Instrument Design and Development from Requirement to Market Placements", Wiley Publication, 2013
2. Khandpur R.S, "Handbook of Biomedical Instrumentation", Tata McGraw-Hill, New Delhi, 2003.
3. Myer Kutz, " Standard Handbook of Biomedical Engineering & Design", McGraw-Hill Publisher, UK,2003
4. Arumugam,"Biomedical Instrumentation", Anuradha Agencies Publishers, Vidayal Karuppar,612606, Kumbakonam,R.M.S:1992
5. Joseph J. Carr and John M.Brown, "Introduction to Biomedical Equipment Technology", Pearson Education, 2004.
6. R. Anandanatarajan,"Biomedical Instrumentation", PHI Learning,2009.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc18_ec02/preview
2. https://www.lecturio.com/
3. www.globalspec.com

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

The Purpose of the course is to provide students with the basic knowledge of image and video processing.

c) Prerequisite

Nil

d) Related Courses

Fundamentals of Machine Learning- ANN and Deep Learning- Machine Vision

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	Utilize the basic concepts of image processing and perform operation on images using various transforms	K3
CO2	Apply various image enhancement and restoration techniques in image processing	K3
CO3	Apply the various image enhancement and compression techniques in image processing	K3
CO4	Make use of the basic concepts of video processing and perform the sampling of video signal	K3
CO5	Choose motion estimation techniques and appropriate coding system for video processing	K3

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	L	L	-	H	-	-	-	H	-	-	L	L	L
CO2	H	H	L	-	L	-	-	-	L	-	-	L	L	L
CO3	M	M	L	-	L	-	-	-	L	-	-	L	L	L
CO4	M	M	L	-	L	-	-	-	L	-	-	L	L	L
CO5	M	L	L	-	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- Image transform: Need for 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- Selective filtering- Image Restoration: Introduction to Image restoration- Image degradation- Image restoration model- Linear and Nonlinear image restoration techniques.

UNIT III IMAGE SEGMENTATION AND IMAGE COMPRESSION 6

Image Segmentation: Point- Line and Edge Detection- thresholding- region-based segmentation- region growing- Image Compression: need for image compression- compression models- lossless and lossy compression- Huffman coding- arithmetic coding- Wavelet-based image compression- JPEG Standards.

UNIT IV INTRODUCTION TO VIDEO PROCESSING 6

Analog video- digital video- time-varying image formation models: Three-dimensional motion models- geometric image formation- photometric image formation- sampling of video signals- filtering operations

UNIT V MOTION ESTIMATION 6

Optical flow- general methodologies- pixel-based motion estimation- block- matching algorithm- mesh-based motion estimation- global motion estimation- region-based motion estimation- multi resolution motion estimation- waveform-based coding- block-based transform coding- predictive coding.

LIST OF EXPERIMENTS **30 Hrs**

S. No.	Name of the Experiment	CO	Skill Level
1	Perform basic operations on images like arithmetic, logical, transformation etc	CO1	S3
2	Discretization of an image using DFT, DCT, DWT	CO1	S3
3	Perform enhancement operation on an image	CO2	S3
4	Apply various restoration techniques on an image	CO2	S3
5	Apply various segmentation techniques on an image	CO3	S3
6	Perform Lossy image compression	CO3	S3
7	Perform Lossless image compression	CO3	S3
8	Conversion of video into various frames	CO4	S3
9	Apply motion estimation techniques on video	CO5	S3
10	Perform video compression and decompression process (Beyond the Syllabus)	CO5	S3

Total: 60 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
3. Yao Wang Jorn Ostermann and Ya quin Zhang, “Video Processing and Communication”, Prentice Hall, 2002.

Reference Books

1. Scotte E Umbaugh, “Digital Image Processing and Analysis-Human and Computer Vision Application with CVIP Tools”, 2nd Edition, CRC Press, 2011.
2. A Murat Tekalp, “Digital Video Processing”, Prentice Hall International, 2nd Edition, 2015.

3. John Woods, “Multidimensional Signal, Image and Video Processing and Coding”, Elsevier, 2nd Edition, 2011.
4. Keith Jack, “Video Demystified – A Hand Book for the Digital Engineer”, Elsevier, 5th Edition., 2007.

Online Resources

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

Course Code	Course Title	L	T	P	C
10212EC214	**FUNDAMENTALS OF MACHINE LEARNING**	**2**	**0**	**2**	**3**

a) Course Category

Program 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 will combine theory and practice to enable the student to gain the necessary knowledge to compete in the ever changing work environment. Machine learning is the technology of designing and implementing algorithms that allow computers to automatically learn from data or past experience and improve their performance without being explicitly programmed. It forms the basis of artificial intelligence. It involves algorithms to design coding by which computers can decipher information. This course covers the fundamental concepts of machine learning and popular machine learning algorithms, core concepts of Bayesian decision theory, Linear regression, Logistic regression and Support Vector Machines along with hands-on problem solving using simple python programming.

c) Prerequisite

Nil

d) Related Courses

ANN and Deep Learning

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the Machine Learning (ML) concepts, Classify the learning paradigms and solve simple ML problems by using simulation tools.	K3

CO2	Utilize the principle and concepts behind Bayes Decision theory and write simple python programs to implement it in prediction, classification and estimation	K3
CO3	Choose from a wide variety of Linear Regression algorithms and solve by implementation using established tools.	K3
CO4	Identify the different Logistic Regression algorithms and code simple programs using software tools.	K3
CO5	Make use of Support Vector Machine concepts and implement algorithms to solve classic ML problems.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I MACHINE LEARNING BASIC 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 tradeoff – Naïve Bayes model.

UNIT III LINEAR REGRESSION **6**

Simple linear regression –Multiple linear regression–Variable selection– F-tests – Least squares estimation – Collinearity – Residual analysis– Nonlinear regression

UNIT IV LOGISTIC REGRESSION **6**

Logistic Regression Model–Multiple logistic regression – Methods for Logistic Regression: Variable selection stepwise Logistic Regression, Best subset Logistic Regression –Application of Logistic Regression.

UNIT V SUPPORT VECTOR MACHINE **6**

Introduction- Maximum Margin Classification- Mathematics behind Maximum Margin classification- Maximum Margin linear separators- non-linear SVM- Kernels for learning non-linear functions.

LIST OF EXPERIMENTS

Hardware requirement:

i5 Processor, 8GB RAM, & Internet Connection

Software Environment:

IDE recommended PYCHARM (Recommended), JUPYTER, VISUAL STUDIO

S.No.	**Name of the Experiment**	**CO**	**Skill Level**
1	Online Retail Case Study	CO1	S3
2	Program to demonstrate Housing Price Prediction	CO2	S3
3	Program to demonstrate on Prediction using Bayes Rule.	CO2	S3
4	Program to demonstrate classification/estimation using Bayes Rule.	CO2	S3
5	Program to demonstrate Simple Linear Regression	CO3	S3
6	Program to demonstrate Multiple Linear Regression	CO3	S3
7	Program to demonstrate Non Linear Regression	CO3	S3
8	Program to demonstrate Binary and Multiple Logistic Regression	CO4	S3
9	Program to demonstrate Binomial Logistic Regression	CO4	S3
10	Program to demonstrate SVM based classification	CO5	S3
11	Case study on non-linear SVM classifier	CO5	S3

Total: 60 Hrs

h) Learning Resources

Text Books

1. Kevin P. Murphy, “Machine Learning: A Probabilistic Perspective”, MIT Press 2012.
2. Ethem Alpaydin, “Introduction to Machine Learning”, 3nd Edition, MIT Press 2014.
3. Richert & Coelho, “Building Machine Learning Systems with Python”, 3rd Edition, Packt Publishers, 2018.

Reference Books

1. Trevor Hastie, Robert Tibshirani, Jerome Friedman, “The Elements of Statistical Learning”, Second edition Springer 2017.
2. Weisberg, Sanford, “Applied Linear Regression”, 4th Edition, John Wiley & Sons, 2014.
3. Bishop, Christopher M. “Pattern Recognition and Machine Learning”. Springer, 2006
4. 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.

Course Code	Course Title	L	T	P	C
10212EC215	**PROFESSIONAL PYTHON PROGRAMMING**	**2**	**0**	**2**	**3**

a) Course Category

Program Elective

b) Preamble

The Purpose of the course is to provide students with the basic knowledge of python programming. To solve real world problems in an efficient manner, this course also emphasis on algorithm and Programming used in different applications.

c) Prerequisite

Basics of Python Programming

d) Related Courses

Digital Image Processing, Introduction to machine learning, ANN and Deep Learning, Fuzzy-Neural 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	Use object-oriented programming concept in python to solve a given problem	K3
CO2	Apply basic operations on different kinds of files like XML, CSV, and SQL database	K3
CO3	Apply common Python functionality and features for data science	K3
CO4	Use Python programming and plot the data using different kinds of plots	K3
CO5	Apply the python programming for networking applications.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I OBJECT ORIENTED PROGRAMMING WITH PYTHON 6

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 6

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 DATASCIENCE 6

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 6

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 6

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	Skill Level
1	Simulation of elliptical orbits in Pygame	CO1	S3
2	Simulation of bouncing ball using Pygame	CO1	S3
3	Demonstrate class variable, instance variable, and self variable for implementing (a) Robot (b) ATM Machine	CO1	S3
4	Develop a Python program to interact with SQLite databases	CO2	S3
5	Demonstrate the processing of XML files in Python	CO2	S3
6	Demonstrate the processing of CSV files in Python	CO2	S3
7	Develop a python program to explore python packages – NumPy and Pandas	CO3	S3
8	Creation of dataframe from ndarrays/lists/list of dictionaries	CO3	S3
9	Demonstration of filtering data in a Pandas dataframe	CO3	S3
10	Demonstrate the use of Matplotlib package and bringing other Python libraries with Matplotlib	CO4	S3
11	Demonstrate the use of line plots and area plots	CO4	S3
12	Demonstrate the use of Bar Charts, Pie Charts	CO4	S3
13	Creation of client server programming using TCP/UDP socket	CO5	S3
14	Develop a python program to send e-mail.	CO5	S3
15	Creation of GUI application using Tkinter module.	CO5	S3

Total: 60 Hrs

h) Learning Resources

Text Books

1. Matt Weisfeld, “The Object-Oriented Thought Process”, Bronkella Publishing LLC, 4^{th} Edition, 2013, ISBN: 978-0-321-86127-6.
2. Lillian Pierson, “Data Science Dummies”, John Wiley Publishers, 2nd Edition, 2017, ISBN:978-1-119-32763-9.

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://nptel.ac.in/courses/106/106/106106182/
3. https://online.umich.edu/courses/introduction-to-data-science-in-python/

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	Classify the special techniques to mitigate the power consumption in VLSI circuits	K2
CO4	Illustrate the power estimation at logic and circuit level	K2
CO5	Explain the software design for low power in various level	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	PO10	PO11	PO12	PSO1	PSO2
CO1	H	H	M	L	-	-	-	-	-	-	-	H	M	-
CO2	M	L	H	M	-	-	-	-	-	-	-	L	L	-
CO3	H	L	M	H	-	-	-	-	-	-	-	L	H	-
CO4	H	H	M	H	-	-	-	-	-	-	-	M	M	-
CO5	M	M	H	H	-	-	-	-	-	-	-	H	L	-

g) Course Content

UNIT I POWER DISSIPATION IN CMOS 9

Sources of power dissipation – Needs for Low Power VLSI Chips - Physics of power dissipation in MOSFET devices: The MIS structure, Long channel MOSFET, Submicron MOSFET, Gate induced drain leakage – Power dissipation in CMOS: Short circuit dissipation, Dynamic dissipation, Load capacitance – Low power VLSI design limits: Principles of low power design, Hierarchy of limits, Fundamental limit, Material limit, Device limit, Circuit limit, System limit and Practical limits.

UNIT II DESIGN OF LOW POWER CIRCUITS 9

Transistor and Gate Sizing: Sizing an Inverter Chain, Transistor and Gate Sizing for Dynamic Power Reduction, Transistor Sizing for Leakage Power Reduction – Equivalent Pin Ordering - Network Restructuring and Reorganization : Transistor Network Restructuring, Transistor Network Partitioning and Reorganization - Special Latches and Flip-flops : Self-gating Flip-flop, Combinational Flip-flop, Double Edge Triggered Flip-flop - Low Power Digital Cell Library : Cell Sizes and Spacing, Varieties of Boolean Functions - Adjustable Device Threshold Voltage

UNIT III POWER OPTIMIZATION USING SPECIAL TECHNIQUES 9

Power reduction in clock networks: Clock gating, Reduced swing clock, Oscillator circuit for clock generation, Frequency division and Multiplication, Other clock power reduction techniques - CMOS floating node: Tristate keeper circuit, Blocking gate - Low power bus: Low swing bus, Charge recycling bus - Delay balancing - Low power techniques for SRAM: SRAM cell, Memory bank partitioning, Pulsed word line and reduced bit line swing

UNIT IV ADVANCED LOW POWER TECHNIQUES 9

Adiabatic Computation - pass transistor logic synthesis - asynchronous circuits - energy recovery circuit design - designs with partially reversible logic: design with reversible logic, adiabatic dynamic logic, energy recovery SRAM core, and optimal voltage selection - supply clock generation.

UNIT V SOFTWARE DESIGN FOR LOW POWER 9

Sources of software power dissipation - Software power estimation: Gate level, Architecture level, Bus switching activity, Instruction level power analysis - Software power optimization: Minimizing memory access costs, Instruction selection and ordering, Power management - Automated low power code generation – Co-design for low power.

Total 45 Hrs

h) Learning Resources

Text Books

1. Kaushik Roy and S.C.Prasad, "Low power CMOS VLSI circuit design", Wiley, 2000
2. Gary Yeap, "Practical low power digital VLSI design", Kluwer, 1998
3. A.P.Chandrasekaran and R.W.Broadersen, "Low power digital CMOS design", Kluwer,1995

Reference Books

1. DimitriosSoudris, Christians Pignet, Costas Goutis, "Designing CMOS Circuits for Low Power", 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", John Wiley and sons, inc. 2001
5. Steven M.Rubin, "Computer Aids for VLSI Design", Addison Wesley Publishing

Online Resources

1. http://nptel.ac.in/syllabus/106105034/
2. https://www.youtube.com/watch?v=LjDb6VQlOeQ
3. http://freevideolectures.com/Course/3059/Low-Power-VLSI-Circuits-and-Systems
4. 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 mathematicaloptimization, 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 submicron technology. Throughout the course, students will beexposed 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) Prerequisite

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	Restate sub-micron challenges and relate them to issues in physical synthesis of ICs.	K2

f) Correlation of COs with Pos

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

g) Course Content

UNIT I DESIGN METHODS AND AUTOMATION TOOLS 9

Design domains and Actions – Design methods and Technologies – Levels of abstractions in Design Automation tools – Graph terminology – data structures for the representation of graphs – Complexity Issues and NP-Hardness: algorithms for NP-hard problems– Graph Algorithms:Depth-First Search Algorithm, Breadth-First Search Algorithms and Dijikstra's Shortest path Algorithms.

UNIT II LAYOUT DESIGN 8

Design Rules – Symbolic Layout – Problem Formulation: Classification of Compaction algorithms- 3/2 dimensional compaction-2D compaction- Hierarchical compaction- Recent trends in Compaction, Informal Problem formulation, Graph theoretical formulation, Maximum design constraints, Algorithms for Constraint graph compaction.

UNIT III PLACEMENT, PARTITIONING AND PLANNING 10

Circuit Representation – Wire length estimation – Placement Problems – Placement Algorithms: Constructive placement, Iterative improvements – Partitioning: K-Lin Partitioning Algorithms - Floorplanning concepts: Terminology and Floorplan representation, Optimization problems in Floorplanning – Shape functions and Floorplan 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 forPhysical Design Automation,” CRC Press, 2008.
2. M. Sarrafzadeh and C.K. Wong, “An Introduction to VLSI Physical Design,” McGrawHill, 1996.

Course Code	Course Title	L	T	P	C
10212EC129	**VLSI FOR WIRELESS COMMUNICATION**	**3**	**0**	**0**	**3**

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, Linear Integrated Circuits, Digital Communication and Communication Systems

d) **Related Courses**

Wireless Communication Networks and Wireless technologies

e) **Course Outcomes**

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the Transmitter and Receiver Architectures	K3
CO2	Discuss the Low Noise Amplifier which includes wideband, narrow band for impedance matching and Power Amplifier	K2
CO3	Describe 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

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

g) Course Content

UNIT I OVERVIEW OF WIRELESS COMMUNICATION SYSTEMS 9

Introduction of wireless system-Transmitter Back End-Quadrature LO generator-Receiver Front end-Filter Design-Rest of receiver front end: non idealities and design parameters-Derivation of Noise Figure (NF) and input third order Intercept points (IIP3) of receiver front end-Partitioning of required NF and IIP3 of receiver front end into individual NF and IIP3

UNIT II LOW NOISE AMPLIFIER AND POWER AMPLIFIER 9

Low Noise Amplifier – Matching Network-Wideband LNA –DC Bias-Gain and frequency Response-Noise Figure-Narrowband LNA-Impedance Matching-Matching of Imaginary and real Part-Interpretation of Power Matching-Power Amplifier Design-Specifications-Power output control-Class A Amplifiers-Class AB/B/C Amplifiers-Class E Amplifier.

UNIT III MIXERS 9

Active Mixer: Balancing Mixer-Qualitative Description of the Gilbert Mixer-Conversion Gain-Distortion-Analysis of Gilbert Mixer of Low Frequency Case and High-Frequency Case-Noise.

Passive Mixer: Switching Mixer – Distortion-Conversion Gain and Noise in Unbalanced Switching-Conversion Gain-Sampling Mixture-Gain-Distortion and noise in Single Ended Sampling Mixer.

UNIT IV FREQUENCY SYNTHESIZER 9

Phase Locked Loops-Phase Detector-VCO-Dividers-LC Oscillators-Ring Oscillators-Phase Noise-Loop Filter-First order filter-Second order filter-High Order filter-Design Approach: A complete synthesizer design example (DECT Application)-Implementation of a Frequency Synthesizer with a Fractional Divider Architecture

UNIT V VLSI ARCHITECTURE FOR WIRELESS COMMUNICATION 9

Design and Implementation of Ultralow-Power ZigBee/WPAN Receiver-Split-LNTA + 50% LO Receiver-Comparison of Split-LNTA + 50% LO and Single-LNTA + 25% LO" Architectures-Gain-NF-IIP3-Current and Voltage-Mode Operations-Circuit Techniques-Impedance Up-conversion Matching- Mixer–TIA Interface Biased for Impedance Transfer Filtering- RC-CR Network and VCO co-design

Total: 45 Hrs

h) Learning Resources

Text Books

1. Bosco H Leung "VLSI for Wireless Communication", Springer, 2nd edition, 2011.
2. Rhee, Woogeun, ed. "Wireless Transceiver Circuits: System Perspectives and Design Aspects", CRC Press, 2015.
3. Crols, Jan, and Michiel Steyaert "CMOS wireless transceiver design", Vol. 411. Springer Science & Business Media, 2013.
4. Razavi, Behzad, and Razavi Behzad "RF microelectronics", Vol. 2. New York: Prentice hall, 2012.

Reference Books

1. ThomasH. Lee "The Design of CMOS Radio–Frequency Integrated Circuits", Cambridge University Press, 2003.
2. Marzuki, Arjuna "CMOS Analog and Mixed-signal Circuit Design: Practices and Innovations", CRC Press, 2020.
3. Emad N Farag and Mohamed I Elmasry, "Mixed Signal VLSI Wireless Design – Circuitsand Systems", Springer, 2002.

Online Resource

1. www.nptelvideos.in/2012/12/wireless-communication.html
2. www.springer.com/us/book/9781461409854/.

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

a) Course Category

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 physics of semiconductors	K2
CO2	Classify the carrier transport mechanisms in semiconductors	K2
CO3	Demonstrate an operation of PN junctions	K2
CO4	Illustrate the physics of operation of bipolar junction transistor	K2
CO5	Illustrate the physics of operation of MOS capacitor and MOSFET	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	M	-	L	-	-	-	-	-	-	-	M	-	-
CO2	H	M	-	M	-	-	-	-	-	-	-	M	-	-
CO3	H	H	-	L	-	-	-	-	-	-	-	M	-	-
CO4	H	H	-	L	L	L	-	-	L	M	L	M	M	-
CO5	H	H	-	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 – FinFETs and Junction less FETs.

Total: 60 Hrs

h) Learning Resources

Text Books

1. Ben G. Streetman and Sanjay Kumar Banerjee, Solid State Electronic Devices, Pearson, 7/e, 2014.

Reference Books

1. 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
4. Achuthan, K N Bhat, Fundamentals of Semiconductor Devices, 1e, McGraw Hill,2015

Online Resources

1. https://nptel.ac.in/courses/117106091
2. https://nanohub.org/groups/semiconductors

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

a) Course Category

Program Elective

b) Preamble

This course explains the fundamental principles of algorithms available for performing arithmetic 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	Describe various algorithm for efficient architecture mapping	K2
CO2	Construct the various adder and multiplier architecture	K2
CO3	Construct the VLSI architecture for various DSP blocks	K2
CO4	Describe CORDIC architecture with any applications	K2
CO5	Illustrate the timing issues in VLSI	K2

f)	Correlation of COs with POs													
	PO1	**PO2**	**PO3**	**PO4**	**PO5**	**PO6**	**PO7**	**PO8**	**PO9**	**PO10**	**PO 11**	**PO 12**	**PSO 1**	**PSO 2**
CO1	H	H	M	L	M				`			H	M	M
CO2	H	L	M	H	L							L	H	H
CO3	M	L	H	M	L	M	L		M	L		L	L	L
CO4	H	H	M	H	L	M	L		M	L		M	M	M
CO5	M	M	H	H	L							H	L	L

g) Course Content

UNIT I ALGORITHM TO EFFICIENT ARCHITECTURE MAPPING 9

One bit incrementer, n-bit incrementer and decrementer, ones' complement, two's complement, Single bit addition, sum of N –natural numbers, Resource sharing , prioritization, greatest common divisor (GCD).

UNIT II ADDER AND MULTIPLIERARCHITECTURE 9

Carry – Skip adder, Carry-Look ahead adder, Carry –Select adder, Array multiplication, squaring, shift and add multiplier, Tree Multiplier, Booth algorithm, Dadda multipliers

UNIT III EFFICIENT VLSI ARCHITECTURES 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, New techniques – 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 propagationdelay, 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

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

a) Course Category

Program Elective

b) Preamble

In this subject we are discussing about the essential of MOS transistor scaling and how the short-channel effects can be minimized.

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	Apply the physics of multigate MOS system	K2
CO3	Identify the performance of Nanowire FETs	K2
CO4	Identify the transistors at the molecular scale and understand about the radiation effects	K2
CO5	Explain about the concept of circuit design using multigate devices	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	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	H	M	-	L	-	-	-	-	-	-	-	M	-	-
CO2	H	M	-	M	-	-	-	-	-	-	-	M	-	-
CO3	H	H	-	L	-	-	-	-	-	-	-	M	-	-
CO4	H	H	-	L	L	L	-	L	L	M	L	M	-	-
CO5	H	H	-	L	L	-	L	-	L	M	L	M	M	-

g) Course Content

UNIT I INTRODUCTION TO NOVEL MOSFETS 9

MOSFET scaling ,short channel effects-channel engineering - source/drain engineering – high k dielectric - copper interconnects - strain engineering, SOI MOSFET, multigate transistors – single gate – double gate – triple gate – surround gate

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 – two dimensional confinement, scattering – mobility.

UNIT III NANOWIRE FETS 9

Silicon nanowire MOSFETs – Evaluation of I-V characteristics – The I-V characteristics for nondegenerate carrier statistics – The I-V characteristics for degenerate carrier statistics – Carbon nanotubes – Carbon nanotube FETs.

UNIT IV TRANSISTORS AT THE MOLECULAR SCALE AND RADIATION EFFECTS 9

Electronic conduction in molecules – General model for ballistic nanotransistors – MOSFETs with 0D, 1D, and 2D channels – Molecular transistors -Radiation effects in SOI MOSFETs, total ionizing dose effects – single gate SOI – multigate devices, single event effect

UNIT V CIRCUIT DESIGN USING MULTIGATE DEVICES 9

Digital circuits – impact of device performance on digital circuits – leakage performance tradeoff – multi VT devices and circuits – SRAM design, analog circuit design – transconductance – intrinsic gain – flicker noise – self heating –band gap voltage reference – operational amplifier – comparator designs, mixed signal – successive approximation DAC, RF circuits

Total: 45 Hrs

h) Learning Resources

Text Books

1. J P Colinge, FINFETs and other multi-gate transistors, Springer – Series on integrated circuitsand systems, 2008
2. Mark Lundstrom Jing Guo, Nanoscale Transistors: Device Physics, Modeling and Simulation,Springer,2006

Reference Books

1. M S Lundstorm, Fundamentals of Carrier Transport**,** 2nd Ed., Cambridge University Press, Cambridge UK, 2000

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 provide 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, Advanced Optical 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	Describe the fundamentals of optoelectronics	K2
CO2	Discuss the different types of display devices and operating principle of laser	K2
CO3	Classify the different types of photo detectors	K3
CO4	Explain about the modulators and switching devices	K2
CO5	Explain the integration methods, materials, OEIC transmitters receivers, guided wave devices and photonic integrated circuits	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUNDAMENTALS OF OPTOELECTRONICS 9

Nature of Light, Wave Nature of Light: Polarization – Interference - Diffraction, Light Sources: Blackbody Radiation, Units of Light, Generation of Photo electronics, Elements of Solid State Physics - Quantum Mechanical Concept, Energy Bands in Solids, Semiconductors and Semiconductor Junction Devices.

UNIT II DISPLAY DEVICES AND LASER 9

Luminescence, Photoluminescence Cathode luminescence, Cathode Ray Tube, Electro Luminescence, Injection Luminescence, LED: Materials - Commercial LED Materials – Construction - Drive circuitry, Plasma Display, Liquid Crystal Displays, Thermal Sensing 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.

UNIT V PHOTONICS & OPTOELECTRONIC INTEGRATED CIRCUITS 9

Hybrid and Monolithic Integration, Applications of Optoelectronic Integrated Circuits, Materials and Processing for OEICs, Integrated Transmitters and Receivers- Front End Photo Receiver - PIN HBT Photo Receiver - OEIC Transmitter, Guided Wave Devices. Photonics, Photonic Integrated Circuits, Recent Developments in Photonic Integrated Circuits.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Pallab Bhattacharya "Semiconductor Opto Electronic Devices", Prentice Hall 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", Mc Graw-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/

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) **Prerequisite**

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	Describe the working principle and measurement techniques of various types of oscillators and signal analyzers.	K2
CO3	Explain the working and measurement techniques of different types of waveform generators.	K3
CO4	Illustrate the various measurements and errors in instrumentations.	K2
CO5	Explain the standard forms of interfaces used in electronic instrumentation for various applications.	K2

f) **Correlation of COs with POs**

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CO2	M	-	-	-	L	-	-	-	-	-	-	M	L	-
CO3	M	-	-	-	L	-	-	-	L	L	L	L	L	-
CO4	M	-	-	-	-	-	-	-	-	-	-	L	L	-
CO5	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 multi meter and ohmmeter, Digital frequency meter, Digital LCR meter, Q-Meter, Digital wattmeter and energy meters, microprocessor based DMM with auto ranging and self-diagnostic features.

UNIT II OSCILLOSCOPE & SIGNAL ANALYZERS 9

General purpose cathode ray oscilloscope – Dual trace, dual beam and sampling oscilloscopes – analog and digital storage oscilloscope - frequency selective and heterodyne wave analyser – harmonic distortion analyser – spectrum analyser

UNIT III WAVEFORM GENERATORS 9

Wien's bridge and phase shift oscillators – Hartley and crystal oscillators – square wave and pulse generators – triangular wave-shape generator - signal and function generators, square, triangular sinusoidal waveform generator – Q meter, electronic counters

UNIT IV MEASUREMENTS AND CALIBRATION 9

Introduction, significance of measurement, measurement characteristics, measurement of quality factor (Q), Calibration of instruments, Static & dynamic characteristics. Current, Power and Energy Measurement, Time measurement, Frequency measurement, phase angle measurement, Humidity and moisture measurement.

UNIT V COMMON INSTRUMENTATION INTERFACES 9

Modern instrumentation and control systems – OSI model – EIA 232 interface standard - EIA 485 interface standard - EIA 422 interface standard – 20 mA current loop – serial interface converters

Total: 45 Hrs

h) Learning Resources

Text Books

1. A.K. Sawhney, A Course in "Electrical & Electronic Measurements and Instrumentation", Nineteenth revised edition, DhanpatRai 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

Course Code	Course Title	L	T	P	C
10212EC135	**NANO PHOTONICS**	**3**	**1**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

This course shall introduce the basic principles, applications and latest advances in the area of Nanophotonics. 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, nanophotonic devices, nanophotonics in medicine, etc,.

c) Prerequisite

Basics Electronic engineering, Electromagnetics field.

d) Related Courses

Fiber Lasers and Application, Opto Electronic Devices

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 interaction of light with nano-scale features on objects	K2
CO2	Explain the basics of photonics, Building blocks of photonic circuits and its effects.	K2
CO3	Discuss the functions, properties and different methods of nanolithography process.	K2
CO4	Describe broadly about the impact of biomedical research in biotechnology.	K2
CO5	Explore the scientific discoveries lead to technological inventions with Nano photonics.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION 9

Introduction, Photonics, Nanophotonics, Light and matter on a nanometer scale, Photonic Band Structures, Bloch's Theorem, 1D, 2D, and 3D photonic crystals, Isofrequencies of Photonic Crystals, Impact of Nanophotonics, Trends in Nanophotonics, Opportunities for Basic Research and Development of New Technologies, scope of nanophotonics.

UNIT II NANOPHOTONICS 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 NANOLITHOGRAPHY 9

Introduction, Lithography, Two Photon Lithography, Near Field Lithography, Near Field Phase Mask, Soft Lithography, Plasmon Printing, Nanosphere Lithography, Dip-Pen Nanolithography, Nanoimprint Lithography, Photonically Aligned Nanoarrays

UNIT IV NANOPHOTONICS FOR BIOTECHNOLOGY 9

Near-Field Bioimaging, Nanoparticles for Optical Diagnostics and Targeted Therapy, Semiconductor Quantum Dots for Bioimaging, Biosensing - Photonic Crystal Biosensors, Optical Nanofiber Sensors. Nanoclinics for Optical Diagnostics and Targeted Therapy.

UNIT V NANOPHOTONICS AND ITS APPLICATIONS 9

Lasers and Photonics: Photonics – Nanophotonics, Optical Nanomaterials: Nanoparticle Coatings - Sunscreen Nanoparticles - Self-Cleaning Glass - Photonic Crystal Fibers, Quantum-Confined Lasers, Photonic-Crystal Light-Emitting Diodes - Photonic-Crystal Sensors- Dense Wavelength Multiplexing and Demultiplexing- Pseudoscopic Frequency-Selective Imaging, Photonics in Future: Power Generation and Conversion - Sensor Technology – Nano medicine

Total: 45 Hrs

h) Learning Resources

Text Books

1. Paras N. Prasad, "Nanophotonics", John Wiley & Sons, Inc. 2004. ISBN:9780471649885.

Reference Books

1. Sergey V. Gaponenko, Introduction to Nanophotonics", Cambridge University Press,2010.
2. F. Graham Smith, Terry A. King and Dan Wilkins, "Optics and Photonics: An Introduction",second edition, John Willey Sons limited, 2007.
3. Gaponenko, S. (2010). Introduction to Nanophotonics. Cambridge: Cambridge University Press. doi:10.1017/CBO9780511750502.
4. Simovski, C., & Tretyakov, S. (2020). An Introduction to Metamaterials and Nanophotonics. Cambridge: Cambridge University Press. doi:10.1017/9781108610735.

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Course Code	Course Title	L	T	P	C
10212EC136	**FIBER LASERS AND APPLICATIONS**	**3**	**1**	**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

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	Understand the theoretical background of laser operationand types	K2
CO2	Understand the fabrication of different lasers using the electromagnetic field equations.	K2
CO3	Understand the various types of laser demonstration withdifferent design parameters	K2
CO4	Analyze the laser characteristics by the modelling of lasercavity. Understand the split step Fourier method.	K2
CO5	Understand the various applications of fiber lasers in different fields.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L	-	-	L	-	-	-	-	-	-	L	-	-
CO2	L	M	M	L	M	-	-	-	-	-	-	M	L	-
CO3	M	M	L	M	-	L	-	-	M	L	L	-	-	-
CO4	L	L	M	M	-	-	-	L	-	-	-	M	-	-
CO5	M	M	L	L	M	M	L	-	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 - multiwavelength 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. Govind P. Agarwal," Applications of Nonlinear Fiber Optics" Second Edition, 2007.
3. Le Nguyen Binh , Nam Quoc Ngo, "Ultra-Fast Fiber Lasers" Principles and Applicationswith MATLAB Models", CRC Press, 2011.
4. Jean-Claude Diels, Wolfgang Rudolph," Ultra short Laser Pulse Phenomena, Fundamentals, Techniques, and Applications on a Femtosecond Time Scale" Academic Press ,Second Edition, 2006.
5. Laser Application in Surface Science and Technology, by H. G. Rubahn; John Wiley and Sons, 1999.
6. Laser Spectroscopy: Basic Concepts and Instrumentation, by Demtroder; Springer, 2004.

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

Nil

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	Expertise in various calibration techniques and signal types for sensors	K2
CO2	Describe construction, working principle, characteristics and applications of various resistance transducers	K2
CO3	Explain the working principle of various inductance and capacitance transducers	K3
CO4	Study 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

	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	-	H	-	-	-	-	-	-	-	-	L	-
CO2	L	-	M	-	-	H	-	L	-	-	-		M	-
CO3	L	M	-	M	-	-	L	-	L	L	-	-	L	-
CO4	-	-	H	M	M	-	-	L	L	L		-	M	-
CO5	-	-	H	M	M	-	-	L	L	L	L	-	H	L

g) Course Content

UNIT I INTRODUCTION TO MEASUREMENTS SYSTEMS 9

Generalized measurement system - Static calibration – Limiting error and probable error- Classification of errors – Error analysis – Statistical methods – Odds and uncertainty – Static characteristics – Accuracy, precision, resolution, threshold, sensitivity, linearity, repeatability, reproducibility, loading effect, drift, static error, span and range, hysteresis, dead time and dead zone, Dynamic characteristics

UNIT II RESISTANCE TRANSDUCERS 9

Classification of transducers – Selection of transducers , potentiometer : Principle of operation, construction details, Strain gauge – types , Load and torque measurement, Resistance temperature detector (RTD)- Thermistor –Hot-wire anemometer– constant current and constant temperature operation - Resistive humidity sensor

UNIT III INDUCTANCE AND CAPACITANCE TRANSDUCERS 9

Induction potentiometer – Variable reluctance transducer – Eddy current transducer –Principle of operation, construction details, characteristics and applications of Linear Variable Differential Transducers, proximity sensors, tacho-generators –Capacitive transducer and types - Differential arrangement – Variation of dielectric constant for measurement of liquid level - Dynamic microphone.

UNIT IV OPTICAL & ELECTRICAL SENSORS 9

Photo conductive cell, photo voltaic, Photo resistive, LDR – Pressure – Diaphragm, Bellows, Tactile sensors, Acoustic Sensors, Radiation Sensors - Smart Sensors - Film sensor, Motion Sensors –Accelerometer, Range Sensors – Ultrasonic Ranging, Laser Range Sensor (LIDAR). Nano sensors, semiconductor sensor.

UNIT V MISCELLANEOUS TRANSDUCERS **9**

Piezoelectric transducer – Hall Effect transducer – Magneto resistor - Digital displacement Transducer– Fiber optic sensor - Introduction to SQUID sensor, Touch screen sensor, Smart Transducer, MEMS and Introduction to linearization of transducer.

Total 45 Hrs

h) Learning 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 Performanceand Design‖, Oxford University Press, Cambridge, 2003 .
4. Murthy D.V.S., ―Transducers and Instrumentation‖, 2nd Edition, Prentice Hallof India Private Limited, New Delhi, 2010.
5. S.Renganathan, ―Transducer Engineering‖, Allied Publishers, 2005.

Online Resources

1. https://onlinecourses.nptel.ac.in/noc21_ee32/preview

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

a) Course Category

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

VLSI Design

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, CPLD, performance and its applications.	K2
CO2	Summarize the various FPGA architectures, programmable interconnects and one hot encoding.	K2
CO3	Account for the syntax and behavior of the VHDL language	K2
CO4	Illustrate the VLSI system design using combinational circuit	K3
CO5	Illustrate the VLSI system design using sequential circuit	K3

f) **Correlation of COs with Pos**

	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO 1	PSO 2
CO1	H	H	M	L	L	-	-	-	-	-	-	H	M	M
CO2	H	L	M	H	M	-	-	-	-	-	-	L	H	M
CO3	M	L	H	M	H	M	-	-	-	-	-	L	L	M
CO4	H	H	M	H	H	M	-	-	-	-	-	M	M	M
CO5	M	M	H	H	M	M	-	-	-	-	-	H	L	M

g) **Course Content**

PROGRAMMABLE LOGIC DEVICE

Introduction, ROM, PLD, PLA, PAL, GAL– Features, CPLD- Commercially available CPLD - Altera series – Max 5000/7000 series - Cypres FLASH 370 Device Technology, Lattice LSI's Architectures – 3000 Series–Applications of CPLDs, Speed Performance and in system programmability.

FIELD PROGRAMMABLE GATE ARRAYS

FPGAs- Logic blocks, Routing architecture, programmable interconnect, Mapping for FPGAs, Xilinx FPGA Architecture: Xilinx XC3000, XC4000 – Altera Architecture: FLEX 8000, One hot encoding, Case studies: Xilinx Virtex II Pro.

VHDL FOR SYNTHESIS

Introduction, data flow, behavioral, structural models, operators, process, concurrentstatements, Sequential Statements, Loops, Modeling Delays, Sequential Circuits, FSM Coding, Library, Packages, Functions, Procedures, Test bench.

FINITE STATE MACHINES

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.

h) **List of experiments**

1.	Introduction to Software and Hardware Tools	CO1, CO2
2.	Implementation of Parallel Adder using VHDL	CO4
3.	Implementation of Floating Point Multiplier using VHDL	CO4
4.	Delay Modelling using VHDL	CO4
5.	Implementation of counters using VHDL	CO5

6.	FSM Design using VHDL	CO5
7.	Design of Vending Machine Controller	CO5
8.	Processor Design 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 Jersey07632

Reference Books

1. Jon F Wakerly, Digital Design: Principles and Practices, Prentice Hall.
2. Douglas L. Perry, VHDL: Programming by Example, McGraw-Hill Education, Fouth Edition.
3. S.Trimberger, Edr., Field Programmable Gate Array Technology, Kluwer, Academic Publications, 1994.
4. Kevin Skahil, VHDL for programmable logic, Addison Wesley.
5. J. Old Field, R.Dorf, Field Programmable Gate Arrays, John Wiley & Sons, Newyork, 1995.
6. S.Brown, R.Francis, J.Rose, Z.Vransic, Field Programmable Gate Array, Kluwer Pubin, 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	Simulate and perform various analysis for the given Electronic Circuit.	S3
CO2	Design a PCB Layout for the given circuit	S4
CO3	Fabricate the PCB and assemble the components.	S2

f. Correlation of COs with POs

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

g. Examination scheme

Examination Scheme for practical dominated course										
Internal evaluation (40M)							**Semester end evaluation (60M)**			
Laboratory experiment (15M)				**Model laboratory test (25M)**			**Part-A (20M)**	**Part-B (40M)**		
Performance in conducting experiment (5)	Result and analysis (3)	Viva Voce (3)	Record (4)	Performance in conducting experiment (15)	Result and analysis (5)	Viva Voce (5)	Theory questions to evaluate the knowledge and understanding (20)	Performance in conducting experiment (25)	Result and analysis (10)	Viva-Voce (5)

h. 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.

i. List of experiments

S.No.	**CO's**	**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

j. Suggested Learning Resources

i) List of 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

ii) List of Major Equipment/ Instrument/Software with Broad Specifications

1. Altium Designer (Licensed version)
2. Express PCB (Free version)
3. Eagle (Free version)
4. MultiSim(Student Version)
5. UtilBoard(Student Version)

iii) **Online resources**

1. www.techdocs.altium.com/
2. www.ni.com (Multisim and Ultiboard - Academic version)
3. www.cadence.com (Orcade - Student version)
4. www.youtube.com (PCB Manufacturing Videos)

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

h) Course Category

Program Elective

i) 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.

j) Prerequisite

Nil

k) Related Courses

Data Communication Networks, Cyber Security for Wearable Devices, Ethical Hacking

l) 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 analyse computer forensic evidence.	K2
CO5	Discuss the essential and up-to-date concepts, algorithms, protocols, tools, and methodology of Computer Forensics.	K2

m) Correlation of COs with POs

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

n) Course Content

UNIT I DIGITAL CRIMES 9

Introduction to Digital Forensics, Definition and types of cybercrimes, electronic evidence and handling, electronic media, collection, searching and storage of electronic media, introduction to internet crimes, hacking and cracking, credit card and ATM frauds, web technology.

UNIT II COMPUTER FORENSICS 9

Definition and Cardinal Rules, Data Acquisition and Authentication Process, Windows Systems-FAT12, FAT16, FAT32 and NTFS, UNIX file Systems, mac file systems, computer artifacts, Internet Artifacts, OS Artifacts and their forensic applications.

UNIT III DIGITAL INVESTIGATIONS 9

Understanding Computing Investigations – Procedure for corporate High-Tech investigations, understanding data recovery work station and software, conducting and investigations.

UNIT IV PROCESSING OF ELECTRONIC EVIDENCE 9

Processing of digital evidence, digital images, damaged SIM and data recovery, multimedia evidence, retrieving deleted data: desktops, laptops and mobiles, retrieving data from slack space, renamed file, ghosting and compressed files.

UNIT V FORENSIC TOOLS 9

Data acquisition- understanding storage formats and digital evidence, determining the best acquisition method, acquisition tools, validating data acquisitions, performing RAID data acquisitions, remote network acquisition tools, other forensics acquisitions tools.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Warren G. Kruse II and Jay G. Heiser, "Computer Forensics: Incident Response Essentials", Addison Wesley, 2002.
2. Nelson, B, Phillips, A, Enfinger, F, Stuart, C., "Guide to Computer Forensics and Investigations, 2nd ed., 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.

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

o) Course Category

Program Elective

p) Preamble

This course will provide students with an understanding on the concepts and protocols of cryptography for cyber security.

q) Prerequisite

Data Communication Networks

r) Related Courses

Network Security, Cyber Security for smart wearables, Automotive Cyber Security

s) 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 basics concepts of cryptography.	K2
CO2	Outline the various symmetric and asymmetric algorithms for cyber security.	K2
CO3	Summarize various Message and Entity Authentication protocols.	K2
CO4	Explain the concepts of system security models	K2
CO5	Infer the network security architecture and layer security issues related to 3G and 4G networks.	K2

t) Correlation of COs with POs

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

u) 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”, 4th Edition, Prentice Hall, 2006.
2. William Stallings, Network Security Essentials: Applications and Standards, Prentice Hall, 4th edition, 2010.

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	Discuss the emerging Abstract models for Blockchain Technology	K2
CO2	Identify major research challenges and technical gaps existing between theory and practice in cryptocurrency domain	K2
CO3	Outline the concepts of Bitcoin and Consensus algorithm	K2
CO4	Explain the concepts of Distributed Consensus algorithm	K2
CO5	Infer the Blockchain platforms and their applications	K2

f) Correlation of COs with POs

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

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 hash function-Hash pointer and Merkle tree.

UNIT II BITCOIN AND CRYPTOCURRENCY 9

A basic crypto currency, Creation of coins, Payments and double spending, FORTH – the precursor for Bitcoin scripting, Bitcoin Scripts, Bitcoin P2P Network, Transaction in Bitcoin Network, Block Mining, Block propagation and block relay, Consensus introduction, Distributed consensus in open environments-Consensus in a Bitcoin network.

UNIT III BITCOIN CONSENSUS 9

Bitcoin Consensus, Proof of Work (PoW)- Hashcash PoW , Bitcoin PoW, Attacks on PoW ,monopoly problem- Proof of Stake- Proof of Burn - Proof of Elapsed Time - Bitcoin Miner, Mining Difficulty, Mining Pool-Permissioned model and use cases, Design issues for Permissioned Blockchains, Execute contracts- Consensus models for permissioned blockchain-Distributed consensus in closed environment Paxos.

UNIT IV DISTRIBUTED CONSENSUS 9

RAFT Consensus-Byzantine general problem, Byzantine fault tolerant system-Agreement Protocol, Lamport-Shostak-Pease BFT Algorithm-BFT over Asynchronous systems, Practical Byzantine Fault Tolerance.

UNIT V PLATFORMS AND APPLICATIONS 9

Introduction to Blockchain platforms: Hyberledger-Ethereum-IOTA-EOS-Multichain-Bigchain, CORDA, Openchain, SOLIDITY, Smart contracts, Truffle Design and issues in cryptocurrency ,Mining, Distributed Applications (DApps), DAO Applications: Internet of Things-Medical Record Management System-Government Identity management –Auto executing contracts-Three signature esrow-Tripple entry accounting-Sidechain-Challenges and Research issues in blockchain.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Mastering Blockchain: Deeper insights into decentralization, cryptography, Bitcoin, and popular Blockchain frameworks by Bashir, Imran, 2017.
2. Arvind Narayanan, Joseph Bonneau, Edward Felten, Andrew Miller, and Steven Gold feder. Bitcoin and cryptocurrency technologies: a comprehensive introduction. Princeton University Press, 2016.
3. Joseph Bonneau et al, SoK: Research perspectives and challenges for Bitcoin and cryptocurrency, IEEE Symposium on security and Privacy, 2015.

References

1. Wattenhofer, The Science of the Blockchain
2. Antonopoulos, Mastering Bitcoin: Unlocking Digital Cryptocurrencies
3. Satoshi Nakamoto, Bitcoin: A Peer-to-Peer Electronic Cash System DR. Gavin Wood, “ETHEREUM: A Secure Decentralized Transaction Ledger,”Yellow paper.2014. • Nicola Atzei, Massimo Bartoletti, and Tiziana Cimoli, A survey of attacks on Ethereum smart contract

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	Exemplify 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

	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	M	L	L	-	-	-	-	L	L	-	L	-	-
CO3	M	M	L	L	-	-	-	-	L	L	-	L	-	-
CO4	M	M	L	L	-	-	-	-	L	L	-	L	-	-
CO5	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

a. Shiho Kim , Rakesh Shrestha, “Automotive Cyber Security”, Springer, 2020
b. Dietmar P.F. Möller, Roland E. Haas, “Guide to Automotive Connectivity and Cybersecurity”, Springer, 2019

Reference Books

4. Craig Gibbs, “Automotive Cybersecurity: Issues and Vulnerabilities”, Nova Science Publisher, 2016
5. Yasir Imtiaz Khan, “Automotive Cyber Security Challenges A Beginner's, Amazon Kindle, 2020

Online Resources

1. https://www.udemy.com/course/automotive-cyber-security/
2. https://www.nhtsa.gov/technology-innovation/vehicle-cybersecurity

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

a) Course Category

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	Identify the security issues in wearable devices.	K2
CO3	Illustrate the various management security issues in wearable technology.	K2
CO4	Discuss the various application wearable devices for cyber security.	K2
CO5	Infer the cyber security issues related to wearable devices in real time scenarios.	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	PSO2
CO1	M	-	-	-	-	-	-	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	L	-	-
CO3	M	-	-	-	-	-	-	-	L	L	-	L	-	-
CO4	M	L	L	L	-	L	-	-	L	L	-	L	-	-
CO5	M	L	L	L	-	L	-	-	L	L	-	L	-	-

g) Course Content

UNIT I 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 TECHNOLOGIES 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

Reference Books

1. Wearable Technologies: Concepts, Methodologies, Tools and Applications (3 Volumes) – Information Resources Management Association (USA)
   DOI: 10.4018/978-1-5225-5484-4

Course Code	Course Title	L	T	P	C
10212EC222	**PRINCIPLES OF NETWORKING & 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 securely.

c) Prerequisite

Data Communication Networks

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	Build the concepts of networking in Wired and Wireless networks	K3
CO2	Apply the tools of Network management and troubleshooting for given scenarios.	K3
CO3	Understanding the basics of Cyber security	K2

CO4	Outline the techniques to prevent Cyber Attacks	K2
CO5	Summarize the various Cyber-attacks and their impacts	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I NETWORK DESIGN & IMPLEMENTATION 6

Review of Network Basics: Network Design: Topologies- Network Plan- IP Addressing & Subnetting-IPv6- DCHP-DNS-Design: Access Network-LAN-WAN.
Network Implementation: Packet Tracer-Performance Analysis: Unicast-Multicast-Broadcast.

UNIT II NETWORK MANAGEMENT & TROUBLESHOOTING 6

Network Management: Network Monitoring: Performance monitoring-Fault monitoring-Account monitoring- Configuration and security management. Network Troubleshooting: Command Line Utilities: ipconfig, Ping, Tracert, nslookup-Network analyser Tools: Wireshark-ipMonitor.

UNIT III INFORMATION SECURITY AND SECURITY THREATS 6

Cyber security Introduction and Overview-Threats to information system-Cyber security and security risk analysis-Information Assurance-Types of Computer Malware **-**Types of Cyber Attacks: Denial of Service, Distributed Denial of Service, Man in Middle Attack, Crypto-jacking, SQL Injection, Cyber-Stalking Cyber frauds and Forgery

UNIT IV CYBER ATTACK PREVENTION 6

Algorithms and Technique-Firewalls-Intrusion Detection & Prevention-Authentication using Hash-Multi-Factor Authentication- Secure Socket Layer- Virtual Private Network.

UNIT V RECENT ATTACKS AND IMPACTS 6

Equifax data theft – VPN filter cyberattack-Wannacry Ransom attack-Peta Cyberattack- US 2016 election manipulation-US power grid hacking-Shadow network attack-Github DDoS attack 2018

Total: 30 Hrs

Lab Total: 30 Hrs

List of experiments

Exp.No	Experiment Name	CO Level	Skill Level
1.	Getting acquainted with CISCO packet tracer	CO1	S3
2.	To design and configure a network using Cisco Packet Tracer.	CO1	S3
3.	Designing & Implementing LAN using subnetting	CO1	S3
4.	Designing a WAN network	CO1	S3
5.	Performance Analysis of a WAN Network (Uni/Multi/Broadcast)	CO1	S3
6.	Getting Acquainted with Windows Management Instrumentation (WMI).	CO2	S3
7.	Getting Acquainted with Simple Network Management Protocol using CISCO Packet tracer.	CO2	S3
8.	Getting Acquainted with troubleshooting a network (using network utilities) • Ipconfig • Ping • Tracert • Nslookup	CO2	S3
9.	Getting Acquainted with network management tool: Wireshark	CO2	S3
10.	Getting Acquainted with network management tool: ipMonitor	CO2	S3
11.	Study of the features of firewall in providing network security and to set Firewall Security in windows.	CO4	S3
12.	Demonstrate intrusion detection system using any tool.(snort or any other S/W).	CO5	S3
13.	Mini project for the design and implementation of a cyber-techniques.	CO2	S3

Total: 60 Hrs

h) Learning Resources

Text Books

1. James W. Kurose, Keith W. Ross, “Computer Networking: A Top-Down Approach”, Pearson, 2021.
2. Douglas E. Comer, “Internetworking with TCP/IP Volume One, 6th edition”, Peasrson,2013.
3. Kutub Thakur, Al-Sakib Khan Pathan, “Cybersecurity Fundamentals-A Real-World Perspective”, Taylor & Francis 2020.
4. Kutub Thakur, Al-Sakib Khan Pathan, “Cybersecurity Fundamentals-A Real World Perspective”, Taylor & Francis, 2020.
5. ISACA, “CSX Cybersecurity Fundamentals Study Guide, ISACA,2015.

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.

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

a) Course Category

Program Elective

b) Preamble

The primary aim of this course is to introduce students about the principles and techniques of 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, students will be able to

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Illustrate the hacker approaches and various attacks	K2
CO2	Outline the concepts of hacker tools for Footprinting 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	Paraphrase the concept behind safeguarding and protecting legitimate systems.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	M	L	L	-	-	-	-	-	L	L	-	-	-	-
CO2	M	L	L	-	L	-	-	L	L	L	-	L	-	-
CO3	M	L	L	-	L	-	-	L	L	L	-	L	-	-
CO4	M	L	L	-	-	-	-	L	L	L	-	L	-	-
CO5	M	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: 30 Hrs

Lab **Total: 30 Hrs**

List of experiments

S. No	Practical Exercises (30 Hrs)
1	Study the use of network reconnaissance tools like WHOIS, dig, traceroute, nslookup to gather information about networks and domain registrars.
2	Study of packet sniffer tools like wireshark, ethereal, tcpdump etc. Use the tools to do the following (a) Observer performance in promiscuous as well as non-promiscous mode. (b) Show that packets can be traced based on different filters.
3	Download and install nmap. Use it with different options to scan open ports, perform OS fingerprinting, do a ping scan, tcp port scan, udp port scan, etc.
4	Detect ARP spoofing using open source tool ARPWATCH.
5	Use the Nessus tool to scan the network for vulnerabilities.
6	Implement a code to simulate buffer overflow attack.
7	Set up IPSEC under LINUX.
8	Install IDS (e.g. SNORT) and study the logs.
9	Use of iptables in linux to create firewalls.
10	Setup a honey pot and monitor the honey pot on network.
11	Create a social networking website login page using phishing techniques
12	Install rootkits and study variety of options.
13	Study of Techniques uses for Web Based Password Capturing.
14	Implement Passive scanning, active scanning, session hijacking, cookies extraction using Burp suit tool
15	Mini Project.

Total: 60 Hrs

h) Learning Resources

Text Books

1. Hands-On Ethical Hacking and Network Defense, 2nd Ed.,Michael T. Simpson, Kent Backman, and James E. Corle.
2. Rafay Baloch," Ethical Hacking and Penetration Testing Guide", CRC Press, 2015, ISBN:78-1-4822-3161-8.

Reference Books

1. Jon Erickson, Hacking: The Art of Exploitation Jon Erickson SPD (2 ed.), No Starch Press, 2008. ISBN 978-1593271442.
2. Georgia Weidman, "Penetration Testing: A Hands On Introduction to Hacking", No Startch Press, First Edition 2014. ISBN-13: 978-1593275648 ISBN-10: 1593275641.
3. Dr. Patrick Engebretson, "The Basics of Hacking and Penetration Testing",Syngress Publications Elseveir, 2013, ISBN : 978-0-12-411644-3

Online resources

1. https://onlinecourses.nptel.ac.in/noc22_cs13/preview
2. https://www.comparitech.com/blog/information-security/ethical-hacking-course/

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	Explore the fundamentals of AI & search methods.	K2
CO2	Explain the fundamentals of AI for Cyber Security	K2
CO3	Outline the various AI algorithms for phishing and spam detection	K2
CO4	Infer the various AI algorithms for Malware detection	K2
CO5	Understand the AI based fraud detection & cloud AI solutions	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	L	L		-	-	-	-	-	-	--	-	-	-	-
CO2	M	L	L	-	-	-	-	-	-	-	-	-	L	-
CO3	M	L	L	-	-	-	-	-	-	--	-	-	L	-
CO4	M	L	L	-	-	-	-	-	-	--	-	-	L	-
CO5	M	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: 30 Hrs

Lab Total: 30 Hrs

List of experiments

S. No	Practical Exercises (30 Hrs)
1	Phishing detection with logistic regression
2	Phishing detection with decision trees
3	Spam detection with SVM
4	Spam detection with Naive Bayes
5	Bayesian spam detector with NLTK
6	Extracting malware artifacts in a dataset
7	Clustering malware with K-Means
8	Random Forest Malware Classifier
9	Bagging, Boosting
10	Miniproject

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", 2019.

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

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.

c) Prerequisite

Nil

d) Related Courses

Tools for Data Science, Data analysis and visualization

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 concept of vector spaces, Eigen values, Eigen vectors and distance measures	K2
CO2	Interpret the fundamentals of process involved in data science	K2
CO3	Describe various data modelling techniques and its evaluation	K2
CO4	Use visualization techniques to represent the data	K3
CO5	Defend the ethics surrounding privacy, data sharing and algorithmic decision-making	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I MATHEMATICS FOR DATA SCIENCE 9

Definition of Vector spaces, Subspaces, sums of Subspaces, Direct Sums, Eigenvalues and Eigenvectors - Eigenvectors and Upper Triangular matrices – Eigenspaces and Diagonal Matrices, Distance measures - Euclidean Distance, Manhattan Distance, Hamming Distance, Cosine Similarity.

UNIT II DATA SCIENCE PROCESS 9

Fundamentals of Data Science, Data Preparation: The Problem Understanding Phase, Data Preparation Phase, Adding an Index Field, Changing Misleading Field Values, Reexpression of Categorical Data as Numeric, Standardizing the Numeric Fields, Identifying Outliers.

UNIT III DATA VISUALIZATION 9

Introduction to data visualization, visualization techniques: scatter plots, line graphs, pie charts, bar charts, heat maps, area charts and histograms, case study: Survey on Covid-19 dataset.

UNIT IV DATA MODELING AND EVALUATION 9

Data Modeling: Partitioning the Data, validating your Partition, Balancing the Training Data Set, Establishing Baseline Model Performance, Model Evaluation: Classification Evaluation Measures, Sensitivity and Specificity, Precision, Recall, and F_β Scores, Method for Model Evaluation.

UNIT V ETHICS IN DATA SCIENCE 9

Importance of ethics in data science, doing good data science, data privacy – degrees of privacy, valuing different aspects of privacy, modern privacy risks, Getting informed consent, The Five Cs – consent, clarity, consistency and trust, control and transparency, consequences, Diversity, Inclusion, future trends.

Total: 45 Hrs

h) Learning Resources

Text Book

1. Sheldon Axler, “Linear algebra done right”, 3rd Edition, Springer,2015.
2. Chantal D. Larose, Daniel T. Larose, “Data Science Using Python and R”, John Wiley & Sons, Inc., First Edition, 2019.

3. D J Patil, Hilary Mason, Mike Loukides, "Ethics and Data Science" , O' Reilly Media Publishers, 1st edition, 2018.

References:

1. E. Davis, "Linear algebra and probability for computer science applications", CRC Press, 2012.
2. Dr. Ossama Embarak, "Data Analysis and Visualization using Python", Apress, 2018,
3. Cathy O'Neil, Rachel Schutt, "Doing Data Science", O' Reilly media publishers, 1st edition, 2013

Online resources:

1. https://towardsdatascience.com/intro-to-data-science-531079c38b22?gi=1fb573279fdb
2. https://www.edureka.co/blog/what-is-data-science/
3. https://www.youtube.com/watch?v=KxryzSO1Fjs
4. https://www.simplilearn.com/tutorials/data-science-tutorial/introduction-to-data-science
5. https://cognitiveclass.ai/courses/data-science-101
6. https://towardsdatascience.com/introduction-to-machine-learning-for-beginners-eed6024fdb08
7. https://www.youtube.com/watch?v=njKP3FqW3Sk
8. https://www.analyticsvidhya.com/blog/2020/03/6-data-visualization-python-libraries/

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

a) Course Category

Specialization Elective

b) Preamble

This course will provide knowledge on data handling, data analysis and the various ways of visualizing the data which is the basic requirement of Artificial Intelligence and Machine learning. It will provide necessary knowledge on how to manipulate data objects, produce graphics, analyze data using common statistical methods and visualizing the data with programming in Python.

c) Prerequisite

Data structures/Object Oriented Programming, Basics of Python programming.

d) Related Courses

Introduction to Data Science, Tools for Data Science

e) Course Outcome

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

CO No.	Course Outcomes	Knowledge Level (Based on Revised Blooms Taxonomy)
CO1	Summarize the concepts of data handling	K2
CO2	Apply the various statistical techniques used in data handling	K3
CO3	Analyze the multivariate data and appreciate its properties	K4
CO4	Identify the insights to the art of visualization	K3
CO5	Analyze the data using visualization toolkit and examine the same	K4

f) Correlation of Cos with POs

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

g) Course Content

UNIT I INTRODUCTION TO STATISTICAL DATA ANALYSIS 9

Data analysis- Importance, Information vs Data - Types of data - Collecting Data ·Data pre-processing, Data cleaning, Data reduction Levels of measurement Measures of variability, central tendency Estimation Regression Hypothesis testing

UNIT II DATA ANALYSIS TECHNIQUES 9

Graph Visualization - Data Summaries - Hypothesis Testing - ML Model-Checking and Comparison - Link Analysis, Mining of Graph, Frequent Item Sets Analysis - High Dimensional Clustering - Hierarchical Clustering, Recommendation Systems

UNIT III MULTIVARIATE DATA 9

Relationships between single categorical and single continuous variable - Multivariate analysis-Analysis of dependence and interdependence - Applications of Multivariate techniques - Multivariate normal distribution - Case Study Application of multivariate analysis on signal processing data

UNIT IV DATA VISUALIZATION 9

Data Visualization Design - Data and Tasks - Data Types - Dataset Types - Basic Charts and Plots - Use of Statistical Indicators - Multivariate Data Visualization -Principles of Perception, Color, Design, and Evaluation, Graphical Integrity, Data-Ink Ratio, Aspect Ratios & Scales - Introduction to Tableau Desktop and Power BI

UNIT V DATA VISUALIZATION TOOLKIT 9

Basic principles - categorical and continuous variables - Exploratory graphical analysis -Creating static graphs, animated visualizations, loops, GIFs and Videos - Data visualization using Tableau and Power BI

Total 45 Hrs.

h) Learning Resources

Text Books

1. Keith Mc Cormick and Jesus Salcedo, SPSS ,“Statistics for Data Analysis and Visualization,” John Wiley & Sons Ltd, 2017.
2. Tony Fischetti, “Data Analysis with R”, Packt publishing, 2015
3. Dallas E. Johnson, “Applied Multivariate Methods for Data Analysis”, Thomson and Duxbury press, 1998.
4. Noabiliinsky, Julie Steele, “Designing Data visualizations”, O’ Reilly Publishers, 2011.

Reference Books

1. Rafael A. Irizarry, Introduction to Data Science: Data Analysis and Prediction Algorithms with R, CRC Press, 2020.
2. Chantal D. Larose and Daniel T. Larose, “Data Science using Python and R”, John Wiley & Sons Ltd, 2019.

Online Resource

1. http://www.python-course.eu/numpy.php
2. https://www.learnpython.org/en/Pandas_Basics
3. https://www.r-bloggers.com/2015/08/data-manipulation-with-dplyr/
4. https://rkabacoff.github.io/datavis/

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

a) Course Category

Program Elective

b) Preamble

This course provides a way to understand the concepts of ANN, Fuzzy systems, Genetic Algorithm, multi-objective optimization algorithm and its applications

c) Prerequisite Courses

Nil

d) Related Courses

ANN and Deep Learning, Machine Learning, Machine Vision

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 fundamental neuroscience concepts and ANN models	K2
CO2	Apply the fuzzy logic and reasoning to handle uncertainty in solving engineering problems.	K2
CO3	Familiarize the concepts of Genetic algorithm and its applications	K2
CO4	Explain the hybridization of neural network, fuzzy and genetic algorithm	K2
CO5	Understand the concepts of multi-objective optimization algorithm and its applications	K2

f) Correlation of COs with POs :

COs	PO1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO1 0	PO1 1	PO1 2	PSO1	PSO2
CO1	H	H	L	L	M	-	-	-	L	L	-	L	L	L
CO2	H	M	L	L	M	-	-	-	L	L	-	L	L	L
CO3	M	H	M	L	M	L	-	-	L	L	-	L	L	L
CO4	H	M	L	L	M	-	-	-	L	L	-	L	L	L
CO5	M	M	M	L	M	L	-	-	L	L	-	L	L	L

g) Course Content :

UNIT I: BASICS OF NEUROSCIENCE AND ANN MODELS 9

The Brain as a neural network - Basic Properties of Neurons – Neuron Models – Rosenblatt’s Perceptron – The widrow-Hoff LMS Learning Algorithm-Order of a Predicate and a Perceptron – Complexity of learning using Feed forward Networks.

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 – Introduction to Fuzzy Decision Making.

UNIT III: GENETIC ALGORITHMS 9

Basic Concepts- Working Principles -Encoding- Fitness Function – Reproduction - Inheritance Operators – Cross Over – Inversion and Deletion -Mutation Operator – Bitwise Operators - Convergence of Genetic Algorithm.

UNIT IV: HYBRID SYSTEMS 9

Hybrid Systems -Neural Networks, Fuzzy Logic and Genetic -GA Based Weight Determination – LR-Type Fuzzy Numbers – Fuzzy Neuron – Fuzzy BP Architecture – Learning in Fuzzy BP-Inference by Fuzzy BP – Fuzzy Art Map: A Brief Introduction – Soft Computing Tools – GA in Fuzzy Logic Controller Design – Fuzzy Logic Controller

UNIT V: MULTI-OBJECTIVE OPTIMIZATION 9

Problem Solving - 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 Periods

h) Learning Resources:

Text Books

1. N. K. Bose and P. Liang , "Neural Network Fundamentals with Graphs, Algorithms and Applications (MCGRAW HILL SERIES IN ELECTRICAL AND COMPUTER ENGINEERING), 1996
2. S.N.Sivanandam , S.N.Deepa, "Principles of Soft Computing", Wiley India Pvt. Ltd., 2nd Edition, 2011.
3. Kalyanmoy Deb, "Multi-Objective Optimization using Evolutionary Algorithms", Wiley, July 2001
4. S.Rajasekaran, G.A.Vijayalakshmi Pai, "Neural Networks, Fuzzy Logic and Genetic Algorithm, Synthesis and Applications ", PHI Learning Pvt. Ltd., 2017.

References

1. Jyh-Shing Roger Jang, Chuen-Tsai Sun, Eiji Mizutani, ―Neuro-Fuzzy and Soft Computing, Prentice-Hall of India, 2002.
2. Kwang H.Lee, ― First course on Fuzzy Theory and Applications, Springer, 2005.
3. George J. Klir and Bo Yuan, ―Fuzzy Sets and Fuzzy Logic-Theory and Applications, Prentice Hall, 1996.
4. James A. Freeman and David M. Skapura, ―Neural Networks Algorithms, Applications, and Programming Techniques, Addison Wesley, 2003.

Online resources

1. www.cs.nthu.edu.tw/~jang/nfsc.htm
2. https://nptel.ac.in/courses/106105173/2
3. https://nptel.ac.in/courses/117105084/

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 covers 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

Machine Learning, Data Science

e) Course Outcomes

Upon successfully completing 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	Illustrate Markov models, Markov processes, and tree-based models	K2
CO4	Elaborate on statistical machine learning techniques.	K2
CO5	Design model based on logistic regression and random forest techniques	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUNDAMENTALS OF STATISTICAL MODELS, LINEAR MODELS AND REGRESSION 9

Introduction: Basic concepts from statistics, definition and uses of models, real-time applications, key steps in the modelling process. Linear models and optimization - least square estimation - Revisiting regression models: analysis of variance model, interpretation of regression coefficients, R-squared and root mean squared error, fitting curves to data.

UNIT II PROBABILISTIC MODELS 9

Introduction to probabilistic models: some examples of probabilistic models, noisy channel model, source-channel model, joint source-channel models, Monte-Carlo Simulations, Building blocks of probability models, Various distributions (Bernoulli, Binomial, Normal distribution), 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. The Elements of Statistical Learning: Data Mining, Inference, and Prediction. By Trevor Hastie, Robert Tibshirani, Jerome Friedman, Hardcover: 745 pages, Publisher: Springer; 2nded. 2009, ISBN-10: 0387848576
2. Statistical Models by A. C. Davison - Paperback: 738 pages, Publisher: Cambridge University Press; 1 edition (30 June 2008) ISBN-10: 0521734495 Cambridge University Press.
3. PratapDangeti," Statistics for Machine Learning": PacktPublishing Ltd, 2017.
4. MasashiSugiyama," Introduction to Statistical Machine Learning", Elsevier,2016
5. Gareth James, Daniela Witten, Trevor Hastie, and Robert Tibshirani, An Introduction to Statistical Learning with Applications in R, Springer, 2015.

Reference Books

1. S.C. Gupta; "Fundamentals of Statistics 7th Edition"; Himalaya Publishing House Pvt. Ltd.
2. Abdul Hamid Khan, Manoj Kumar Srivastava, and Namita Srivastava; "Statistical Inference: Theory of Estimation"; PHI Learning.

Online Resources

1. Statistics tutorial- https://www.youtube.com/channel/UCQKwruq0LY3cjvSx7_M5JAg
2. Inferential Statistics- https://www.youtube.com/watch?v=- (Unit I.,II and III)
   FtlH4svqx4&list=PLSQl0a2vh4HDl0hgK8nIBgBjLji5Eu9ar(Unit I.,II and III)

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

a) Course Category

Program 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

Digital Image Processing, Machine Learning

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Apply the geometric properties, algorithms and distance measures of binary images to facilitate pre-processing of images in machine vision	K3
CO2	Utilize the concept of region splitting and merging for image segmentation in machine vision images	K3
CO3	Make use of the edge detection operators to extract and track relevant features from images and evaluate its performance	K3
CO4	Outline the concepts involved in geometrical optics and techniques for computing the depth from images	K2
CO5	Discuss dynamic vision and new developments in object recognition systems	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO MACHINE VISION & BINARY IMAGE PROCESSING TECHNIQUES 9

Introduction – Machine vision –Relationship to other fields –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 - compact Distance measures - Distance transforms - Medial axis - Morphological operators - Thinning- Expanding and Shrinking- Matlab Exercises on binary algorithms & morphological operators

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- Matlab exercises on various methods for automatic thresholding

UNIT III EDGE DETECTION 9

Gradient - Steps in edge deduction - Robert's operator - Sobel operator - Prewitt operator - Comparison 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 – Matlab exercises on edge detectors and its performance evaluation

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
2. Wataru Ohyama, Soon Ki Jung, Frontiers of Computer Vision: 26th International Workshop, IW-FCV 2020, Ibusuki, Kagoshima, Japan, 2020

Reference Books

1. Gonzalez, Rafael C. and Woods, Richard Eugen, Digital Image Processing, 3rdEdition, Prentice Hall,2008
2. David Forsyth and Jean Ponce, Computer Vision: A modern Approach, Prentic Hall India 2004.

Online Resources

1. https://ocw.mit.edu/courses/electrical-engineering-and-computer-science/6-801-machine-vision-fall-2004/lecture-notes/
2. http://faculty.salina.k-state.edu/tim/mVision/Introduction.html
3. https://faculty.ucmerced.edu/mcarreira-perpinan/teaching/ee589/lecture-notes.pdf

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

a) Course Category:

Program 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:

1. Introduction to Data Science
2. Data Analysis and Visualization

d) Related Course

Nil

e) Course Outcomes:

Upon the 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 basic operations on Data Extraction and Transformation	S2
CO2	Demonstrate the Data Modelling and Visualization Techniques	S3
CO3	Implement the Data Analytics with Metadata and Data Blending	S2

f) Correlation of COs with POs

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

g) Course Contents: Theory

UNIT I Data Science Tools: 15

Overview of Languages for Data Science, Open-Source Tools, Cloud Based Tools, Python and R for Data Science, Power BI Desktop, Tableau Public.

UNIT II Data Extraction and Transformation: 15

Using files (excel, pdf, csv, etc.) as a data source, Using SaaS connectors, extracting data from folders and databases, Formatting data, Transformation of data, Understanding of Data types, Data profiling for data quality check, Working with Parameters.

UNIT III Data Modelling and Visualization: 15

Relationships, Cardinality, Cross filter direction, DAX syntax, DAX functions, Measures using DAX, Page layout & Formatting, Top-down and bottom-up analytics, Drill down, Drill through, Basic Charts, Dual axes graphs, Page navigations, Volume and value-based analytics.

UNIT IV Meta Data and Data Blending: 15

Management of metadata and extracts, Joins (Left, Right, Inner, and Outer) and Union, Cross-database joining, Data Blending

UNIT V Dashboards: 15

Building and Formatting Dashboards using size, objects, views, filters, and legends, adding annotations with descriptions, Highlight actions, URL actions, and filter actions.

Total: 75 Hours

h) Learning Resources:

Text Books:

1. Chantal D. Larose and Daniel T. Larose, "Data Science Using Python and R," John Wiley & Sons Ltd, 2019.
2. Alberto Ferrari and Marco Russo, "Introducing Power BI," Microsoft Press, 2016.

Reference Books:

1. Joshua N. Milligan, "Learning Tableau 2020," Packet Publishing, 2020.

Online Resources:

1. https://www.coursera.org
2. https://www.upgrad.com
3. https://www.udemy.com
4. https://www.tutorialspoint.com/python_data_science/index.htm
5. https://intellipaat.com/power BI training/

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

a) Course Category

Programme Elective

b) Preamble

This course is proposed to meet a growing professional need of individuals skilled in artificial intelligence, data analytics, statistical programming and other software skills. The course integrates theory and practice to enable the student to gain the necessary knowledge to compete in the ever changing work environment. This course covers the fundamental concepts of machine learning, core concepts of Bayesian decision theory, Linear regression, Logistic regression, Support Vector Machines, clustering and dimensionality reduction techniques along with hands-on problem solving using simple python programming

c) Prerequisite

Nil

d) Related Courses

Deep Learning

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Outline the basic concepts of Machine Learning and implement using python programming	K3
CO2	Apply Bayesian Decision theory principles, Bayes Classifier and Estimator for classification and prediction	K3
CO3	Describe 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	Apply the Clustering algorithms and Dimensionality reduction techniques for developing applications and implement the algorithms using python.	K3

f) Correlation of COs with POs

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

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	Skill Level
1	Online Retail Case Study	CO1	S3
2	Program to demonstrate Housing Price Prediction	CO1	S3
3	Program to demonstrate on Prediction using Bayes Rule.	CO2	S3
4	Program to demonstrate, classification/estimation using Bayes Rule.	CO2	S3
5	Program to demonstrate Simple/Multiple Linear Regression	CO3	S3
6	Program to demonstrate Binary and Multiple Logistic Regression	CO3	S3
7	Program to demonstrate SVM based classification	CO4	S3
8	Program to demonstrate the working of the decision tree based ID3 algorithm.	CO4	S3
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	S3
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	S3
11	Program to demonstrate PCA on face recognition.	CO5	S3
12	Program to demonstrate PCA on Iris dataset.	CO5	S3

Total: 60 Hrs

h) Learning Resources

Reference Books

1. Kevin P. Murphy. Machine Learning: A Probabilistic Perspective, MIT Press 2012.
2. Ethem Alpaydin, Introduction to Machine Learning, 2nd Edition, MIT Press 2010
3. Richert & Coelho, Building Machine Learning Systems with Python, 3rd Edition, Packt Publishers, 2018
4. Trevor Hastie, Robert Tibshirani, Jerome Friedman, The Elements of Statistical Learning, Second edition Springer 2017.
5. Weisberg, Sanford, Applied Linear Regression, 4th Edition, John Wiley & Sons, 2014
6. David W. Hosmer Jr., Stanley Lemeshow, Rodney X. Sturdivant, Applied Logistic Regression, 3rd Edition John Wiley & Sons, 2013
7. Andreas C. Müller, Sarah Guido, Introduction to Machine Learning with Python, O'Reilly Media, Inc., 2016

Online Resources

1. AndrewNg,“MachineLearning”,StanfordUniversity, https://www.coursera.org/learn/machine-learning/home/info
2. Sudeshna Sarkar, **“**Introduction to Machine Learning”, IIT Kharagpur. https://nptel.ac.in/courses/106105152/1
3. Prof. Balaraman Ravindran, **“**Introduction to Machine Learning”, IIT Madras. https://nptel.ac.in/courses/106106139/1
4. Machine Learning Tutorials, Machine Learning Tutorial (tutorialspoint.com)
5. Machine Learning Mastery, Best Machine Learning Resources for Getting Started (machinelearningmastery.com)

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

a) Course Category

Program 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

Nil

d) Related Courses

Machine Learning

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Analyze various parameters to improve the performance of deep learning models	K4
CO2	Apply various CNN network models and transfer learning for different applications	K3
CO3	Summarize the architectural features of diverse deep CNN networks.	K2
CO4	Apply various RNN network models for sequence and text processing	K3

CO5	Apply various adversarial network models for image generation	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I OPTIMIZATION OF DEEP LEARNING MODELS 6

Review of architectural principles of deep networks - configure capacity of model with nodes and layers - Configure gradient precision with nodes and layers - Configure what to optimize with loss functions - Configure speed of learning with learning rate, Fix over-fitting and penalize weights with regularization. Decouple layers with dropout - Halt training with early stopping - K-fold cross validation.

UNIT II BASICS OF CONVOLUTIONAL NEURAL NETWORKS 6

CNN overview - Building blocks of Convolution Neural Networks - Convolution operation with strides - Convolution Layers, Pooling Layers, Fully Connected Layers, Greedy layer wise training. CNN based deep learning and Transfer learning based deep learning.

UNIT III DEEP CONVOLUTION NEURAL NETWORKS 6

CNN architectures - LeNet, Alexnet, VGG, GoogleNet, Xception and Inception models - Application of transfer learning with Alexnet and Googlenet models for image classification task.

UNIT IV RECURRENT NEURAL NETWORKS 6

Support for sequences in Neural Networks - Recurrent Neural Networks - Basic architecture, variants of RNN models - LSTM architecture - GRU architecture - Application of RNN models for sequence and text processing.

UNIT V AUTOENCODERS AND ADVERSARIAL NETWORKS 6

Autoencoder models - Introduction to Generative Adversarial Networks - Generator, Discriminator, Adversarial Networks - Application of autoencoder for dimensionality reduction and adversarial model for image generation.

Total: 30 Hrs

h) Learning Resources

Text Books

1. Heaton, Jeff, Ian goodfellow, yoshua bengio, and aaron Courville, " Deep learning", 2018.
2. Michelucci, U. " Applied Deep Learning—A Case-Based Approach to Understanding Deep Neural Networks", Apress Media, LLC: New York, NY, USA, 2018.
3. Brownlee, Jason, "Better Deep learning: Train faster, reduce overfitting, and make better predictions", Machine Learning Mastery, 2019.
4. Patterson Josh, and Adam Gibson, "Deep learning: A practitioner's approach", O'Reilly Media, Inc., 2017.
5. Manaswi, Navin Kumar, " Deep learning with applications using python: chatbots and face, object, and speech recognition with tensorflow and keras", Apress, 2018.

Reference Books

1. Pattanayak, Santanu, Pattanayak, and Suresh John, "Pro deep learning with tensorflow", New York, NY, USA, Apress, 2017.
2. Aggarwal CC. "Neural networks and deep learning", Springer, 2018.
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://www.deeplearningbook.org/contents/optimization.html
4. https://nptel.ac.in/courses/106/106/106106224/

i)List of Experiments

S. No	Name of the experiment	CO	Skill Level
1	a) Understanding and working with Keras and Tensorflow b) Design a dense neural network using Tensorflow c) Example of evaluating deep neural network models with different numbers of nodes. d) Example of evaluating deep neural network models with different numbers of layers (6 Hours)	CO1	S3
2	a) Design simple CNN for MNIST dataset b) Design a larger CNN for Cifar dataset c) Image data generator and improve model performance with data augmentation process d) Training a convnet from scratch for small dataset (6 Hours)	CO2	S3
3	a) Use a pre-trained convent architecture for image classification b) Design recent variant of CNN model for image classification (6 Hours)	CO3	S3
4	a) Design a1D CNN model for sentiment analysis and 1D signal analysis b) Design a simple LSTM model for sequence classification c) Design a CNN model with LSTM architecture for sequence classification (6 Hours)	CO4	S3
5	a) Design a auto encoder for image generation and dimensionality reduction b) Design DCGAN for image generation (6 Hours)	CO5	S3

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

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 Optimization	K2
CO2	Describe the concepts of Convex Optimization	K2
CO3	Appreciate the application of optimization for Machine Learning	K2
CO4	Explain the concepts of Non-Convex Optimization.	K2

CO5	Familiarize special topics in Optimization techniques	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I Fuzzy Sets 9

Introduction to Optimization, sequences and limits, derivative matrix, level sets and gradients, Taylor series; unconstrained optimization - necessary and sufficient conditions for optima.

UNIT II Fuzzy Inference System 9

Convex sets, convex functions, optima of convex functions, Convex Optimization Problems, Steepest descent, Newton and quasi Newton methods. Conjugate direction methods.

UNIT III Neural Networks 9

Introduction, Incremental Gradient, Sub gradient and Proximal Methods. Non-smooth Convex Optimization, DC (Difference of Convex functions) Programming.

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UNIT IV Neural Network and Fuzzy Logic Applications 9

Non-convex approaches - projected gradient descent, alternating minimization, Applications - Sparse recovery, affine rank minimization, low-rank matrix completion.

UNIT V Adaptive Neuro-Fuzzy Inference Systems and Applications 9

Accelerated first order methods, Bayesian methods, Coordinate methods, Cutting plane methods Interior point methods, Optimization methods for deep learning, parallel and distributed methods.

Total: 45 Hrs

h) Learning Resources

Text Books

1. S. Boyd and L. Vandenberghe: Convex Optimization, Cambridge University Press, 2004.(UNIT-I & II)
2. SuvritSra, Sebastian Nowozin and Stephen Wright(Editors), Optimization for Machine Learning, The MIT Press, Dec. 2011.(unit-III)
3. T. Hastie, R. Tibshirani and M. J. Wainwright, Statistical Learning with Sparsity: the Lasso and Generalizations, Chapman and Hall/CRC Press, 2015.

Reference Books

1. Roberto Battiti, Mauro Brunato. The LION Way: Machine Learning plus Intelligent Optimization. Lionsolver, Inc. 2013.
2. Bubeck, Sebastien. "Theory of Convex Optimization for Machine Learning." arXiv preprint arXiv: 1405.4980, 2014.
3. D.E.Goldberg Addison "Genetic algorithms in Search, Optimization, and Machine learning" Wesley Publishers, 1989

Online Resources

1. http://simons.berkeley.edu/talks/peter-richtarik-2013-10-23.
2. Introduction to Convex Optimization in Machine Learning
3. Kristin Bennett, Emilio Parrado-Hernandez. Interplay of Optimization and Machine Learning Research, Journal of Machine Learning Research, 2006.

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

a) Course Category

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

Data structures, Object Oriented Programming, Python.

d) Related Courses

Machine Learning, Deep Learning

e) Course Outcome

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 of Data Science	K2
CO2	Analyze data by using various statistical and data mining approaches	K3
CO3	Analyze and Visualize the data using APIs and tools	K3
CO4	Enumerate and create the insights to art of visualization	K2
CO5	Analyze the implementation and management tools to organize the information system.	K3

f) **Correlation of Cos with Pos**

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

g) **Course Content**

UNIT I Introduction to Data Science 6

Definition – Why data science – Exploring Data Engineering Pipelines and Infrastructure – Data Scientist - Data Science Process Overview –Defining goals – Retrieving data – Data preparation – Data exploration – Data modeling – Presentation.

UNIT II Extract knowledge from Data 6

Learning from Data with Machine - Math, Probability, and Statistical Modeling – Using Clustering to Subdivide Data - Modeling with Instances - Building Models that Operate Internet-of-Things Devices.

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	Skill level
1	Generating random numbers using probability distributions a. Write an R program to create an ordered factor from data consisting of the names of months. b. Write an R program to get the statistical summary and nature of the data of a given data frame. c. Write a Python program which accepts the radius of a circle from the user and compute the area. d. Write a Python program to display your details like name, age, address in three different lines.	CO1	S3
2	Programs based on Data aggression, Filtering and Transformation	CO2	S3
3	Programs based on appending / merging data a. Create, manipulate and plot the time series data using R for annual rainfall details. b. Create a 2D Numpy array for student database perform indexing arrays by slicing and perform basic operations on the array	CO3	S3
4	Creation of Basic Visualizations • Bar chart • Geographic map • Crosstab report • Scatter plot • Line chart	CO4	S3
5	Developing a project to visualize data using Tableau and Python	CO5	S3

Total: 60 Hrs

h) Learning Resources

Text Books

1. Jeffrey S. Saltz, Jeffrey M. Stanton, An Introduction to Data Science, SAGE Publications, 2017, ISBN: 9781506377537
2. Lillian Pierson, Jake Porway, Data Science For Dummies, Wiley publication, 2017, ISBN: 978-1-119-32763-9
3. Noab Iliinsky, Julie Steele, Designing data visualizations, O' Reilly publishers, 2011.

Reference Books

1. Rafael A. Irizarry, Introduction to Data Science: Data Analysis and Prediction Algorithms with R, CRC Press, 2020.
2. Davy Cielen, Arno D. B. Meysman, Mohamed Ali, "Introducing Data Science", Manning Publications Co., 1st edition, 2016.

Online Resources

1. http://www.python-course.eu/numpy.php
2. https://www.learnpython.org/en/Pandas_Basics
3. https://www.r-bloggers.com/2015/08/data-manipulation-with-dplyr/

4. https://towardsdatascience.com/intro-to-data-science-531079c38b22?gi=1fb573279fdb
5. https://www.simplilearn.com/tutorials/data-science-tutorial/introduction-to-data-science
6. https://www.udemy.com
7. https://in.coursera.org/

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

a) Course Category

Program Elective

b) Preamble

This course provide 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

Fundamentals of Machine Learning

d) Related Courses

Deep Learning, Reinforcement Learning

e) Course Outcome

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	Describe the basic fundamental and applications of Natural language processing	K2
CO2	Applying morphological analysis, inflective and derivational morphology, tree structure for dictionaries and Speech Tagging	K3
CO3	Analyze the various approaches on syntax in Natural language processing	K4
CO4	Analyze the differentiation of semantic and discourse in terms of Natural language processing	K4
CO5	Implement an NLP system for various applications by using the tools for sentiment classification & chatbot systems	K3

f) Correlation of COs with POs

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	3	2	-	-	1	-	1	-	1	1	-	2	-	2
CO2	3	2	1	-	1	-	1	-	1	1	-	2	-	2
CO3	3	2	2	2	1	-	1	-	1	1	-	2	-	2
CO4	3	2	2	2	1	-	1	-	1	1	-	2	-	2
CO5	3	2	2	2	2	1	1	-	1	1	-	2	-	2

Unit I INTRODUCTION 12

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 12

Linguistic essentials - Lexical syntax- Morphology and Finite State Transducers - English Word Classes- The Penn Treebank Part of speech Tagging – Named Entities and Named Entity- Tagging Rule Based Part of Speech Tagging -HMM Part-of-Speech Tagging –Conditional Random Fields- Evaluation of Named Entity Recognition

Unit III SYNTAX ANALYSIS 12

Constituency Grammars-Context Free Grammars for English –Tree Banks-Lexicalized Grammars-Constituency Parsing-Dependency Parsing

Unit IV SEMANTIC AND DISCOURSE ANALYSIS 12

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 12

Question Answering -Case Study of Sentiment Classification, Chatbots.and Dialogue Systems

Total: 60 Hours

Text Book

1. Daniel Jurafsky and James H. Martin Speech and Language Processing (2nd Edition), Prentice Hall;2 nd ed., 2008.
2. Roland R. Hausser, Foundations of Computational Linguistics: Human- Computer Communication in Natural Language, Paperback, MIT Press, 2011.

References:

1. MachineLearning for Textby Charu C.Aggarwal,Springer,2018 edition
2. 2. Foundations of Statistical Natural Language Processing by Christopher D.Manning And Hinrich Schuetze,MIT press,1999
3. 3. Steven Bird,Ewan Klein and Edward Loper Natural Language Processing with Python,O’Reilly Media;1edition,2009

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Online Resources:
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1. https://blog.algorithmia.com/introduction-natural-language-processingnlp/
2. https://www.udacity.com/course/natural-language-processingnanodegree--nd892
3. https://www.coursera.org/learn/language-processing
4. https://towardsdatascience.com/a-practitioners-guide-to-naturallanguage-processing-part-i-processing-understanding-text-9f4abfd13e72
5. https://www.edx.org/course/natural-language-processin
6. NLTK – Natural Language Tool Kit - http://www.nltk.org/
7 https://www.cs.vassar.edu/~cs366/docs/Manning_Schuetze_StatisticalNLP.pdf
8. https://www.nltk.org/book/
9. https://www.nltk.org/genindex.html
10. www.cs.berkeley.edu/~klein/cs294-5/index.html
11. http://www.cse.unt.edu/~rada/CSCE5290/
12. http://www.cl.cam.ac.uk/teaching/1213/L100/materials.html

List of Experiments

SINO	CYCLE-1	CO mapping of Experiments
1	Write a program to tokenize text	CO 1
2	Write a program to count word frequency and to remove stop words	CO1
3	Write a program to program to tokenize Non-English Languages	CO2
4	Write a program to get synonyms from WordNet	CO2
5	Write a program to get Antonyms from WordNet	CO3
	CYCLE-2	
6	Write a program for stemming Non-English words	CO3
7	Write a program for lemmatizing words Using WordNet	CO4
8	Case study-based program (IBM) or Sentiment analysis	CO4
9	Write a program for POS Tagging or Word Embedding’s.	CO5
10	Write a program to differentiate stemming and lemmatizing words	CO5

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. Also, it provides the persuade of Artificial Intelligence in Speech recognition. Also, It gives the understanding about basic speech recognition techniques and distortion measures to analyze the speech signal.

c) Prerequisite

Discrete Time Signal Processing

d) Related Courses

Introduction to machine learning, ANN and Deep Learning, Fuzzy-Neural 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	Describe the basic concepts of speech signals and its representation in Time domain.	K2
CO2	Illustrate the Mathematical Modeling for Speech signal Processing	K3
CO3	Explain the different Speech Recognition Systems	K2
CO4	Implement AI methods for Automatic Speech Recognition	K3
CO5	Demonstrate different AI applications in Speech Synthesis	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I BASIC CONCEPTS 6

The process of speech production, 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 6

Features and Pattern Comparison Techniques: Speech distortion measures – mathematical and perceptual – Log Spectral Distance, Dynamic Time Warping, Multiple Time – Alignment Paths

UNIT III SPEECH RECOGNITION 6

Components of a typical recogniser, parameterisation of the speech signal, dynamic time warping, distance measures, the Hidden Markov Model, the generative model paradigmSpeech Recognition, Speech Features, The Auditory System as a Filter Bank, The 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, Python Programs

UNIT V APPLICATIONS IN MUSIC SYNTHESIS 6

Computer Music Synthesis, Music Signal Analysis, Music Retrieval, Speaker Verification

Total: 60 Hrs

h) Learning Resources

Text Books

1. JohnSpoken Language Processing" by Xuedong Huang, Alex Acero and Hsiao-wuen Hon, Prentice Hall, 2001 (ISBN 0-13-22616-5)
2. Rabiner Lawrence R., and Ronald W. Schafer, Introduction to Digital Speech Processing, Now Publishers Inc, 2007 (ISBN: 978-1-60198-070-0)

Reference Books

1. Daniel Jurafsky and James H Martin, “Speech and Language Processing – An Introduction to Natural Language Processing, Computational Linguistics, and Speech Recognition”, Pearson Education

List of Experiments

S.NO	EXPERIMENTS	CO mapping of Experiments
1	Visualizing Audio Signals -Analyze an audio signal of 100 Hz, using Python	CO1
2	Characterizing the Audio Signal using Python andconvert it into frequency domain using Fourier Transform mathematical tool	CO1
3	Generating Monotone Audio Signal using Python	CO2
4	Extract the features from signal, using Python and MFCC technique.	CO2
5	Recognition of Spoken Words	CO3
6	Conversion of speech to text	CO3
7	Classification of Voiced/Unvoiced Speech	CO4
8	Pole Zero modeling of speech signal	CO4
9	Linear and nonlinear filter bank	CO5
10	Frequency domain motion estimation	CO5

COURSE CODE	COURSE TITLE	L	T	P	C
10212EC138	**INTRODUCTION TO ARTIFICIAL INTELLIGENCE AND MACHINE LEARNING**	**3**	**0**	**0**	**3**

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

Mathematics for Electronics & Communication Engineers, Applied Statistics

d. Related Courses

Machine Learning for Wireless Communication, Artificial Intelligence based Wireless Network Design, Artificial Intelligence in Optical Communication

e. Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Interpret Artificial Intelligence (AI) methods and describe their foundations.	K2
CO2	Apply search algorithms for problem solving, inference, perception, knowledge representation and learning.	K3
CO3	Demonstrate knowledge reasoning and knowledge representation for solving real world problems	K3
CO4	Discuss the characteristics of machine learning and binary classification	K2
CO5	Use different linear methods for classification and regression with their optimization through different regularization techniques	K3

f) Correlation of COs with POs

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

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

A 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

The 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

g. Learning Resources

Text Books

1 Russell, S. and Norvig, P. Artificial Intelligence - A Modern Approach, 3rd edition, Prentice Hall, 2015

2 Peter Flach: Machine Learning: The Art and Science of Algorithms that Make Sense of Data, Cambridge University Press, Edition 2012.

References

1 Introduction to Artificial Intelligence & Expert Systems, Dan W Patterson, PHI., 2010 2. SKaushik, Artificial Intelligence, Cengage Learning, 1st ed.2011.

2 Ric, E., Knight, K and Shankar, B. Artificial Intelligence, 3rd edition, Tata McGraw Hill. 2009

3 Luger, G.F. Artificial Intelligence -Structures and Strategies for Complex Problem Solving,6th edition, Pearson, 2008

4 Alpaydin, E. Introduction to Machine Learning. 2nd edition, MIT, 2010

5 Nilsson Nils J, “Artificial Intelligence: A new Synthesis, Morgan Kaufmann Publishers Inc. 1998

Online Resources

1 https://nptel.ac.in/courses/112/103/112103280/

2 https://nptel.ac.in/courses/106/106/106106202/

3 https://www.coursera.org/lecture/guided-tour-machine-learning-finance/artificial-intelligence-and-machine-learning-part-i-kgIR0

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

a) Course Category

Honor Elective

b) Preamble

The course provides the knowledge in recent wireless technologies of 5G air interface / radio access networks in a composite manner.

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	Describe the technologies and architectures of 5G standard	K2
CO2	Discuss the various types of MIMO technology and channel modeling of millimeter wave communication	K2
CO3	Explain different wireless LAN technologies.	K2
CO4	Describe the network and transport layer solutions for Wireless standards	K2
CO5	Discuss the future communication networks such as multi UAV networking,V2V, V2I	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	PS O1	PS O2
CO1	H	M				-	M	L	L	-	-	H	-	-
CO2	H	H	M	L	L	-	-	-	L	-	-	H	H	-
CO3	H	H			L	-	-	-	L	-	-	H	-	-
CO4	H	H			L	-		-	L	-	-	H	M	-
CO5	M		H			H	M	-	L	M	-	-	-	M

g) Course Content

UNIT I OVERVIEW OF 5G 09

Development of LTE towards 5G – Technologies for 5G – 5G Architecture: Basics of RAN Architecture, Waveform in 5G – W OFDM, F OFDM, NOMA– Numerology for 5G.

UNIT II MASSIVE MIMO FOR 5G 09

Massive MIMO: point to point MIMO, Multi User MIMO, pilot contamination in massive MIMO – Performance measure, capacity bounds – Millimeter Wave Communication: Channel modeling, Radio and Propagation Channel Models, Large – Scale Channel Model, MIMO Spatial Channel Model–Millimeter-Wave Communications: Challenges, State-of-the-Art Technology.

UNIT III WLAN TECHNOLOGIES 09

Introduction – WLAN technologies: IEEE802.11 System architecture, protocol architecture, 802.11b – 802.11a: HIPER LAN1, HIPER LAN2 – Bluetooth – IEEE 802.11ad (60 GHz WLAN): MAC and PHY overview – Visible light communication – IEEE 802.15.7 PHY and MAC overview.

UNIT IV WIRELESS PROTOCOLS 09

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 FUTURE MOBILE NETWORKS 09

Drone networking – Multi-UAV networks: architectures, Challenges for micro UAVs, connected and autonomous cars – Wireless technologies for Vehicle-to-Infrastructure (V2I) and Vehicle-to-vehicle (V2V) communications

Total: 45 Hrs

h) Learning Resources

Text Books

1 SuvraSekhar Das, Ramjee Prasad, “Evolution of Air Interface Towards 5G Radio Access Technology and Performance Analysis“, River Publications, 2018.
2 Jochen Schiller, “Mobile Communications, Second Edition“, Pearson Education 2012.
3 Dahlman, Stefan Parkvall, “5G NR: The Next Generation Wireless Access Technology“, Elsevier Publications, 2018.
4 KavehPahlavan, “Principles of wireless networks”, Prentice-Hall of India, 2008.
5 Kamesh Namuduri, “UAV Networks and Communications“, Cambridge University Press, 2017.

Reference Books

6. Hao Jiang, Guan Gui, “Channel modeling in 5G wireless communication systems“, Springer, 2020.
7. R. Vannithamby and S. Talwar, “Towards 5G: Applications, Requirements and Candidate Technologies“, John Willey & Sons, West Sussex, 2017.
8. T. S. Rappaport, R. W. Heath Jr., R. C. Daniels, and J. M. Murdock, “Millimeter Wave Wireless Communication“, Pearson Education, 2015.
9. Asif Oseiran, Jose F.Monserrat and Patrick Marsch, “5G Mobile and Wireless Communications Technology”, Cambridge University Press, 2016.
10. Jonathan Rodriquez, “Fundamentals of 5G Mobile Networks”, Wiley, 2015
11. Fei Hu, Dong Xiu Ou, Xin-lin Huang, “UAV Swarm Networks: Models, Protocols, and Systems“,1st edition, CRC Press, 2021.

Online Resources

4. https://onlinecourses.nptel.ac.in/noc22_ee56
5. https://onlinecourses.nptel.ac.in/noc22_ee65
6. https://www.youtube.com/watch?v=6YBh2cjnJrY
7. https://www.free5gtraining.com

Course Code	Course Title	L	T	P	C
10212EC140	**MACHINE LEARNING FOR WIRELESS COMMUNICATIONS**	**3**	**0**	**0**	**3**

a) CourseCategory

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

Communication systems, Wireless Communication

d) RelatedCourses

Cellular Mobile communication

e) CourseOutcomes

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

CO Nos.	CourseOutcomes	Knowledge Level (BasedonRevised Bloom's Taxonomy)
CO1	Apply the ML-based algorithm for spectrum sharing and channel allocation	K3
CO2	Explain the methods for resource allocation and system level modeling	K2
CO3	Demonstrate ML-based signal modulation and coding techniques	K3
CO4	Describe ML-based channel coding and decoding algorithm	K2
CO5	Explain ML-based optimization techniques in wireless communication system	K2

f) Correlation of Cos with POs

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

g) CourseContent

UNIT I: ML FOR SPECTRUM ACCESS AND CHANNEL ALLOCATION 9

Introduction-Online 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

Introduction and Motivation- 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: ML BASED ADAPTIVE MODULATION AND CODING DESIGN 9

Introduction and Motivation- SL assisted AMC- RL assisted AMC- Adaptive Learning for Symbol Detection: Introduction, Preliminaries, system Model- Reproducing Kernel Hilbert Space Approach for symbol detection

UNIT IV: JOINT CHANNEL EQUALIZATION 9

Introduction-Overview of Neural Network based Channel Equalization: Principles of Equalization and Detection-Performance of OFDM Systems with Neural Network-Based Equalization- Channel Coding with Deep Learning: Overview of 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 Techniques for Autonomous Network Management-Data-Driven Base-Station Sleeping Operations by Deep Reinforcement Learning-Dynamic Frequency Reuse through a Multi-Agent Neural Network Approach- ANN-Based Models for Traffic and Mobility Prediction

Total: 45 Hrs

h) Learning Resources

Text Books

1 FA-LONG LUO, Machine Learning for Future Wireless Communications, Silicon Valley, California, USA.
2 Ruisi He and Zhiguo Ding, Applications of Machine Learning in Wireless Communications (Telecommunications), Institution of Engineering and Technology, 2019.

Reference Books

1 Ioan-Sorin Comşa and Ramona Trestian, Next-Generation Wireless Networks Meet Advanced Machine Learning Applications, IGI Global Information Science Reference, 2019.
2 K. Suganthi, R. Karthik, G. Rajesh and Peter Ho Chiung Ching, Machine Learning an d Deep Learning Techniques in Wireless and Mobile Networking Systems, CRC Press, 2021.

Online Resources

1 https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%2010.pdf
2 https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%209.pdf
3 https://www.ll.mit.edu/outreach/radar-introduction-radar-systems-online-course

Course Code	Course Title	L	T	P	C
10212EC140	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	Describes the basic concept of Wireless Network Architecture	K2
CO2	Discuss the network optimization concepts	K2
CO3	Interpret the game theory 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

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO1	PSO2
CO1	H	M	L	M	L	-	-	M	-	-	M	L	-	-
CO2	H	H	M	-	-	-	-	-	-	-	-	-	L	-
CO3	M	L	L	-	-	-	-	-	-	M	-	-	-	-
CO4	M	M	-	-	-	-	-	-	-	-	-	M	-	L
CO5	M	L	-	-	L	-	-	-	-	-	M	L	-	-

g) Course Content

UNIT I WIRELESS NETWORKS ARCHITECTURE 9

Introduction to wireless networks architecture - technology and standards - Introduction to LTE - Architecture of the LTE - Air Interface - Evolution from 4G to 5G - Enabling Technologies for 5G

UNIT II 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

UNIT III GAME THEORY 9

Basic Concept of Game Theory, History, Applied areas, Classification of Games, Cooperative Games - Non-cooperative Games, Evolutionary Games.

UNIT IV GAME THEORY IN COMMUNICATION AND NETWORKING 9

Uplink power control in CDMA Networks: Single cell CDMA networks, Multi cell 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

UNIT V APPLICATIONS 9

Applications of cognitive radio networks, Heterogeneous networks using supervised and unsupervised learning, Network intelligence in IoT design, 6G wireless Networks.

Total: 45 Hrs

h) Learning Resources

Text Books

1 S. Glisic, B.Lorenzo, “Advanced Wireless Networks: 4G Cognitive Opportunistic and Cooperative Technology”, 2ndEdition, John Wiley and Sons.
2 Fa-Long Luo, “Machine Learning for Future Wireless Communications” John Wiley and Sons, ISBN: 978-1-119-56225-2
3 Hsiao Hwa Chen, MohsenGuizani, “Next-Generation Wireless Systems and Networks”, John Wiley and Sons, 2006.
4 Zhu Han, DusitNiyato, WalidSaad, Tamer Basar, Are Hjorungnes, “Game Theory in Wireless and Communication Networks- Theory, Models and Applications”, Cambridge university press. 2012.
5 Ioan-SorinComşa, Ramona Trestian, ”Next-Generation Wireless Networks Meet Advanced Machine Learning Applications”, 2019

Reference Books

1 Elaine Rich, Kevin Knight and Shivashankar B Nair, “Artificial Intelligence”, TMH.
2 Dan W. Patterson, “Introduction to Artificial Intelligence and Expert Systems”, Pearson.
3 Savo Glisic, “Advanced Wireless Networks: Technology And Business Models” 3rd Edition, John Wiley, ISBN 13: 9788126565016
4 Jaime Lloret Mauri, KayhanZrar Ghafoor, Danda B. Rawat ,& Javier Manuel Aguiar Perez, “Cognitive Networks: Applications and Deployments”, CRC Press, 978-1482236996
5 Rappaport T.S, “Wireless Communications: Principles and Practice”, 2nd Edition, Pearson Education, 2007.

Online Resources

1. https://home.iitk.ac.in/~rohitbr/courses.html
2. http://aimaterials.blogspot.com/p/syllabus.html

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

a. Course Category

Honors 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 as part of course projects.

c. Prerequisite courses

NIL

d. Related Courses

Machine learning for Wireless Communication, Introduction to artificial intelligence and machine learning

e. Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on revised Bloom's Taxonomy)
CO1	Explain the fundamentals of optimization and describe their applications.	K2
CO2	Solve convexity optimization problems in multi user wireless systems.	K3
CO3	Apply Quadratic optimization and duality principle in MIMO OFDM systems.	K3
CO4	Discuss optimization technique for Signal and channel estimation, and apply convexity for PCA and SVM	K2
CO5	Illustrate the concepts of geometric optimization for cooperative communication and Radar systems	K3

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	PSO 1	PSO 2
CO1	M	H	M	-	-	-	-	-	-	-	-	-	-	-
CO2	H	M	H	L	-	L	L	-	-	-	L	-	L	-
CO3	H	M	M	-	-	L	L	-	-	-	L	-	L	-
CO4	M	H	L	L	-	-	-	-	-	-	-	L	L	-
CO5	H	M	L	-	-	-	M	-	-	-	-	L	-	-

g) Course Content

UNIT I BASICS OF OPTIMIZATION 9

Introduction to 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

g. 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?." 2008

Online Resources

1 https://onlinecourses.nptel.ac.in/noc20_ee59/preview

2 http://simons.berkeley.edu/talks/peter-richtarik-2013-10-23

3 Introduction to Convex Optimization in Machine Learning

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

a) Course Category

Honor Elective

b) Preamble

This course will provide the knowledge about the fundamentals of mm Wave devices and its importance in the modern communication system. This course also gives the knowledge about the mm Wave frequency bands in communication systems along with antennas used for mm Wave systems.

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	Discuss the fundamentals of Millimeter wave devices and circuits.	K2
CO2	Interpret the various components of Millimeter wave Communications system.	K2
CO3	Explain mm wave communication Systems.	K2
CO4	Describe the mm wave MIMO communication systems.	K2
CO5	Discuss the antennas for millimeter wave communication system	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION to mm WAVE **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- ADC's and DAC's.

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 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

a. K.C. Huang, Z. Wang, "Millimeter Wave Communication Systems", Wiley-IEEE Press, March 2011.
b. Robert W. Heath, Robert C. Daniel, James N. Theodore S. Rappaport, Murdock, "Millimeter Wave Wireless Communication", Prentice Hall, 2014.

Reference Books

1. Xiang, W; Zheng, K; Shen, X.S; "5G Mobile Communications: Springer, 2016.
2. Chia-Chin Chong, Kiyoshi Hamaguchi, Peter F. M. Smulders and Su-Khiong, “Millimeter - Wave Wireless Communication Systems: Theory and Applications,” Hindawi Publishing Corporation, 2007.
3. John S. Seybold “Introduction to RF propagation,”John Wiley and Sons, 2005.

Online Resources

1. https://link.springer.com/chapter/10.1007/978-3-030-92188-0_14

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

a) Course Category

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	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	Explain the optical neural network architecture	K2
CO5	Discuss the various applications of AI in optical networks and challenges and opportunities of AI in optical	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I EMERGING OPTICAL COMMUNICATION TECHNOLOGIES FOR 5G 9

Optical interfaces for wireless - common public radio interface - Evolved CPRI - Next generation fronthaul interface - Optical transmission technologies for X-haul - Optical Transport Network - Software Defined Network Fundamentals - Industry standards and development for 5G oriented optical networks.

UNIT II INTRODUCTION TO ARTIFICIAL INTELLIGENCE 9

History of AI - Overview of Artificial Intelligence - Machine Learning and Deep Learning- Supervised and Unsupervised Learning - Reinforcement Learning - Key Technologies to make 5G in reality using AI - AI assisted networks - Transforming optical industries by AI - AI subfields and techniques applied to optical networks.

UNIT III ARTIFICIAL INTELLIGENCE IN OPTICAL COMMUNICATIONS 9

Introduction - Convolutional neural network for Image data – Convolution – Polling - Down-sampling operation – Activation - Nonlinear operation - Recurrent neural network for sequential data - End to end for Joint Optimization With DL-Based Channel Model - Generative Adversarial Network for Data Augmentation - Deep Reinforcement Learning for Network Automation.

UNIT IV OPTICAL NEURAL NETWORK ARCHITECTURES 9

Optical realizations of perceptron - Perceptron pattern classification using Planar Interconnection Devices - Volume Holograms - Optical realizations of multilayer perceptron’s - optoelectronic realizations of multilayer perceptron - All optical realizations of multilayer perceptron - Optical realizations of Self organizing neural networks - Coherent self-organized Kohonen networks - Optical realizations of Hopfield and Boltzman neural networks.

UNIT V APPLICATIONS OF AI IN OPTICAL NETWORKS 9

Applications of AI in optical transmission: Characterization and operation of transmitters - EDFA- - Receivers and mitigation of nonlinearities - QoT estimation, Applications of AI in optical networking: Software defined networking - Optical burst switching - Passive optical networks - Intra-datacenter networking, New opportunities and challenges for the use of AI in optical networks: Optical transmission systems attack and intrusion detection - Automating network management operations - Applications in on-chip networks

Total: 45 Hrs

h) Learning Resources

Text Books

1 Alan E. Willner, "Optical Fiber Telecommunications VII", Elsevier Academic Press, 2020

2 Gurjit Kaur, Pradeep Tomar, Marcus Tanque, "Artificial Intelligence to Solve Pervasive Internet of Things Issues", Academic Press Publications, 2020

3 Dr.Ayman Elmaasarawy, " The Future Roles of Artificial Intelligence in Securing and Optimizing Services of 5G over Optical Transport Network", 2021

4 Cornelia Denz, "Optical Neural Networks", Optics and Photonics, 1998

5 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

Online Resources

1. https://doi.org/10.3389/frcmn.2021.656786
2. https://www.youtube.co/watch?v=OZ0By39RpnI
3. https://www.youtube.com/watch?v=nClPAfPGgt0
4. https://www.youtube.com/watch?v=dWaKPc26-sw

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 provides basic information on fundamental concepts of smart antennas and its beam forming principles. Also to understand the channel environment and design principles involves in modelling modern antennas for various applications.

c) Prerequisite

Electromagnetics and Transmission Lines

d) Related Courses

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	Describe the physical concept of antennas arrays.	K2
CO2	Analysis channel characteristics in the propagation medium.	K4
CO3	Analysis smart antennas and its architecture.	K4
CO4	Discuss various estimation algorithms to estimate AoA in smart antennas.	K2
CO5	Explain various beam forming techniques in smart antennas.	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I ANTENNA ARRAY FUNDAMENTALS 6

Overview of Antenna Arrays- Beam steered Linear Array. Array Weighting – Binomial-Blackman- Hamming- Gaussian- Kaiser- Bessel. Circular Arrays- Beam steered Circular arrays- Rectangular planar arrays- Fixed Beam Arrays- Butler Matrices- Fixed side lobe cancelling- Retro directive arrays- Passive and active retro directive array.

UNIT II PROPAGATION CHANNEL CHARACTERISTICS 6

Flat Earth Model- Multi path Propagation mechanisms- Propagation channel basics – Fading- fast fading model- multipath with no direct path- multipath with direct path- motion in a fast fading channel- Channel impulse response- Power delay profile- Power angular profile- power delay – angular profile- Channel dispersion- Slow fading model- Improving signal quality- Equalization- Diversity- Rake Receiver- MIMO.

UNIT III INTRODUCTION TO 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 beamforming- 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.	Write a MATLAB code for Butler matrix labyrinth of phase shifters for N array elements	CO2
2.	Write a MATLAB code for Rayleigh distribution	CO3
3.	Write a MATLAB code for Fast fading effect with given velocity	CO3
4.	Write a MATLAB code for Minimum Mean square error for optimizing weights of smart antenna.	CO3
5.	Write a MATLAB code for Minimum Variance method for reducing array out noise variance.	CO3
6.	Write a MATLAB code for least mean square algorithm for array weights	CO3
7.	Analyze MUSIC AoA estimation algorithm using MATLAB	CO4
8.	Analyze Root MUSIC AoA estimation algorithm using MATLAB	CO4
9.	Analyze ESPRIT AoA estimation algorithm using MATLAB	CO4
10.	Write a MATAB code to construct the array steering vector for the angle of arrival	CO5
11.	Write a MATAB code for Least squares constant modulus Algorithm and calculate array steering vectors	CO5
12.	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

Course Code	Course Title	L	T	P	C
10212EC145	**DIGITAL IC DESIGN**	**3**	**0**	**0**	**3**

a) Course Category

Program Elective

b) Preamble

The course includes fundamentals of the issues in the digital integrated circuits design, the different implementation strategies, arithmetic blocks, the design of sequential circuits, memory cells and the timing concepts in latch and flip-flops are discussed.

c) Prerequisite

VLSI Design

d) Related Courses

Low Power VLSI Design

e) Course Outcomes

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 design metric and MOS physics	K2
CO2	Explain the different strategies involved in digital IC design.	K2
CO3	Illustrate the different arithmetic blocks.	K2
CO4	Understand the basic sequential circuit's components and CMOS memory arrays.	K2
CO5	Explain the interconnect and clocking issues.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	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-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, Macrocells, Megacells 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 Parasitics - Computation of R, L and C for given interconnects - Buffer Chains - Timing classification of digital systems - Synchronous Design - Origins of Clock Skew/Jitter and impact on Performance - Clock Distribution Techniques - Latch based clocking - Synchronizers and Arbiters -Clock Synthesis and Synchronization using a PhaseLocked Loop.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Jan M. Rabaey, Anantha Chadrakasan, BorivojeNikolic, Digital Integrated Circuits: A Design Perspective, PHI, Second Edition, 2016.
2. 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/low power vlsi

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 provides the fundamental knowledge about filters, comparators, data converters and PLL.

c) Prerequisite

Analog 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.	K2
CO4	Illustrate the data converters in two different modes	K2
CO5	Explain the concept of PLL and noise analysis in both time domain and frequency domain.	K2

f) Correlation of COs with POs

	PO 1	PO 2	PO 3	PO 4	PO 5	PO 6	PO 7	PO 8	PO 9	PO 10	PO 11	PO 12	PSO 1	PSO 2
CO1	H	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 – opamps, 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 , Opamp as a comparator – input-offset voltage errors, charge-injection errors, making charge-injection signal independent, minimizing errors due to charge-injection, speed of multi-stage comparators, Latched comparators.

UNIT IV DATA CONVERTER 9

Ideal D/A converter, ideal A/D converter, quantization noise, deterministic approach, stochastic approach, signed codes, performance limitations, resolution, offset and gain error, accuracy and linearity Nyquist rate digital-to-analog converters.(DAC). Decoder-based converters – resistor string converters, folded resistor-string converters, multiple resistor-string converters.

UNIT V PHASE LOCKED LOOP 9

Basic phase-locked loop architecture, voltage controlled oscillator, divider, phase detector, loop filer, the PLL in lock, Linearized small-signal analysis – second-order PLL model, limitations of the second-order small-signal model, Jitter and phase noise.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Tony Chan Carusone, David A. Johns, Kenneth W. Martin “Analog Integrated Circuit Design” Second Edition, 2012.

Reference Books

2. Phillip Allen and Douglas R. Holberg ,“CMOS Analog Circuit Design”
3. Willy M. C. Sansen, “Analog Design Essentials”
4. Behzad Razavi, “Design of Analog CMOS Integrated Circuits” McGraw Hill, 33rd reprint ,2016
5. R.Jacob Baker, “CMOS Mixed Signal Circuit Design by, Wiley India, IEEE Press, reprint 2008.
6. R.Jacob Baker CMOS Circuit Design, Layout and Simulation by, Wiley India, IEEE Press, Second Edition, reprint 2009.

Online Resources

https://www.youtube.com/playlist?list=PLLDC70psjvq5vtrb0EdII4xIKA15ec-Ij

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 flow of CMOS fabrication flow	K2
CO2	Compare and contrast the diffusion and oxidation mechanisms	K2
CO3	Demonstrate the various deposition methods	K2
CO4	Illustrate the pattern transfer techniques	K2
CO5	Analyze and understand the IC processing	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO IC TECHNOLOGY 9

Brief History of Semiconductor technology, Silicon structure and properties, Czochralski Growth, Float Zone Growth, Characterization & evaluation of Crystals; Wafer Preparation-Silicon Shaping, Etching and Polishing, Chemical cleaning.

UNIT II DIFFUSION AND OXIDATION 9

Types of diffusion, Ficks laws, junction depth, Stopping mechanisms, Gaussian implantation profile, Variations to predicted distribution, Implantation damage and annealing, Oxidation growth mechanism, Structure of SiO2, Oxidation techniques and system, Oxide properties

UNIT III DEPOSITION AND EPITAXIAL GROWTH 9

Deposition requirements and techniques: Physical and Chemical Vapor deposition, Epitaxy-Vapour Phase Expitaxy, Defects in Epitaxial growth, Metal Organic Chemical Vapor Deposition, Molecular beam epitaxy.

UNIT IV PHOTOLITHOGRAPHY AND ETCHING 9

Introduction to photo/optical lithography, Contact/ proximity printers Projection printers, Mask generation, photo resists. Dry & Wet etching, methods for anisotropic etching, Plasma etching, Reaction ion etching (RIE)

UNIT V VLSI PROCESS INTEGRATION 9

Junction and Oxide Isolation, LOCOS methods, Trench Isolation, SOI; Metallization, Planarization. Fundamental consideration for IC Processing, NMOS IC Technology, CMOS IC Technology, Bipolar IC Technology

Total: 60 Hrs

h) Learning Resources

Text Books

a. Peter Van Zant, "Microchip Fabrication: A Practical Guide to Semiconductor Processing", McGraw- Hill Professional, Sixth Edition, 2014

Reference Books

12. S.M. Sze (Ed), VLSI Technology, 2nd Edition, McGraw Hill (2017).
13. Gary. S. May and S. M. Sze, "Fundamentals of semiconductor fabrication", John Wiley, First Edition, 2003.
14. Marc J. Madou, "Fundamentals of Microfabrication and Nanotechnology - Volume II", CRC Press, Third Edition, 2011.
15. James D. Plummer, Michael D. Deal, Peter B. Griffin, "Silicon VLSI Technology: Fundamentals, Practice and Modeling", Prentice Hall India Private Limited, 2000.
16. Stephen Campbell, "Science of Microelectronic Fabrication", Oxford University Press, 2001

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	Analyse the various test generation methods for CMOS logic circuits.	K2
CO3	Identify the design for testability methods for combinational & sequential CMOS circuits.	K2
CO4	Recognize 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

	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	M	H	L	M	-	-	-	-	L	-	-	L	L	-
CO3	H	M	M	L	L	-	-	-	L	-	-	M	L	-
CO4	M	M	L	-	-	-	-	-	-	-	L	-	L	-
CO5	M	M	L	-	-	-	-	L	L	-	-	L	L	L

g) Course Content

UNIT – I TESTING AND FAULT MODELS 9

Importance of testing, Challenges, Levels of abstractions and Functional vs. Structural approach to testing-Complexity of the testing problem-Software testing-Modelling of Fault, Logical Fault - Fault detection - Fault location - Fault dominance - Test optimization and fault coverage.

UNIT – II TEST GENERATION 9

Digital Test Pattern Generation for logic circuits-Test generation for combinational logic circuits - Testable combinational logic circuit design - Test generation for sequential circuits - design of testable sequential circuits-IDDQ testing-The LFSRs and their use in random test generation and response compression.

UNIT – III DESIGN TESTABILITY 9

Testability analysis-Scan cell design-Scan architectures-Scan design rules-Scan design flow-Special purpose scan designs Logic and fault simulation-Adhoc and structured approaches to DFT-Various kinds of scan design-Fault models for PLAs-Bridging and delay faults and their tests-Memory Testing.

UNIT – IV TEST ALGORITHMS 9

Design rules-Logic BIST architectures Test compression - Pattern Generators-Estimation of test length-Test points to improve testability-Analysis of aliasing in linear compression-BIST methodologies-BIST for delay fault testing - Test algorithms - Test generation for Embedded RAMs.

UNIT–V MEMORY DESIGN TESTING AND FAULT DIAGNOSIS 9

Memory Fault Modeling-testing and Memory Design for Testability and Fault Tolerance RAM Fault Modeling-Electrical Testing-Peusdo Random Testing-Megabit DRAM Testing-Nonvolatile Memory Modeling and Testing-Application Specific Memory Testing-Fault models for diagnosis: Cause-effect diagnosis, Effect-cause diagnosis.

Total: 45 Hrs

h) Learning Resources:

Text Books:

1. W. W. Wen, “VLSI Test Principles and Architectures Design for Testability”, Morgan Kaufmann, Publishers. 2006
2. M. L. Bushnell and V. D. Agrawal, Essentials of Electronic Testing for Digital, Memory, and Mixed-Signal VLSI Circuits, Kluwer Academic Publishers. 2000
3. N. Jha & S.D. Gupta, “Testing of Digital Systems”, Cambridge, 2003.
4. P.K. Lala, "Digital Circuit Testing and Testability", Academic Press, 2002

Reference Books:

1. A.L.Crouch, “Design Test for Digital IC’s and Embedded Core Systems”, Prentice Hall International, 2002.
2. ZainalabeNavabi, “Digital System Test and Testable Design: Using HDL Models and Architectures”, Springer, 2010

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**

Digital Electronics, Digital 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 design architectures for DSP algorithms.	K3
CO2	Apply retiming and algorithmic strength reduction technique optimize design parameters	K3
CO3	Apply high level algorithm transformation to optimize design parameters.	K3
CO4	Apply algorithmic strength Reduction in Filters and Transforms	K3
CO5	Apply pipelining and parallel processing in IIR and adaptive filters	K3

f) Correlation of COs with POs

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

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 – cooley tukey algorithm –Iterated Convolution

UNIT IV **ALGORITHMIC AND NUMERICAL STRENGTH REDUCTION IN FILTERS AND TRANSFORMS 9**

Algorithmic strength reduction in filters-Parallel FIR filter and parallel fast FIR filter – Fast Fourier transforms - Discrete cosine transforms –Sub-expression Elimination, Sub-expression Sharing in Digital Filters

UNIT V PIPELINIG PARALLEL IN RECURSIVE AND ADAPTIVE FILTERS 9

Introduction – pipelined interleaving in digital filters –pipelining in 1st order IIR digital filters and higher order IIR digital filters –parallel processing for IIR filter low power IIR filter design using pipelining and parallel processing

Total 45 Hrs

h) Learning Resources

Text Books

1. Keshab K.Parhi, “VLSI Digital Signal Processing Systems, Design and Implementation”, John Wiley, Indian Reprint, 2007.
2. S.Y.Kuang, H.J. White house, T. Kailath, “VLSI and Modern Signal Processing”, Prentice Hall, 1995

Reference Books

1. U. Meyer –Baese, "Digital Signal Processing with Field Programmable Arrays", Springer, Second Edition, Indian Reprint, 2007

Online Resource

1. https://books.google.co.in/books?isbn=8126510986
2. http://nptel.iitg.ernet.in /

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

a) Course Category

Program elective

b) Preamble

The goal of this course is to understand the fundamentals of analog circuit IC design, analog CMOS sub circuits 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	Explain the characteristics of CMOS analog electronics circuits	K2
CO2	Discuss the Analog CMOS Sub circuits like reference Current Source and current mirrors.	K2
CO3	Explain the CMOS single stage amplifiers in CMOS Circuits	K2
CO4	Illustrate the CMOS differential amplifier with current mirror load	K2
CO5	Explain the Two Stage and cascade Op Amps in CMOS Circuits	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION AND CMOS DEVICE MODELING

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 SUBCIRCUITS

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

Common-Source stage (with resistive load, diode connected load, current-source load, triode load, source degeneration), common-gate stage, cascode stage, folded cascade stage. Frequency responses of CS stage, CD stage, CG stage, cascode stage

UNIT IV CMOS DIFFERENTIAL AMPLIFIER

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

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.

g) List of experiments

S.No	Practical Exercises (30 Hours)
1.	Introduction to Software Tools
2.	Implementation of CMOS sub circuits cascode current mirror using SPICE
3.	Implementation of CMOS sub circuits Wilson and Widlar sub circuits using SPICE
4.	Frequency responses of CS stage, CD stage, CG stage amplifier using SPICE
5.	Frequency responses of CMOS Cascode amplifier using SPICE
6.	Quantitative analyses of common-mode response of Differential pair with MOS loads using SPICE
7.	Gain boosting, slew rate, power supply rejection of Two-stage CMOS op-amp using SPICE

h) Learning Resources

Text Books

1. Philip E. Allen, Douglas R. Halberg, “CMOS Analog Circuit Design”, Oxford University Press, 2nd Edition, 2003
2. Yannis Tsividis,”Mixed Analog-Digital VLSI Devices and Technology”,McGraw-Hill Publication, 2nd Edition, 1999

Reference Books

1. Vineetha P.Gejji Analog and Mixed Mode Design - Prentice Hall, 1st Edition , 2011
2. JeyaGowri Analog and Mixed Mode Design- Sapna publishing House 2011

Online Resources

1. https://www.google.co.in/search?hl=en
2. IN&source=hp&biw=&bih=&q=ANALOG+VLSI+DESIGN+.PPT&btnG=Google+Search&gbv=1

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 the Virtuoso 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	Identify the issues at various stages of VLSI physical design	K2
CO2	Illustrate the work space creation & writing RTL code, design simulation using INCISIVE Simulator and Synthesis Using GENUS Tool	S3

CO3	Design and implement of an combinational circuit using Pre-Layout Simulation/Post Synthesis simulation and physical design /automatic Layout Generation	S3
CO4	Design and implement of an sequential circuit using Pre-Layout Simulation/Post Synthesis simulation and physical design /automatic Layout Generation	S3
CO5	Design and implement of 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**													
	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
CO4	M	L	H	M	H	L	L	-	L	L	-	M	M	M
CO5	H	L	L	L	H	M	-	-	M	L	-	-	M	L

<table>
<tr><td colspan="11">g) Examination Scheme for practical dominated course</td></tr>
<tr><td colspan="7">Internal evaluation
(40M)</td><td colspan="4">Semester end evaluation
(60M)</td></tr>
<tr><td colspan="4">Laboratory experiment
(15M)</td><td colspan="3">Model laboratory test
(25M)</td><td>Part-A
(20M)</td><td colspan="3">Part-B
(40M)</td></tr>
<tr><td>Performance in conducting experiment
(5)</td><td>Result and analysis
(3)</td><td>Viva Voce
(3)</td><td>Record
(4)</td><td>Performance in conducting experiment
(15)</td><td>Result and analysis
(5)</td><td>Viva Voce
(5)</td><td>Theory questions to evaluate the knowledge and understanding (20)</td><td>Performance in conducting experiment
(25)</td><td>Result and analysis
(10)</td><td>Viva-Voce
(5)</td></tr>
</table>

h) **Course Content**

Theory **15 Hours**

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.

i) List of experiments

S. No	**CO Mapping**	**Practical Exercises (60 Hours)**
1.	CO2	Introduction to Cadence Tools viz. Schematic and Layout Design
2.	CO2	Work Space Creation & Writing RTL Code for CMOS Inverter
3.	CO3	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/J K Flip Flop using the INCISIVE Simulator

8.	CO4	Design Synthesis of SR/J K Flip Flop using the GENUS Tool
9.	CO4	Physical Design /Automatic Layout Generation of 4-bit Synchronous Counter
10.	CO5	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.	All COs	Mini Project using Cadence

Total: 75 Hrs

j) Learning Resources

Textbooks

1. S.M. Sait , H. Youssef, "VLSI Physical Design Automation", World scientific, 1999.
2. M.Sarrafzadeh, "Introduction to VLSI Physical Design", McGraw Hill (IE), 1996.Wayne Wolf, "FPGA-Based System Design", Pearson Education, 1e, 2005.
3. N.A.Sherwani , "Algorithms for VLSI Physical Design Automation", (3/e), Kluwer,1999.

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://nptel.ac.in/courses/106/105/106105161/
2. https://www.youtube.com/watch?v=q3po_gNaTBw
3. https://www.youtube.com/watch?v=0PB9er-__As

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-ofthe-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 Bloom's Taxonomy)
CO1	Build reconfigurable system using HDL and FPGAs.	S1
CO2	Perform partial reconfiguration for various applications using peripheral devices.	S2
CO3	Demonstrate an embedded system on FPGA using IP blocks.	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	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

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.

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

h) Learning Resources

Text Books

1. S. Hauck,"Reconfigurable Computing: Theory and practice of FPGA based Computation", Morgan Kaufmann, 2008.
2. Simon,"Programming FPGA's : Getting started with Verilog:, McGraw – Hill Education,2016.
3. Wayne Wolf, "FPGA-Based System Design", Pearson Education, 1e, 2005.
4. S. Palnitkar, "Verilog HDL",Pearson Education, 1e, 2003.

Reference Books

1. Andrew Dehon , “Reconfigurable Computing – The theory and Practice of FPGA based Computing”, 2008, Elsevier

Online Resources

1. Prof. Ken Eguro, University of Washington, Video lecture on Reconfigurable Computing, Sponsored by Microsoft Research
2. https://www.microsoft.com/en-us/research/video/candidate-talk-reconfigurable- computingarchitectural-and-design-tool-challenges/
3. http://www.verilog.com/

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 Security issues in communication systems.	K2
CO2	Discuss about traditional and modern symmetric cipher	K2
CO3	Interpret network theory concepts and its application in asymmetric cipher	K2
CO4	Describe about message identity, authentication and digital signature standards	K2
CO5	Explain about security at different layers of network.	K2

f) Correlation of COs with Pos

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

g) Course Content

UNIT I INTRODUCTION TO COMMUNICATION SYSTEM SECURITY 9

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-Other Methods for Physical-Layer Security-The Jamming Attacks-Code-Division Multiple Access (CDMA) and Jamming Capacity-Bloom Filters and Or-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- Transportation 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, The 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://resources.infosecinstitute.com/certification/communications-and-network-security/

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	Describe 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	Describe the Bus system and error handling in vehicular networks.	K2
CO5	Interpret the security and safety issues in vehicular communication with mobility modelling techniques	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO VEHICULAR COMMUNICATION 9

V2X: Vehicle-to-X (V2X) Communication for Intelligent Transportation Systems (ITS),V2X communication regimes , Standards and Technologies – layered architecture – Infrastructure-based vs. infrastructure-less technologies – Long-Term Evolution (LTE), 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, Routing – flooding, broadcast storm problem, Geocast

UNIT III VEHICULAR NETWORKS 9

A Historical Perspective and Review of Vehicular Networks: Cross-System Functions, Requirements for Bus Systems, Classification of Bus Systems, Application in the 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: Overview – Frame Format – Bus Timing – Topology – Error detection – Sleep/Wake-up modes – Advanced Frames – MOST Protocol: Overview - Physical Layer – Network and Fault Management – Diagnostics – Interface Controller – Applications – Overview of Automotive Ethernet protocols

UNIT V SAFETY APPLICATION AND MOBILITY MODELLING 9

Safety and non-safety applications, Vehicular Network Simulation – bidirectionally coupled road traffic and communication network simulators for vehicular network simulation – mobility models – Random models, flow and traffic models, behavioral models, trace and survey-based models, joint transport and communication simulations

Total: 45 Hrs

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, AntonellaMolinaro and Riccardo Scopigno, "Vehicular ad hoc Networks: Standards, Solutions, and Research", Springer, 2015.
2. Theodore S. Rappaport, "Wireless Communications: Principles and Practice", Second Edition, Prentice Hall, 2001.
3. Andrea Goldsmith, "Wireless Communications", Cambridge University Press, 2005.
4. M. Emmelmann, B. Bochow and C. C. Kellum, Vehicular Networking: Automotive Applications and Beyond, Wiley, 2010.
5. Dominique Paret, "Multiplexed Networks for Embedded Systems: CAN, LIN, FlexRay, Safe-by-Wire", Wiley, 2007.
6. M. Watfa, Advances in Vehicular Ad-Hoc Networks: Development and Challenges, Information Science Reference, 2010.
7. H. Moustafa, Y. Zhang, Vehicular Networks: Techniques, Standards, and Applications, CRC Press, 2009.

Online Resources

1 http://www.cs.odu.edu/~mweigle/courses/cs795-s07/

2 http://www.cs.odu.edu/~mweigle/courses/cs895-s07/

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

a) Course Category

Minor Elective

b) Preamble

In this course student will learn the different types of sensors and its fundamentals, self-generating and smart sensors which are used in modern electronics world. Students are also learning how the sensors are used in wearable technology and its application to the 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	Describe the Self Generating Sensors and Smart Sensors	K2
CO4	Explain the Importance of wearable technologies.	K2
CO5	Discuss the application of wearable Devices in Tele Communication and Biomedical Applications	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO 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 SENSORS AND ITS TYPES 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-Wearable applications: temperature sensitive fabric-electrochemical sensors.Integrated and Smart sensors- IEEE 1451 standard & Transducer Electronic Datasheets (TEDs)- Overview of various smart sensors- Digital temperature sensor (DS1621, TMP36GZ)-Humidity sensor (DHT11, DHT22, FC28)- IR sensor (FC51).

UNIT IV EMERGENCE OF WEARABLE DEVICES 9

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

UNIT V APPLICATIONS OF WEARABLE SYSTEMS 9

Cameras in wearable devices- Applications in safety and security- navigation- Enhancing sports media- Automatic digital diary- Wearable devices with Global Positioning System (GPS) - integration for tracking and navigation. The Meta Wearables – Textiles and clothing- Social Aspects: Interpretation of Aesthetics- Adoption of Innovation-On-Body Interaction- Medical Diagnostics- Medical Monitoring-Patients with chronic disease- Hospital patients- Elderly patients- Multi parameter monitoring.

Total: 45Hrs

h) Learning Resources

Text Books

1 Annalisa Bonfiglio, Danilo De Rossi, "Wearable Monitoring Systems", Springer, 2011.

2 Sandeep K.S. Gupta, Tridib Mukherjee, Krishna Kumar Venkatasubramanian, "Body Area Networks Safety, Security, and Sustainability," Cambridge University Press, 2013.

3 Jacob Fraden, "Hand Book of Modern Sensors: physics, Designs and Applications", 3rd ed., Springer, 2010.

4 Edward Sazonov, Michael R Neuman, "Wearable Sensors: Fundamentals, Implementation and Applications" Elsevier, 2014

Reference Books

1. Jon. S. Wilson, "Sensor Technology Hand Book", Elsevier Inc., 2005.
2. Subhas C. Mukhopadhyay, "Wearable Electronics Sensors-For Safe and Healthy Living" Springer International Publishing, 2015.
3. Hang,Yuan-Ting,"Wearable medical sensors and systems",Springer-2013.
4. Mehmet R. Yuce,Jamil Y.Khan, "Wireless Body Area Networks Technology Implementation and Applications", Pan Stanford Publishing Pvt.Ltd, Singapore, 2012
5. Guang-Zhong Yang(Ed.), "Body Sensor Networks, "Springer, 2006
6. Andreas Lymberis, Danilo de Rossi, "Wearable eHealth systems for Personalised Health management: state of the art and future challenges", IOS Press, 2004.

Online Resources

1 https://www.himss.org/resources/wearable-technology-applications-healthcare-literature-review

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

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 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 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	Identify the significant applications of Structural health monitoring in various disciplines of Engineering.	K2
CO2	Interpret the feasibility of present-day sensor technology used in Structural health monitoring devices.	K2
CO3	Explain the Feature Extraction methods in SHM	K2
CO4	Classify among the currently available data acquisition and transmission methods used to determine the structural damage.	K2
CO5	Illustrate the strategy to identify the flaws and how to detect it	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO SENSORS 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

Basics of Sensors: Transducers & Actuators, 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: Basics of Smart Materials like Piezoelectric, Shape Memory Alloys, ER & MR Fluids etc.

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 reorganization methods, neural networks, 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 Hours

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.

Reference Books

1. Health Monitoring of Structural Materials and Components Methods with Applications, Douglas E Adams, John Wiley and Sons, 2007.
2. Structural Health Monitoring and Intelligent Infrastructure, Vol1, J. P. Ou, H. Li and Z. D. Duan, Taylor and Francis Group, London, UK, 2006.
3. Structural Health Monitoring with Wafer Active Sensors, Victor Giurglutiu, Academic Press Inc, 2007.

Online Resources

1. https://research.csiro.au/data61/structural-health-monitoring
2. https://beanair.com/conditioning-monitoring-system.html
3. https://www.hindawi.com/journals/ace/2010/724962/
4. https://www.ndt.net/events/NDTCanada2014/app/content/Slides/40_Tamutus.df
5. https://cpwd.gov.in/Units/FinalDraftHandbook_Apr2007.pdf.

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

Wireless sensor networks and its applications, 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	Describe the evolution of internet technology and need for IoT and its various protocols and software.	K2
CO2	Apply IoT protocols in cellular and industry applications.	K3
CO3	Discuss IoT data for business solution in various domains in secured manner.	K2
CO4	Comprehend the basic automotive parts and the need for sensor integration in different automotive systems	K2
CO5	Identify various communication standards and protocols followed within the automotive systems.	K2

f) Correlation of Cos with POs

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

g) Course Content

UNIT I EVOLUTION AND INTRODUCTION 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 hardwares - 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 INTRODUCTION TO 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

λ sensors- Exhaust temperature sensor- NOx sensor- PM sensor- Fuel quality sensor- Level sensor- Torque sensor- Speed sensor- Mass flow sensor- Manifold pressure sensor- Wheel speed sensors/direction sensors - Steering position sensor (multi turn)- Acceleration sensor (inertia measurement), Brake pneumatic pressure sensor, ABS sensor, Electronic stability sensor.

UNIT V MODERN TRENDS AND TECHNICAL SOLUTIONS 9

Enabling Connectivity by Networking: In vehicle communication standards, CAN and LIN, Telematic solutions, Portable or embedded connectivity- Endorsing Dependability in Drive-by wire systems: Terminology and concepts , Why by-wire, FLEXRAY, Requirements on cost and dependability, Drive-by-wire case studies- prototype development- Future of In vehicle communication.

Total: 45 Hrs

h) Learning Resources

Text Books

1 Alessandro Bassi, Martin Bauer, Martin Fiedler, Thorsten Kramp, Rob van Kranenburg, Sebastian Lange, Stefan Meissner, "Enabling things to talk – Designing IoT solutions with the IoT Architecture Reference Model", Springer Open, 2016

2 Jan Holler, Vlasios Tsiatsis, Catherine Mulligan, Stamatis Karnouskos, Stefan Avesand, David Boyle, "From Machine to Machine to Internet of Things", Elsevier Publications, 2014.

3 Robert Bosch GmpH "Automotive Electrics, Automotive Electronics: Systems & Components" , 2014, 5th Edition, BOSCH.

4 John Turner, "Automotive Sensors", 2010, 1st Edition, Momentum Press, New York.

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 Marinetti, 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, 2011, BOSCH.

4 Jiri Marek, Hans-Peter Trah, Yasutoshi Suzuki, IwaoYokomori, "Sensors for Automotive Technology", 2010, 4th Edition, Wiley, New York.

Online Resources

1 https://archive.nptel.ac.in/courses/106/105/106105166/

2 https://onlinecourses.nptel.ac.in/noc21_ee85/preview

3 https://www.allaboutcircuits.com/technical-articles/internet-of-things-communication-protocols-iot-data-protocols/

4 https://www.slideshare.net/abdulrabbasi33/sensors-actuators

Course Code	Course Title	L	T	P	C
10212EC166	**M2M COMMUNICATION WITH IoT AND LTE**	**3**	**0**	**0**	**3**

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 the existing infrastructure.

c) Prerequisite

Nil

d) Related Courses

IoT in Automotive systems

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Discuss the fundamentals of M2M communication and its building blocks along with their characteristics	K2
CO2	Explain the technologies designed for M2M Communication	K2
CO3	Describe the fundamentals of Internet of Things 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

	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	-	-	H	-	-
CO2	H	M	L	L		-	-	-	L	-	-	H	M	-
CO3	H	M				-	-	-	L	-	-	H	-	-
CO4	H	M	-		L	-		-	L	M	-	H	-	-
CO5	M		H			H	M	-	L	M	-	-	-	M

g) Course Content

UNIT I INTRODUCTION TO M2M COMMUNICATION 09

Machine to Machine: Definition, Typical Architecture of M2M – High-Level System Architecture – ETSI M2M Service Capabilities – REST Architectural Style – M2M Opportunities – Telemetry vs. M2M communications, – M2M Standards.

UNIT II M2M TECHNOLOGIES 09

Wired networks for automation systems: HART, CAN, Industrial Ethernet – Wireless networks for automation systems: Wireless HART, ISA100.11a – M2M capillary networks: WSNs, Low-power Bluetooth, 802.11ah – Medium Access Control (MAC) Protocols for M2M Communications.

UNIT III INTERNET-OF-THINGS (IoT) FOR M2M 09

Introduction to IoT: Sensor , Transducer & Actuators – IoT Architecture – IoT enabling technologies – Zigbee IEEE 802.15.4 – IPv6 for M2M.

UNIT IV M2M IN CELLULAR NETWORKS 09

Evolution of LTE Networks – M2M over LTE: LTE-U, LTE-A, LTE Advanced Pro: Requirements and implementation – Case study: LTE-A radio planning for Sensor devices deployment.

UNIT V M2M APPLICATIONS 09

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 Bahga and V. Madisetti, “Internet of Things, A hands-on approach“, 1st edition, CreateSpace Independent Publishing Platform, 2014.
3 Erik Dahlman, Stefan Parkvall and Johan Skold“, 4G: LTE advanced pro and the road to 5G“, 3 rd Edition, Elsevier Publications, 2011.
4 Erik Dahlman, Stefan Parkvall “5G NR: The Next Generation Wireless Access Technology“, Elsevier Publications, 2018.

References

1. Oliver Hersent, David Boswarthick, Omar Elloumi, “The Internet of Things: Key Applications and Protocols“, 2nd Edition, Wiley Publications, 2012.

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

Course Code	Course Title	L	T	P	C
10212EC167	**FLEXIBLE ELECTRONICS FOR AUTOMOBILE APPLICATIONS**	**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

Circuit Theory, Linear Integrated Circuits

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 electrical and electronic analogy of a vehicle system	K2
CO2	Describe the electrical equipment's and their use in vehicle circuit measurements	K2
CO3	Explain the electronic equipment's and their use in vehicle circuit measurements	K2
CO4	Describe various digital circuits used for vehicle automation	K2
CO5	Explain computer and microprocessor useful for automotive vehicle	K2

f) Correlation of Cos with POs

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

g) Course Content

UNIT I: ELECTRICAL AND ELECTRONIC SYSTEMS IN AUTOMOBILE SYSTEM 9

Overview-Electronic components in vehicles: Electronic Control units, 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 EQUIPMENT 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 TEST EQUIPMENT AND MEASUREMENT 9

Electronic fundamentals: 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, current probe, 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**

Introduction to 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: 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.

Reference Books

1 William B.Ribbens Butterworth, Heinemann, “Understanding Automotive Electronics”, 5th Edition, 1998.
2 Douglas V Hall, Microprocessor and Interfacing: Programming and Hardware, 2ND Edition, TMH, 2003

Online Resources

1 https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%2010.pdf
2 https://www.ll.mit.edu/sites/default/files/outreach/doc/2018-07/lecture%209.pdf
3 https://www.ll.mit.edu/outreach/radar-introduction-radar-systems-online-course

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

a) Course Category

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

e) Course Outcomes

Onsuccessfulcompletionofthis coursethestudentwillbeableto

CONos.	CourseOutcomes	Knowledge Level(BasedonRevisedBloom's Taxonomy)
CO1	Explain the general purpose 8-bit and 16-bitmicroprocessor andinstructionset	K2
CO2	Explain the 8-bit microcontroller architecture and itsinstructionset	K2
CO3	Describe the peripheral interfacingrequired to design an embedded system	K2
CO4	Familiarize various types of serial communication protocol	K2
CO5	Discuss thevarious aspects of complete embeddedsystemdesignthroughcase studies	K2

f) Correlation of Cos with POs

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

g) CourseContent

UNITI INTRODUCTION TO EMBEDDED SYSTEMS 8

Embeddedsystemdefinition, classification ofembeddedsystem, embedded systemdesignprocess, skills requiredfor anembedded system designer, reset circuit, power upreset.

UNITII MICROCONTROLLER 10

Difference between microprocessor and microcontroller,Overview of the architecture of 8051 microcontroller, Memory organization, and special function registers,AddressingModes, Instructionformats, Instructionset,InterruptandInterruptroutines, I/OPorts, Assembly Language programming.

UNITIII INTERFACING PERIPHERALS USING EMBEDDED C 10

Data types and time delays, IO programming, logical operations and data conversions, timer and counter programming, serial port programming, LCD interfacing, key board interfacing

UNIT IV COMMUNICATION PROTOCOL 8

Communication Basics, Serial communication protocols: UART, RS232, RS485, Serial Peripheral Interface (SPI), Inter Integrated Circuits (I2C), Introduction to CAN and USB.

UNITV CASE STUDY 9

ADC / DAC interfacing. Relays, stepper motor and DC motor interfacing with PWM. Casestudy using 8051: washingmachine, Trafficlight controller, Microwave oven.

Total – 45Hrs

h) Learning Resources

ReferenceBooks

1. RajKamal,“EmbeddedSystems:Architecture,ProgrammingandDesign”,SecondEdition,TataMcGraw-Hill Education, 2011.
2. Frank Vahid, Givargis, “Embedded Systems Design: A Unified Hardware / Software Introduction”, Wiley Publications, 2006.
3. RameshGaonkar,“MicroprocessorArchitecture,Programming,andapplicationswiththe8085”,Sixth Edition,PenramInternationalPublishingPvt. LTD,2013.
4. AjoyRay,KBhurchandi,“AdvancedMicroprocessorsandPeripherals”,Second Edition,McGraw Hill Education–2006.
5. MohamedAliMazidi,JaniceMazidi,RolinMcKinlay,“The8051Microcontrolle

randEmbeddedSystems:UsingAssembly andC",SecondEdition,Pearsoneducation,2011

6. M.Natale, A.Ghosal, "Understanding the CAN Communication Protocol", Springer, 2012.
7. Don Anderson, "Universal Serial Bus System Architecture", Addison Wesley, 2007.

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 provide the analysis of various sensors and transducers by giving them in-depth knowledge about static, dynamic characteristics and error analysis methods.

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	a. Explain the classification and static characteristics of transducers. b. Describe various errors and perform error analysis.	K2
CO2	Discuss the working principle and characteristics of Magnetic and Radiation sensors	K2
CO3	Describe construction, working principle, characteristics and applications of various resistance transducers	K2
CO4	Explain the working principle various inductance transducers and capacitance transducers	K2
CO5	Interpretthe operation and applications of modern industrial transducers	K2

f) Correlation of Co’s with Po’s

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO 10	PO 11	PO12	PSO1	PSO2
CO1	M	L										L	M	L
CO2	M	L	M	L	L			L				L	M	L
CO3	M	L		M			L		L	L			L	L
CO4	M	L	L	M	M			L	L	L			M	L
CO5	M	L	M	M	M			L				L	M	L

g) Course Content

UNIT I INTRODUCTION TO MEASUREMENTS AND SENSORS 9

Generalized measurement system - Classification of transducers – Selection of transducers- Static characteristics – Dynamic Characteristics- Units and standards – Staticcalibration – Classification of errors - Limiting error and probable error –Error analysis – Statistical methods – Odds and uncertainty

UNIT II MAGNETIC& RADIATIONSENSORS 9

Sensor based on Villari effect for assessment of force, torque, proximity, Wiedemann effect for yoke coil sensors, Thomson effect, Hall effect, and Hall drive, performance characteristics.

Radiation sensors: LDR, Photovoltaic cells, photodiodes, photo emissive cell types, materials, construction, response. Geiger counters, Scintillation detectors, Introduction to smart sensors.

UNIT III RESISTIVE TRANSDUCERS **9**

Principle of operation, construction details, characteristics andapplications of potentiometer - Strain gauge – types - Resistance temperaturedetector (RTD) - Thermistor –Hot-wire anemometer – constant current andconstant temperature operation - Resistive humidity sensor. .

UNIT IV INDUCTIVE AND CAPACITIVE TRANSDUCERS **9**

Induction potentiometer – Variable reluctance transducer – Eddy currenttransducer –Principle of operation, construction details, characteristics andapplications of Linear Variable Differential Transducers –Capacitivetransducer and types - Differential arrangement – Variation of dielectricconstant for measurement of liquid level - Dynamic microphone..

UNIT V ADVANCED TRANSDUCERS 9

Piezoelectric transducer – Hall Effect transducer – Magneto resistor -Digital displacement transducer– Fiber optic sensor - Introduction to SQUIDsensor, Touch screen sensor, Smart Transducer, MEMS : Accelerometer, gyroscope, pressure sensors and magnetic field sensor, Nano Material based bio sensors.

Total 45 Hrs

h) Learning Resources

Text Books

1. Ernest O.Doebelin,- Measurement system, 6th Edition, Tata McGraw Hill EducationPrivate Ltd, New Delhi, 2012.
2. A.K. Sawhney,- A course in Electrical & Electronic Measurement and Instrumentation, DhanpatRai and Company Private Limited, Reprint: 2014.

Reference Book

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 andDesign‖, Oxford University Press, Cambridge, 2003
4. Murthy D.V.S., ―Transducers and Instrumentation‖, 2nd Edition, Prentice Hall of IndiaPrivate Limited, New Delhi, 2010.
5. S.Renganathan, ―Transducer Engineering‖, Allied Publishers, 2005
6. A. R. Jha, MEMS and Nanotechnology-Based Sensors and Devices for Communications, Medical and Aerospace Applications, 1st edition, 2008

CourseCode	CourseTitle	L	T	P	C
10212EC170	**EMBEDDED SECURITY**	**3**	**0**	**0**	**3**

a) **CourseCategory**

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) **RelatedCourses**

Nil

e) **CourseOutcomes**

Uponthesuccessful completionofthe course, student will be able to:

CONos.	CourseOutcomes	Knowledge Level(BasedonRevised Bloom's Taxonomy)
CO1	Explain the basic concepts involved in embedded systems security.	K2
CO2	Articulate 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	Explore various data protection protocols for embedded systems.	K2
CO5	Describe the embedded system security issues in real time scenarios.	K2

f) CorrelationofCOswithPOs

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
CO6	L	-	M	M	H	L	L	-	M	M	H	H	H	H

g) CourseContent

UNITI INTRODUCTION TO EMBEDDED SYSTEMS SECURITY 9

Introduction: Security – Embedded systems – Embedded security trends – Security policies – Security threats – Multiple independent levels of security – Core embedded OS security requirements.

UNITII SECURE EMBEDDED SOFTWARE DEVELOPMENT 9

Introduction – Principles of High-Assurance Software Engineering – Minimal Implementation – Component Architecture: Runtime Componentization – Least Privilege – Secure Development Process: Change Management, Development Tool Security, Secure Coding, Software Testing and Verification, Development Process Efficiency.

UNITIII 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.

UNITIV 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.

UNITV EMBEDDED SECURITY APPLICATIONS 9

Embedded Network Transactions – Automotive Security – Secure Android – Next-Generation Software – Defined Radio.

Total: 45 Hrs

h) Learning Resources

TextBook

1. Embedded Systems Security: Practical Methods for Safe and Secure Software and Systems Development Paperback – Import, 25 April 2012 by David Kleidermacher , Mike Kleidermacher.
2. CRYPTOGRAPHY AND NETWORK SECURITY PRINCIPLES AND PRACTICE SEVENTH EDITION by William Stallings, Pearson Education Limited 2017
3. Bruce Schneier, "Applied Cryptography", second edition, John Wiley and Sons Inc, 2012

Reference Book

1. Security Engineering: A Guide to Building Dependable Distributed Systems 2nd Edition by Ross J. Anderson, 2012.

Online Resources:

1. https://www.sciencedirect.com/book/9780123868862/embedded-systems-security
2. http://www.cs.vsb.cz/ochodkova/courses/kpb/cryptography-and-network-security_-principles-and-practice-7th-global-edition.pdf

Course Code	Course Title	L	T	P	C
10212EC171	**BASICS OF 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 theinsight 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 purposetransducers. 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 onsocial 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	Explainthe basic idea of measurements, characteristics and the errors associated withmeasurements.	K2
CO2	Discuss the concept of resistive sensors which can be employed for real lifeapplications	K2
CO3	Realize the concept of reactive sensors employed for real life applications	K2
CO4	Describe the working principle of special purpose sensors and the need for developingsmart sensors.	K2

CO5	Describe the taxonomy of the wearable devices and its design constraints for measuringphysical and biological signals.	K2

f) Correlation of Co's with Po's

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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 AND SENSORS 9

Functional Elements of a Measurement System and Instruments, Applications and Classificationof Instruments, Types of measured Quantities, Measures of Dispersion, Sample deviation andsample mean, Units and standards, Calibration and errors . General concepts and terminology ofSensor systems, Transducers classification-sensors and actuators, General input-outputconfigurations, Static and dynamic characteristics of measurement system.

UNIT II RESISTIVE SENSORS 9

Resistive sensors- Potentiometers, strain gages (piezo-resistive effect), resistive temperaturedetectors (RTD), thermistors, magnetoresistors, light dependent resistor (LDR), resistivehygrometers, resistive gas sensors. Wearable applications: Strain sensor for monitoringPhysiological signals, body movement.

UNIT III REACTIVE SENSORS 9

Inductive sensors - variable reluctance sensors, Hall effect, Eddy current sensors, Linear variabledifferential transformers (LVDT), variable transformers, magneto-elastic, magneto-resistive, andmagnetostrictive sensors. Capacitive sensors- variable capacitor, differential capacitor. Wearableapplications: Body/textile antennas for wireless data transmission.

UNIT IV SELF GENERATING SENSORS 9

Thermoelectric sensors, piezoelectric sensors, pyroelectric sensors, photovoltaic sensors, electrochemical sensors, Wearable applications: temperature sensitive fabric, electrochemicalsensors.

UNIT V SCOPE OF WEARABLE DEVICES 9

Role of Wearables, Attributes of Wearables, The Meta Wearables – Textiles and clothing, SocialAspects: Interpretation of Aesthetics, Adoption of Innovation, On-Body Interaction; Case Study:Google Glass, health monitoring, Wearables: Challenges and Opportunities, Future and ResearchRoadmap.

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, Implementationand Applications" Elsevier, 2014

Reference Book

1. A.K. Sawhney, "Electrical and Electronic Measurements and Instrumentation", DhanpatRai.

Course Code	Course Title	L	T	P	C
10212EC172	**Smart City**	3	**0**	**0**	**3**

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

f) 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	Conceptualize Smart city essentials	K2
CO2	Identify the Technologies used in smart city	K2
CO3	Explore smart objects for IoT centric products	K2
CO4	Categorize the different methods to benchmark smart cities	K2
CO5	Explain the various smart city applications for village cluster project	K2

a) Correlation of COs with POs

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

g. Course Content

UNIT I Introduction **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, etc., Wireless – RFID, WiFi, Bluetooth, etc. Different 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, Smart Cities as Systems of Systems, IoT Centric approach, IoT Protocols: 6LowPAN, Cellular, NFC, LoRa, Sigfox, Neul**.**

UNIT V Smart City Applications **9**

European Smart cities, Singapore, Taipei and Surabaya, Mumbai and New Delhi. Smart Village Clusters and Urbanization: Application of smart city concepts

Reference Books

1. Carlo Ratti and Matthew Claudel, ―The City of Tomorrow: Sensors, Networks, Hackers, and the Future of Urban Life (The Future Series)‖, Yale University Press,2016.
2. Stephen Goldsmith, Susan Crawford, ―The Responsive City: Engaging Communities Through Data-Smart Governance‖, 1st Edition Jossey Bass – Wiley, 2014.

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

a) Course Category

Minor Elective

b) Preamble

Understandingtheglobaltrendsanddevelopmentmethodologiesofvarioustypesofproducts and services Conceptualize, prototype and develop product management plan for anew product based on the type of the new product and development methodology integrating the hardware, software, controls,electronics andmechanicalsystems.

c) Prerequisite

Nil

d) Related Courses

e) Course Outcomes

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

CONos.	Course Outcomes	Knowledge Level(BasedonRevised Bloom's Taxonomy)
CO1	Interpret the various global trends to develop the new product.	K3
CO2	Summarizethetypesofproductrequirements, productdevelopment methodologies and management.	K2
CO3	Conceptualize the product of integrating hardware, software, controls, electronics and mechanical system anddetailedproductdesignandtesting.	K3
CO4	Develop product test specifications standards, validate theproduct and confirm its performance as per designspecifications.	K3
CO5	Enumerate the end product development process of trade off, IPR, security and Configuration management.	K2

f) Correlation of CO’s with PO’s

	PO 1	PO 2	PO3	PO4	PO5	PO 6	PO 7	PO 8	PO 9	PO10	PO11	PO12	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

UNITI 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 Product sand Services-Typesof Product Development-OverviewofProductDevelopmentmethodologies-ProductLifeCycle - ProductDevelopmentPlanningandManagement

UNITII REQUIREMENTS AND SYSTEM DESIGN 9

Requirement Engineering - Types of Requirements - Requirement Engineering - Traceability Matrix andAnalysis-RequirementManagement-SystemDesign &Modeling-Introduction to SystemModeling-SystemOptimization- SystemSpecification- Sub-SystemDesign -InterfaceDesign

UNITIII DESIGNANDTESTING 9

Conceptualization - Industrial Design and User Interface Design - Introduction to Concept generationTechniques –Challenges in Integration of Engineering Disciplines - Concept Screening & Evaluation –Detailed Design-Component Designand Verification– Mechanical,Electronics and 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 toRapid Prototyping and Rapid Manufacturing-System Integration,Testing,Certification and Documentation

UNITIV SUSTENANCEENGINEERING ANDEND-OF-LIFE (EOL) SUPPORT 9

IntroductiontoProductverificationprocessesandstages-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.

UNITV BUSINESSDYNAMICSENGINEERINGSERVICESINDUSTRY 9

The Industry - Engineering Services Industry - Product development in Industry versus Academia - The IPD Essentials-Introductionto vertical specific product development processes - Manufacturing/Purchase and Assembly of Systems-Integration of Mechanical, Embedded and S/W systems – Product development Trade-offs - Intellectual Property Rights and Confidentiality - Security and configuration management.

Total: 45 Hrs

h) LearningResources

TextBooks

1. 1.KarlTUlrichandStephenDEppinger,"ProductDesignandDevelopment", TataMcGrawHill,FifthEdition,New Delhi,2011
2. 2. John W Newstormand KeithDavis, "Organizational Behavior", Tata McGrawHill, Eleventh Edition,NewDelhi, 2005.

ReferenceBooks

1. HiriyappaB,“CorporateStrategy –ManagingtheBusiness”,Authorhouse,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, NewDelhi,2003
4. MarkSSanders and Ernest JMcCormick,"Human Factors in Engineering and Design", McGraw Hill Education, Seventh Edition, NewDelhi, 2013.

Course Code	Course Title	L	T	P	C
10212EC206	**EMBEDDED SYSTEMS AND ROBOTICS**	**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 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	Demonstrate PIC based embedded systems	S3
CO2	Design and demonstrate real time systems using Arduino	S3
CO3	Design robots using Webots based on e-puck for the given specification and demonstrate it	S3

f) Correlation of COs with Pos

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
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) Examination Scheme for practical dominated course

Internal evaluation (40M)							Semester end evaluation (60M)			
Laboratory experiment (15M)				**Model laboratory test (25M)**			**Part-A (20M)**	**Part-B (40M)**		
Performance in conducting experiment (5)	Result and analysis (3)	Viva Voce (3)	Record (4)	Performance in conducting experiment (15)	Result and analysis (5)	Viva Voce (5)	Theory questions to evaluate the knowledge and understanding (20)	Performance in conducting experiment (25)	Result and analysis (10)	Viva-Voce (5)

h) Course Content :

Theory **15 Hours**

PIC-Architecture, pin diagram, ports, on chip peripherals Embedded C programming – General Structure, Data types.

Embedded C programming – General Structure, Data types.

Arduino- introduction, IDE, different arduino, Boards & shields.

Analog I/O & o/p.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

RTOS fundamentals.

i) 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	PWM generation using PIC
7.	CO1	Motor speed control using PIC
8.	CO2	Exploring the features of Arduino IDE and Boards
9.	CO2	LED Interfacing using Arduino
10.	CO2	RGB LED interface using Arduino
11.	CO2	LCD Interfacing using Arduino.
12.	CO2	LDR Interfacing using Arduino.
13.	CO2	IR sensor interfacing using Arduino
14.	CO2	Ultrasonic sensor interface using Arduino
15.	CO2	Temperature sensor interfacing using Arduino.
16.	CO2	Motor interface using Arduino
17.	CO2	Bluetooth Interfacing using Arduino
18.	CO2	GSM module Interfacing using Arduino

19.	CO2	WiFi Interfacing using Arduino
20.	CO3	Building a Robot Car
21.	CO3	Programming the Robot Car using Arduino
22.	CO3	Exploring the features of Webots
23.	CO3	LED Control of e-puck Robot in Webots
24.	CO3	Motor Control of e-puck Robot in Webots
25.	CO3	LED and Motor Control of e-puck Robot using keyboard in Webots
26.	CO3	Line Follower e-puck Robot in Webots

Total: 75 Hrs

j) Learning Resources

Textbooks

1. Massimo Banzi, "Getting Started with Arduino" 2 nd edition. O'Reilly, 2011.
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.
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-1984.
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.

Online Resources

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

Course Code	Course Title	L	T	P	C
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) and 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	Understand the various concept of the IoT and their technologies.	K2
CO2	Develop the IoT application using different hardware platforms.	K3
CO3	Implement the various IoT Protocols.	K3
CO4	Understand the basic principles of cloud computing.	K2
CO5	Develop and deploy the IoT application into cloud environment.	K3

f) Correlation of COs with POs

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

g) Course Content

UNIT I FUNDAMENTALS AND APPLICATIONS OF EMBEDDED IOT 5

Introduction to Internet of Things (IoT)– Functional Characteristics – Recent Trends in the Adoption of IoT – Societal Benefits of IoT, Health Care — Machine to Machine (M2M) - Smart Transportation – Smart Living – Smart Cities- Smart Grid, Industry.

UNIT II ARDUINO UNO AND RASPBERRY PI 3 8

Arduino introduction, 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 III COMMUNICATION PRINCIPLES 6

Protocol Standardization for IoT, Machine to machine (M2M) and WSN Protocols, Basics of RFID, Protocols- IEEE 802.15.4, ZigBee, IPv6 technologies for IOT,.

UNIT IV COMMUNICATION INTERFACES 6

IEEE 802.11 Wireless Networks Attacks: Basic Types, WEP Key Recovery Attacks, Keystream Recovery Attacks against WEP – RFID Security – Security Issues in ZigBEE: Eavesdropping Attacks, Encryption Attacks – Bluetooth Security: Threats To Bluetooth Devices and Networks.

UNIT V CLOUD ANALYTICS FOR IOT APPLICATION 5

Evolution of Cloud Computation, Commercial clouds and their features, open source IoT platforms, cloud dashboards, Big data analytics and Hadoop. Interfacing and data logging with cloud: Thing speak, Blync platform.

Text Book:

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.

References:

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

LIST OF EXPERIMENTS (20 Hours)

S.No	Name of the Experiment	CO	Skill Level
1	Basics of Internet of Things: Sensors, Actuators, IoT architecture and Gateway.	CO1	L2
2	Blinking LED through Raspberry pi or Arduino.	CO2	L4
3	IoT sensors interface with Raspberry pi or Arduino OR nodeMCU (Temperature/Light sensors).	CO2	L4
4	Integration of Actuators with Raspberry pi or Arduino (Servo motor/Relay).	CO2	L4
5	Capture Image with Raspberry pi or Arduino.	CO2	L4
6	Design Traffic control system: using Raspberry pi or Arduino.	CO2	L4
7	IoT Networking: Connectivity technologies, Protocols and Interoperability in IoT.	CO3	L3
8	Design Temperature dependent auto cooling system: Using Raspberry pi or Arduino.	CO3	L3
9	IoT applications in home automation: Implementing IoT home application using Raspberry pi or Arduino.	CO4	L2
10	Case study: Emergence of IoT Healthcare through Cloud Computing.	CO5	L4

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

Course Code	Course Title	L	T	P	C
10213EC101	**INTRODUCTION TO ROBOTICS**	**3**	**0**	**0**	**3**

a) **Course Category**

Open Elective

b) **Preamble**

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

c) **Prerequisite**

Nil

d) **Related Courses**

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	Discuss the classifications of Robotics Inspection category.	K2
CO3	Describe materials handling system of robots	K2
CO4	Interpret Robot End effectors and Selection of robotics	K2
CO5	Discuss robot applications in automation.	K2

f) **Correlation of COs with POs**

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

g) **Course Content**

UNIT I INTRODUCTION 6

Types of industrial robots, Load handling capacity, general considerations in Robotic material handling, material transfer, machine loading and unloading, CNC machine tool loading, Robot centered cell

UNIT II ROBOTS FOR INSPECTION 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, economics of robotisation, Impact of robot on industry and society.

UNIT V APPLICATIONS OF ROBOTICS 12

. Application of Robots in continuous arc welding, Spot welding, Spray painting, assembly operation, cleaning, robot for underwater applications.

Total: **45 Hrs**

h) **Learning Resources**

Text Books

1. Richaerd D Klafter, Thomas Achmielewski and MickaelNegin, “Robotic Engineering – An integrated Approach” Prentice HallIndia, New Delhi, 2001Mikell P.Groover, “Industrial Robotics”, McGraw Hill, 2nd edition, 2012.
2. Mikell P. Groover,”Automation, Production Systems, and Computer Integrated Manufacturing“, 2nd Edition, John Wiley & sons, Inc, 2007

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. YoremKoren, “Robotics for Engineers”, McGraw-Hill Book Co., 1992.
5. Groover M.P et al., “Industrial Robotics – Technology, Programming & Applications”, McGraw-Hill. 1986.
6. James A Rehg, “Introduction to Robotics in CIM Systems”, Prentice Hall of India, 2002.
7. 2. Deb S R, "Robotics Technology and Flexible Automation", Tata McGraw Hill, New Delhi, 1994

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	Discuss 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.	K2
CO3	Describe video management system of video analytics, trouble shooting, recording, storage and security.	K2
CO4	Discuss the video networking concepts, delivery methods and trouble shooting.	K2
CO5	Explain CCTV characteristics, components and case study of ATMand vehicle parking system.	K2

f) **Correlation of COs with POs**

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	H	-	L	-	-	-	-	-	-	-	L	L	M	M
CO2	M	L	L	-	L	-	L	M	-	-	-	-	-	L
CO3	M	L	L	M	M	L	-	-	-	-	L	L	L	-
CO4	M	L	-	-	L	L	-	-	-	-	-	M	M	-
CO5	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 DIGITALVIDEO HARDWARE **9**

Evolution of Video Surveillance Hardware, selection of Right Cameras, PTZ Protocols and Communications, Two-WayAudio, Configuring and Commissioning Digital VideoEncoders, Digital VideoCables 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 Vehicleparking system.

Total-45Hours

h) **Learning Resources**

i. **TextBooks**

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

ii. **References**

1. Murat A. Tekalp, "Digital VideoProcessing", Prentice Hall, 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**

Linear Integrated Circuits

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	Identify and understand the need for development of wearable devices and its influence on various sectors.	K3
CO2	Discus the applications of various wearable inertial sensors for biomedical applications.	K3
CO3	Comprehend the design and development of various wearable bio-electrode and physiological activity monitoring devices for use in healthcare applications.	K3
CO4	Identify the use of various wearable locomotive tools for safety and security, navigation.	K3
CO5	Acquaint the usage of wearable devices as assistive devices, diagnostic devices and other modern applications.	K3

f) **Correlation of Co's with Po's**

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

g) **Course Content**

UNIT I INTRODUCTION TO WEARABLE DEVICES 9

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

UNIT II 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, Acti graphs.

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; Photo plethysmo graphy (PPG), 3D imaging and motion capture.

UNIT V SCOPE OF WEARABLE DEVICES

9

Role of Wearable sensors, Attributes of Wearable sensors, The Meta Wearable – 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. “Seamless Healthcare Monitoring”, Toshiyo Tamura and Wenxi Chen, Springer 2018

4. “Wearable Sensors -Fundamentals, Implementation and Applications”, by Edward Sazonov and Michael R. Neuman, Elsevier Inc., 2014.

Reference Book

1. A.K. Sawhney, “Electrical and Electronic Measurements and Instrumentation”, DhanpatRai.

Course Code	Course Title	L	T	P	C
10213EC104	WIRELESS COMMUNICATIONNETWORKS	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**

On successful completion of this course the student will be able to

CO Nos.	Course Outcomes	Knowledge Level(Based on Revised
CO1	Discuss the radio signal propagation models and its impact on communication system performance.	K2
CO2	Illustrate the multiple access schemes based on reservation and random access methods. Explain the concepts of Wi-Fi.	K2
CO3	Describe 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**

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

g) **Course Content**

UNIT I OVERVIEWAND 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 ofPoissonProcessandAnalysisofAloha-CSMAwithCollisionAvoidanceandCollisionDetection-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

UNITV MOBILITY AND WPANS 9

Principles of Handovers: Switching Conditions, Hysteresis, Detection - Mobility in Cellular Systems: The Gateway Concept, Measurement Reports, Mobility Procedures-Mobile IP: Basic Components, Tunneling, Enhancements For Mobile Ipv6-Wireless Personal Area Networks (PANS): Bluetooth80215.1, Zigbee802.15.4.

Total: 45 Hrs

h) **Learning Resources**

TextBooks

1. V.K.Garg,Wireless Communications and Networking,MorganKaufmann,2007,ISBN: 9780123735805.
2. D.P.AgrawalandQ.-A.Zeng,Introduction to Wireless and Mobile Systems, Third Edition, CengageLearning,2010,ISBN:1439062056.
3. W.Stallings,WirelessCommunications & Networks, Second Edition,PrenticeHall,2004, ISBN:0131918354.
4. T.S.Rappaport,Wireless Communications, Second Edition, Prentice Hall,2002,ISBN: 0130422320
5. J.Schiller,MobileCommunications,SecondEdition,AddisonWesley,2003,ISBN : 0321123816

Online Resources

1. www.nptelvideos.in/2012/12/wireless-communication.html
2. nptel.ac.in/courses/117105076/pdf/2.2%20Lesson%203%20.pdf
3. https://www.coursera.org/learn/wireless-communication.../5g-mobile-communications
4. https://www.mooc-list.com/.../wireless-communication-emerging-technologies-courser...

Practice Aspects:

NS3 simulator Tool

Course Code	Course Title	L	T	P	C
10213EC105	**BASICS OF SIGNAL PROCESSING**	**2**	**2**	**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 of analysis of systems using various transformation techniques, and its application to various fields.

c) **Prerequisite**

Mathematics

d) **Related Courses**

Image Processing and its Applications

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	Classify the CT and DT signals and systems and describe its characteristics	K3
CO2	Determine the frequency components present in a deterministic signal	K3
CO3	Describe the characteristics of LTI systems in the time domain and frequency domain	K3
CO4	Compute the output of an LTI system in the time and frequency domains	K3
CO5	Identify the development tools and blocks involved in DSP applications.	K2

f) **Correlation of Cos with POs**

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

g) **CourseContents**

UNITI CLASSIFICATIONOFSIGNALSANDSYSTEMS 13

Standard signals- Step, Ramp, Pulse, Impulse, Real and complex exponentials and Sinusoids_Classification of signals – Continuous time (CT) and Discrete Time (DT) signals, Periodic &Aperiodic signals, Deterministic & Random signals, Energy & Power signals - Classification ofsystems-CT systems and DT systems- – Linear & Nonlinear, Time-variant & Time-invariant,Causal& Non-causal,Stable & Unstable.

UNITII ANALYSISOFCONTINUOUSTIMESIGNALS 13

Fourierseriesforperiodicsignals-FourierTransform–properties-LaplaceTransformsandproperties

UNITIII LINEARTIMEINVARIANTCONTINUOUSTIMESYSTEMS 13

Impulseresponse-convolutionintegrals-DifferentialEquation-FourierandLaplacetransformsinAnalysisofCT systems-Systemsconnected inseries/parallel.

UNITIV ANALYSISOFDISCRETETIMESIGNALS 13

BasebandsignalSampling–FourierTransformofdiscretetimesignals(DTFT)–PropertiesofDTFT- Z Transform& Properties, DFT

UNIT V APPLICATIONS OF SIGNAL PROCESSING 8

Signal Processing Applications: Speech and Audio Processing, Multimedia (image & video) processing, Underwater acoustic signal processing, Biological signal analysis.

Total60 Hrs

g) **Learning Resources**

Text Book:

1. Allan V.Oppenheim, S.Wilsky and S.H.Nawab, “Signals and Systems”, Pearson, 2015.

Reference Books

1. JohnG.Proakis&DimitrisG.Manolakis,"DigitalSignalProcessing–Principles,Algorithms&Applications",4thedition,PearsonEducation/PrenticeHall,2007
2. A.V.Oppenheim,R.W.SchaferandJ.R.Buck,"Discrete- TimeSignalProcessing",8thIndian Reprint,Pearson,2004
3. S.Salivahanan,A.Vallavaraj,CGnanapriya,"DiscreteSignalProcessing",TataMcGraw-hillPublication,2002.
4. EmmanuelC..Ifeachor,&Barrie.W.Jervis,"DigitalSignalProcessing",2ndedition,PearsonEducation/PrenticeHall,2002.
5. SanjitK.Mitra,"DigitalSignalProcessing–AComputerBasedApproach",TataMcGrawHill,2007.
6. B.P.Lathi,"PrinciplesofLinearSystemsandSignals",SecondEdition,Oxford,2009
7. R.E.Zeimer,W.H.TranterandR.D.Fannin,"Signals&Systems-ContinuousandDiscrete",Pearson,2007
8. JohnAlanStuller,"AnIntroductiontoSignalsandSystems",Thomson,2007.

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 the course is to provide students with the basic knowledge of image processing applied to various fields of engineering.

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	Illustrate the components of digital image, image acquisition and the various color models	K2
CO2	Identify the various 2D image transforms	K2
CO3	Explain 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**

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

g) **Course Content**

UNIT I FUNDAMENTALS OF DIGITAL IMAGE 9

Introduction – Origin – 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, Wavelet-based image compression, compression standards, applications of image compression.

Total: 45 Hours

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.VeeraKumar, “Digital Image processing,” TataMcGraw 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.

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**

Basics of embedded systems, 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	Explain the concepts of PLC used in industrial Automation.	K2
CO3	Familiarize the concept of SCADA used in industrial automation	K2
CO4	Explain the concept of Distributed Control System	K2
CO5	Familiarize the concepts of industry 4.0.	K2

g) Correlation of Cos with POs

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

CO4	M	L	L	-	-	-	M	-	L	L	-	L	-	-
CO5	M	L	-	-	-	-	-	-	L	L	-	L	M	-

f) Course Content

UNITI INTRODUCTION 9

Introduction to Industrial automation system, Basic elements of automated system, Requirement of automation systems, 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

Programmable Logic Controller (PLC): Introduction to PLC, 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, data manipulation and other higher level programming instruction with case studies.

UNIT III SCADA SYSTEMS: 9

Introduction, definition and history of SCADA, typical SCADA System Architecture, Communication requirements, Desirable properties of SCADA system, Features, advantages, disadvantages and applications of SCADA.SCADA systems in operation and case studies

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, Historian, Integration of business inputs with process data, Leveraging remote terminal unit (RTU).

UNIT V TECHNOLOGIES ENABLING INDUSTRY 4.0 9

Introduction and 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**

i. **Text Books**

1. S.K. Singh, *“*Industrial Instrumentation and control”–The Mc Graw Hill companies 3rd edition – 2009.
2. F. G Shinskey Process Control Systems, McGrahill Publications.
3. Curtis D. Johnson “Prentice Process control Instrumentation Technology”– Hall India,8thedition, 2006
4. Thomas Hughes, “Programmable Logic Controller”,ISA Publication.[Unit II].
5. StuartA. Boyer, “SCADA supervisory control and data acquisition”, ISA Publication.
6. McMillan.G.K, “Process/ Industrial instrument and handbook”, McGraw-Hill,NewYork,1999 [UNITIV]
7. Machine- to-machine communications edited by vojislab B. misic, Jelenamisic, CRSpressTaylor&francisgroup–2015.
8. Internet of Things: A hands on approach by Arshdeep Bahga, Vijay madisetti Published by ArshdeepBahga,Vijaymadisetti-2014.[UNITV]

ii. **Reference Books**

1. Samuel M. Herb, “Understanding Distributed Processor Systems for Control*”,* ISA Publication.
2. Thomas Hughes,“Programmable Logic Controller”,ISA Publication.
3. StuartA.Boyer,*“*SCADAsupervisorycontrolanddataacquisition”,ISAPublication
4. PoppovikBhatkar,“DistributedComputerControlforIndustrialA utomation”,Dekkar Publication

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)
C01	Understand BuildingManagement system and Automation.	K2
C02	Describe various Sensors and Transducers and Automation components in BMS	K2
C03	Explain the Fire alarm system and Access control system	K2
C04	Describe Security Systems and its components used in BuildingAutomation.	K2
C05	Understand the HVACand Energy Management systems.	K2

f) **Correlation of COs with POs**

	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	M	L	L	-	-	-	M	-	L	L	-	-	-	-
CO2	M	-	-	-	-	-	-	-	L	L	-	L	-	-
CO3	M	-	-	-	-	-	-	-	L	L	-	-	-	-
CO4	M	L	L	-	-	-	M	-	L	L	-	L	-	-
CO5	M	L	-	-	-	-	-	-	L	L	-	L	-	-

g) **Course Content**

UNIT I INTRODUCTION TO BUILDING MANAGEMENT SYSTEM AND AUTOMATION 9

Concept and application of Building Management System (BMS) and Automation, requirements and design considerations and its effect on functional efficiency of building automation system, architecture and components of BMS

UNIT II AUTOMATION COMPONENTS IN BMS 9

Temperature Sensors: RTD, Thermistor, Thermocouple, Bimetallic strip - Pressure Sensors: Diaphragm type, piezoelectric sensors –Different types of mounting of pressure sensors in duct, rooms and pipes – Air flow sensor: Anemometer, velocity pressure sensors – Flow sensors: Turbine flow meter, Orifice, Venturi, Pitot tube, ultrasonic flow meter–Different types of mounting for air & water flow meters

UNITIII FASAND ACCESS CONTROL SYSTEMS 9

Fire, Fire modes–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.

UNITIV SECURITY SYSTEMS 9

Fundamentals: Introduction to Security Systems, Concepts. Perimeter Intrusion: Concept, Components, Technology, Advanced Applications. 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.

UNITV HVACSYSTEM AND ENERGY MANAGEMENT9

Fundamentals: Introduction to HVAC, HVAC Fundamentals, Control Panel: HVAC Control Panel, MCC Basics, Panel Components Communication: Communication Basics, Networks, BACNet, Modbus , LON, Energy Savings concept & methods, lightning control, Building Efficiency improvement, Bureau of EnergyEfficiency (BEE) standards, Green Building(LEED)Concept&Examples .

Total: 45 Hrs

h) Learning Resources

i. **TextBooks**

1. Understanding Building automation Systems (Direct Digital Control, Energy Management, Life safety, Security, Access control, Lightning, Building management Programs), Reinhold A, Carlson and Robert A, Di Giando menico
2. HVACsystems Design Hand book, Fifth edition, Roger W.Haines.
3. CCTV (Newnes), Vlado Damjanovski, 1999.
4. Process Control –Instrument Engineers Hand book, Bela G. Liptak, Chilton book co.

COURSE CODE	COURSE TITLE	L	T	P	C
10213EC109	EMBEDDED SYSTEMS	3	0	0	3

a) **Course Category:**

Open Elective

b) **Preamble:**

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

.

c) **Prerequisite Courses:**

Nil

c) **Related Courses:**

Nil

d) **Course Outcomes:**

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

CO Nos	Course Outcomes	K-Level
CO1	Explain the role of individual components involved in a typical embedded system	K2
CO2	Describe the embedded systems life cycle and selection process	K2
CO3	Explicate different communication protocols and interfaces	K2
CO4	Familiarize different compilation and debugging techniques	K2
CO5	Explain the various applications using embedded system design	K2

e. Correlation of COs with POs (Program Outcomes defined by National Board of Accreditation, India)

	PO1	PO2	PO3	PO4	PO5	PO6	PO7	PO8	PO9	PO10	PO11	PO12	PSO1	PSO2
CO1	2	1	2	1	3	-	-	-	1	-	1	1	1	2
CO2	1	2	3	1	2	-	-	-	2	-	-	2	-	-
CO3	-	1	-	2	-	3	-	-	-	-	-	-	2	1
CO4	1	2	3	-	-	-	-	-	-	-	-	-	2	-
CO5	-	-	2	-	3	-	-	-	-	-	-	2	2	1

f. Course Content:

UNIT-IINTRODUCTION 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-Agricultural Applications-Automobile Sector-Vending Machines-Smart Cards-Digital Camera-Smart City.

Total-45 Hours

g. Learning Resources:

Text Books:

1. Raj Kamal (2015). Embedded Systems: Architecture, Programming and Design (3rd Edition), New Delhi: Mcgraw Hill Education (India).
2. Steve Heath "Embedded Systems Design" Second Edition, Elsevier, 2009.
3. Arnold S. Berger, Embedded Systems Design: An Introduction to Processes, Tools, and Techniques, CMP Books, 2002.

Reference Books:

1.Frank Vahid & Tony Givargis, "Embedded System Design-A Unified Hardware/Software Introduction", Third Edition, John Wiley & Sons Inc., Reprint 2010.

Online Resources:

1.https://www.youtube.com/watch?v=4CPIjYGIYqc
2.https://www.youtube.com/watch?v=y70V0qHAFNQ
3.https://www.youtube.com/watch?v=yAOfqK1kQso

Course Code	Course Title	L	T	P	C
10213EC110	**FPGA ARCHITECTURES AND APPLICATIONS**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

This course discusses the features, programming and applications of Programmable Logic Devices. The students shall emphasize the VLSI architectures such as xilinx, Actel, Altera, plessy, plus logic, AMD, quick logic, algotronic Concurrent logic, technology mapping and design flow. This course introduce the Routing Terminology and flexibility of FPGA Routing Architectures. 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	Explain the routing terminology and flexibility of FPGA Routing Architectures	K2
CO4	Illustrate the State assignments for FPGAs and FSM.	K2
CO5	Illustrate the VLSI system design using combinational and sequential circuit	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	PSO1	PSO2
CO1	H	H	M	L	L	-	-	-	-	-	-	H	M	M
CO2	H	L	M	H	M	-	-	-	-	-	-	L	H	M
CO3	M	L	H	M	H	M	-	-	-	-	-	L	L	M
CO4	H	H	M	H	H	M	-	-	-	-	-	M	M	M
CO5	M	M	H	H	M	M	-	-	-	-	-	H	L	M

g) Course Content

UNIT I INTRODUCTION TO CPLDS

Introduction to CPLDs- PROM, PLA, PAL, 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

Commercial FPGAs- programming techniques, Xilinx, Actel, Altera, plessy, plus logic, AMD, quick logic, algotronic Concurrent logic Crosspoint Solutions, Mapping for FPGAs, Design flow, One hot encoding

UNIT III ROUTING FOR FPGAS

Routing Terminology, General Strategy for Routing in FPGAs, Routing for Row-Based FPGAs, Routing for Symmetrical FPGAs.

Flexibility of FPGA Routing Architectures-FPGA Architectural Assumptions, Experimental Procedure, Limitations of the Study

UNIT IV FINITE STATE MACHINES

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

Controller, data path and functional partitions, Parallel adder cell, parallel adder sequential circuits, counters, multiplexers, parallel controllers.

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. 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. Douglas L. Perry, VHDL: Programming by Example, McGraw-Hill Education, Fouth Edition.
4. Kevin Skahil, VHDL for programmable logic, Addison Wesley.
5. S.Brown, R.Francis, J.Rose, Z.Vransic, Field Programmable Gate Array, Kluwer Pubin, 1992.

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

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 historical background and evolution of intelligent transportation systems (ITS) and its types	K2
CO2	Illustrate the hardware requirements and data necessities of ITS.	K2
CO3	Demonstrate the knowledge of ITS user requirements and amenities	K2
CO4	Outline the planning requirements of ITS in various transportation modes to improve their safety and efficiency	K2
CO5	Show the cutting-edge of ITS applications and visualize the evolution of transportation in the near future.	K2

f) Course Content

UNIT I FUNDAMENTALS OF ITS 9

Introduction to ITS, the 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

Application of sensors to Traffic management – Traffic Prediction systems; Transponders and Communication systems - Data management centers - Elements of Vehicle Location and Route Navigation and Guidance concepts - ITS Data collection techniques – Detectors, Automatic Vehicle Location (AVL), Automatic Vehicle Identification (AVI), GIS, video data collection.

UNIT III ITS USER REQUIREMENTS AND AMENITIES

Advanced Traffic Management systems (ATMS), Advanced Traveler 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

ITS Models and Evaluation Methods - Planning and human factor issues for ITS - Case studies on deployment planning and system design and operation - ITS and safety - ITS and security, ITS for research, development and business models

UNIT V ITS APPLICATIONS

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.

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).
4. National ITS Architecture Documentation, US Department of Transportation, 2007

Reference Books

1. Sussman, Joseph S. Perspectives on intelligent transportation systems (ITS). Springer Science & Business Media, 2008.

Online Resources

1. https://www.pcb.its.dot.gov/eprimer/default.aspx

Course Code	Course Title	L	T	P	C
10213EC112	**WIRELESS COMMUNICATION TECHNOLOGIES**	**3**	**0**	**0**	**3**

a) Course Category

Open Elective

b) Preamble

Wireless communication is a broad term that incorporates all procedures and forms of connecting and communicating between two or more devices using a wireless signal through wireless communication technologies and devices. This course focuses on the fundamental concepts of mobile communication, various propagation models, signaling schemes and recent trends in wireless communication.

c) Prerequisite

Nil

d) Related Courses

Wireless Networks

e) Course Outcomes

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

CO Nos.	Course Outcomes	Knowledge Level (Based on Revised Bloom's Taxonomy)
CO1	Describe the evolution of wireless communication systems.	K2
CO2	Comprehend 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	Assess the recent trends in wireless communication and resource management	K2

f) Correlation of COs with POs

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

g) Course Content

UNIT I INTRODUCTION TO WIRELESS COMMUNICATION SYSTEM 9

Evolution of mobile communications - Types of wireless communication systems - Comparison of common mobile radio systems- Trends in cellular radio and personal communication – An overview on generations of wireless technology: 1G, 2G, 3G, 4G/ LTE

UNIT II CELLULAR SYSTEM DESIGN FUNDAMENTALS 9

Cellular system- hexagonal geometry cell and concept of frequency reuse- Channel assignment strategies - Handoff Strategies: Types of Handoffs, Prioritizing Handoff- Interference and system capacity: Co- channel and adjacent interference, Umbrella cell concept, Trunking and Grade of service - Improving coverage & capacity in cellular system: Cell splitting, Cell sectoring, Repeaters, Micro cell zone concept.

UNIT III MOBILE RADIO PROPAGATION AND SIGNAL TRANSMISSION 9

Signal Propagation: Basic propagation mechanisms, path loss, and 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 - NOMA

UNIT V RECENT TRENDS IN WIRELESS COMMUNICATION 9

Machine type communication: Fundamental techniques, massive MTC, V2X communication - D2D communication:4G to 5G Research challenges, Radio resource management for mobile broadband D2D, RRM and system design for D2D, Power control and Mode selection.

Total: 45 Hrs

h) Learning Resources

Text Books

1. Theodore, S. Rappaport, “Wireless Communications, Principles, Practice”, Second Edition, PHI, 2002.
2. Andrea Goldsmith, “Wireless Communications”, Cambridge University Press, 2005

Reference Books

1. William Stallings, “Wireless Communications and Networks”, Second Edition, Pearson Education, 2004.
2. Andreas F Molisch, “Wireless Communications, Wiley, 2011.
3. Afif Osseiran, Jose F. Monserrat and Patrick Marsch, “5G Mobile and Wireless Communications Technology, Cambridge University Press, 2016.
4. David Tse and Pramod Viswanath, Fundamentals of Wireless Communication, Cambridge University Press, 2005, South Asian Edition, 2006.

Online Resources

1. https://www.digimat.in/nptel/courses/video/106106167/L01.html
2. https://onlinecourses.nptel.ac.in/noc21_ee66/preview
3. https://youtu.be/SljXFf0vgvw

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 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	Explain the key benefits of passive elements and active elements	S3
CO2	Interface various automotive sensors and actuators with given Microcontrollers	S4
CO3	Demonstrate the various switching and control devices.	S3
CO4	Design an automotive electronic system for monitoring engine performance, infotainment and telematics.	S4
CO5	Recognize the appropriate protocols used in vehicle networking	S2

f) **Correlation of COs with POs**

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

g) **Examination Scheme**

Examination Scheme for practical dominated course										
Internal evaluation (40M)							**Semester end evaluation (60M)**			
Laboratory experiment (15M)				**Model laboratory test (25M)**			**Part-A (20M)**	**Part-B (40M)**		
Performance in conducting Experiment (5)	Result and analysis (3)	Viva Voce (3)	Record (4)	Performance in conducting experiment (5)	Result and analysis (5)	VivaVoce (5)	Theory questions to evaluate the knowledge and understanding (20)	Performance in conducting experiment (25)	Result and analysis (10)	Viva-Voce (5)

g) **Theory 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, Vehicletelematics system

UNIT V Networking **6**

Automotive Bus: LIN, CAN, MOST, FlexRay,Automotive-Ethernet- Bus- Architecture
Design & Simulation Tool: Matlab, VectorCANoe Simulation Tool

Total: 30 Hrs

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 and Pressure values.
4.	**Comfort Electronics**	CO2	Task4: Automatic climate control
5.		CO2	Task5: Reverse Parking assistance
6.	**Performance Monitoring System**	CO2	Task6: Engine Ignition On/Off System
7.		CO2	Task7: Coolant and Brake Fluid Level Indicators
8.	**Vehicle Telematics**	CO3	Task8: Vehicle Tracking
9.		CO3	Task9: Vehicle to Vehicle and Vehicle to Infrastructure
10.		CO3	Task10: Vehicle telematics
11.	**Automotive Network**	CO3	Task11: Simulation of CAN communication using MATLAB
12.		CO3	Task12: Simulation of CAN/LIN communication using Vector CANoe

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, “VehicularNetworking: Automotive Applications and Beyond”, Wiley,2010

Reference book

1. Timo Kosch, Christoph Schroth, Markus Strassberger, Marc Bechler, “Automotive Internetworking”, Wile